"The Machine is, in fact, the metamorphosis of ancient art and craft; that we are at last face to face with the machine- the modern Sphinx- whose riddle the artist must solve if he would that art live-"

**Frank Lloyd Wright, *The Art and Craft of the Machine* (1901)**

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IP Thesis

It seems the role of designer in the twenty-first century is not to define ourselves through the application of fine form language, usability, and marketing but to navigate the conceptual tension between what is expected and what is possible though emerging technology. How is the technology of digital fabrication renegotiating antiquated notions of craftsmanship and the conceptual role of designer as creator? Just as Frank Lloyd Wright posed the riddle of the machine in the 1900s, these questions and more function as a critical proving ground where the validity of a design must be assessed in the context of ongoing conflict. The discord of manual craftsmanship with mechanized processes is fertile ground for contemporary design, a negotiation that must be addressed lest we run the risk of being consumed by our conceptual infatuation, or slaves to the tools of our trade.

What are the sources of this conflict and how have they been negotiated in the past, as Wright illustrates, this conflict is by no means a recent development. Any application of digital fabrication gambles with predictability, an outcome dictated by process. While predictability is not compulsory with the use of digital processes, it all to often the norm rather than exception when the role of digital fabrication is not critically evaluated. Beyond functioning as an enabler of production, we must ask if the ends justify the means. This is perhaps the primary conflict we must not ignore otherwise we concede mastery of craft and sacrifice inventive design on the altar of predictable process. In short "genius must progressively dominate the contrivance"[1] else we become slaves, functioning as mere extensions of the machines we utilize.

[1] Wright, Frank Lloyd. *The Art and Craft of the Machine,* 1901

Notions of craftsmanship are also highly contested in the designer's relationship with digital technology. Perhaps an extension of our discussion of predictability, varying means of digital fabrications possess distinct signs of process and its inherent limitations. Laser cutting leaves burnt edges and a pungent odor, subtractive CNC routers and mills leave numerous tool marks and radiused corners, and three-dimensional printers exhibit surface tessellations and limited resolution. All of these marks of process threaten to overpower the formal elements of any design. The craftsperson must be self aware of their own skill set but also cognizant of what, and more importantly what not, digital fabrication methods are capable of.

As a continuation of craft, valid use of digital fabrication requires a critical examination of material choice. Unfortunately, most rapid fabrication methods sacrifice utility for expediency. While the end object can be beautifully crafted, it comes at the cost of non-functionality and vice-versa. As a result, digitally fabricated items often suffer from a prototypical perception due to a combination of readily identifiable process and material compromises. The designer cannot ignore these expectations, but rather should challenge what is possible given these constraints.

Beginning with the industrial revolution, artists and craftsman have been negotiating their roles within a culture adapting progressively more technological systems and processes. Early critics like John Ruskin argued fiercely for the supremacy of the human hand. In opposition to the mechanized perfection possible through the use of machines, Ruskin instead argued that an imperfect object was inherently more valuable because it demonstrated a flourish of human expression. "Imperfection is in some sort essential to all that we know of life. It is the sign of life in a mortal body, that is to say, of

a state of progress and change."[2] Ruskin embodies an attempt to create value by emphasizing an early movement towards conceptualism. The craftsperson is capable of communicating an idea through their actions, a machine cannot, and this makes an imperfect object more valuable in what it could embody. The instant we demand perfection from the human craftsperson without reason is the moment the craftsperson becomes as empty as the object being created, relegating him to a mere animated tool.

Nearly fifty years later, Frank Lloyd Wright boldly challenges the romanticism of Ruskin's craftsperson and calls for the integration of technology. "The Machine is Intellect mastering the drudgery of earth.... its function ultimately to emancipate human expression!"[3] Wright's argument is in many ways the antithesis of Ruskin's; embrace technology and move beyond the drudgery of physical manufacture. The machine was the great democratizer, freeing craftsmen to move beyond the realm of mere utility. Wright also warned that the machine was capable of doing great good, but only in hands willing to use technology to create a more beautiful world, instead of those with a selfish desire to increase their own leisure or wealth. In negotiating the conflict between technology and perception of "art" objects, Wright exemplifies the development of art as something created outside of a linear or mechanized process, democratizing skilled craftspeople to the role of artist/designer. In Wright's most concise language, technology should simply function to "clothe necessity with the living flesh of virile imagination"[4].

In 1923, Walter Gropius tempered much of the conceptualism endorsed by Ruskin and Wright with German Bauhaus. "The artist was a man 'remote from the world', at once

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[2] Ruskin, John. *The Nature of Gothic,* 1853.
[3] Wright
[4] Wright

too unpractical and too unfamiliar with technical requirements to be able to assimilate his conceptions of form to the processes of manufacture"[5] Gropius was a harsh critic of the art "academy" where mechanical skills of drawing or painting were taught under the pretense of creating professions. He argued at the time that such professions were imposters of the arts, no better than machines because while they possessed the necessary skills, they lacked a holistic understanding of the changing world around them. Quite the opposite of Wright, these individuals were too engrossed by the tools of expression to utilize technology's economy and efficiency: stalled, marveling at their own ideology and fetishizing the creative process.

We can see how historically the conflict between art and technology has been a constant flux, in part a reaction to socio-economic and cultural trends but also due to a certain level of insecurity on the part of the craftsperson. Ruskin's vacillation with the adoption of mechanized production seems to stem from a fear of obsolescence on the behalf of the craftsman. Wright seeks to reconcile the luddite-esque Ruskinites with the romantic technocrats of the early 20th century, as later described by Gropius. In developing criterion for assessing the validity of technology in recent art practice, we should first look to how this negotiation has been handled in the 21st century given the previously discussed historical context.

DIY subculture and advancements in three-dimensional printing technology have melded with environmental concerns to push the idea of desktop manufacturing into the popular lexicon. "Home-scale machines, such as 3D printers, laser cutters, and programmable sewing machines, combined with the right electronic design blueprint,

[5] Gropius, Walter. *The New Architecture and The Bauhaus,* 1923

enable people to manufacture functioning products at home, on demand, at the press of a button. In just a few hours, these mini-factory machines can produce a simple object like a toothbrush, or make complex machine components, artisan-style jewelry or household goods."[6]

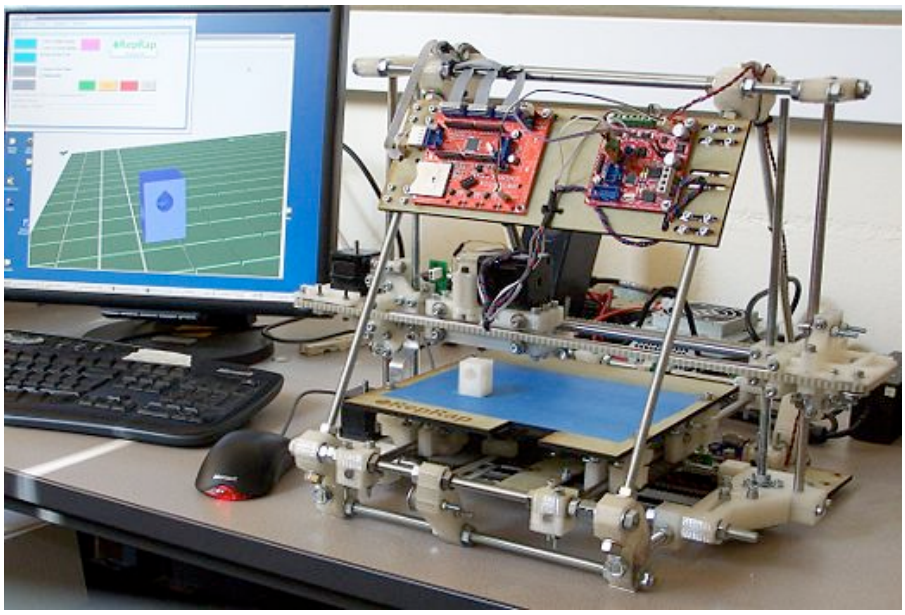

*Figure 1: Reprap Mendal, a second generation self-replicating 3-D Printer*

Today the promise of a desktop "factory" remains a Utopian mirage upon the horizon. Beyond cost-benefit barriers, 3-D printing technology remains in its infancy and is prototypical at best due to many of the aforementioned constraints of material, craft, and predictable results. The jump from rapid-prototyping to rapid-fabrication and its implications in terms of the artist/technology dialectic remains largely unexplored.

Enrico Dini is one of the few designers working to push beyond these expectations with his architectural scale 3-D printer, d-shape. "Dini's machine marks a

[6] Lipson, Hod and Melba Kurman. *Factory@Home,* 2010.

vital step change from the shoebox-size 3D printing of today, to tomorrow's ability to print complete structures on site"[7]

*Figure 2: Enrico Dini and d-Shape Printer*

The most readily apparent constraint Dini challenges is that of scale. In moving beyond the expected miniaturization we are confronted with a new attribute to validate this use of technology: utility. The massive printer is capable of printing structures at a truly architectural scale using sand and an inorganic binder. The resulting structures are as strong as reinforced concrete and resemble sandstone that would have taken millennia to constitute naturally. The permanence of the material also challenges our prototypical expectations of substandard material substitution. Unfortunately, figure 2 also illustrates one of Dini's shortcomings: craft. His structures clearly show the marks of process, dramatic stratification and poor resolution compete with the organic curvilinear design of

[7] Abrahams, Tim. *The Worlds First Printed Building,* 2010.

the pavilions. To the uninitiated, it is simply poor craftsmanship and to the seasoned technocrat, it is but a base exploration of technology. Dini fails to reconcile his design with the possibilities, and inversely the limitations of the process he has chosen and therefore setting both in sharp contrast rather than a complementary correlation.

Wright's riddle remains unsolved and a relevant tool for an artist or designer to assess the validity of our own relationship with technology. The machine as a tool is vicarious in its ability to ensnare or emancipate imagination. Herein we may propose criterion for evaluating the use of a mechanical or manual process with respect to challenging the expected outcome of each. The core of the conflict is in striking a balance between the necessity of process with the noise of possibility. Technology of today affords an opportunity to create objects once thought impossible, but does having such power justify its exercise?

Herein lies the dictum of my Integrative Project; the design of an object must be as innovative as the means to produce it. Without such a cyclical relation, the designer is a slave to his tools (predictable) or the design may become so naively idealistic that it exists outside of the realm of manufacture (unattainable).

In choosing a means to explore this concept I wanted to exploit my prior work to best effect, while also producing relevant work with my Industrial and Furniture Design interests. In the four years I have spent at the University of Michigan, I have heavily leveraged the digital manufacturing resources available. In some cases, like *Novum Organum* I have made a very active effort to conceal the means of production. These spheres were shaped on a 4-axis CNC mill, then hand finished and polished to remove any tool marks. This piece begins to accurately embody my belief in the power of digital

fabrication and the balancing act required to ensure the process does not override or distract from the concept.

*Novum Organum,* Author 2010

In other cases, my designs have focused on the digital technology itself. In the fall of 2008 I began working on ProSys, a subtractive rapid prototyping system capable of reproducing most of its structural parts. This helped to give me an intimate understanding of the working system behind digital manufacturing, as well as how to optimize a mechanical system for maximum efficiency of materials and space. Clearly this was design as an exploration of technology.

As an aspiring Industrial Designer I have had a very strong attraction to furniture. These items must simultaneously function as large sculpture, an object that looks shapely and beautiful when not in use, but also experienced on a very physically intimate level. Well-designed furniture is utilitarian, but also performative; it caresses entire areas of our

body and can set the mood for any situation. Our relationship with furniture is more complex than almost any other designed object.

My Integrative project seeks to utilize my prior work using digital fabrication technology, and marry it with my fascination with furniture design to explore the explore the efficacy of and criterion for the appropriate use of 3d rapid prototyping technology as a means of fabrication. For this investigation I will work in two parallel veins, process and product.

Process involves the technical design and construction of a large scale 3D printer. The bed of the printer is large enough to print any furniture object contained within a four-foot cube. My design utilizes Polylactic Acid (PLA) in fused deposition modeling process. Millimeter by millimeter I will be capable of producing functioning furniture objects to challenging the prototypical notion surrounding this technology. By building the printer I will utilize my prior knowledge of Cartesian robot systems while becoming intimately familiar with the capabilities and limitations of 3D printing.

Simultaneously I will be investigating the "product" portion of my thesis. Here we see the production of a unique furniture object specifically designed for this process. The furniture design will function vicariously as being uniquely informed by process while simultaneously challenging the expected craft, material, and form language. The borders between manual and mechanized labor will be indistinguishable, challenging my audience's notions of perfection and value. This design will suggest an answer to the criterion suggested herein.

- *The design must be as innovative as the means to produce it. Without such a cyclical relation, the designer is a slave to his tools (predictable) or the design may become so naively idealistic that it exists outside of the realm of manufacture (unattainable).*

- *Challenge the expected outcome of mechanical and manual processes and in doing so blur the distinctions between them.*

- *Strike a balance between the necessity of process with the noise of possibility*

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