Harvard Business Review 哈佛商业评论

3D Technologies: A Gateway to Innovative Design

Robert Plant. **December 2013**

The way corporations think about manufacturing and its precursor 'Design,' is about to undergo significant changes. This is due to the emergence of 3D technologies and their integration into a lean design model, one in which the complexity of the assembly and the manufacturing processes are both minimized. Executives therefore need to reflect if their company is ready and prepared to embrace 3D Technologies and the steps needed in order to take their design strategies to the next level.

The first aspect of this emerging model is 'Additive Manufacturing.' A term used to denote an integrated technology environment based upon 3D technologies. This set of technologies includes 3D printing; high resolution 3D scanning, and computer aided design systems which allows for both rapid prototyping and rapid manufacturing.

While additive technology platforms can be used for standalone projects, prototyping, and experimental environments; the power of the technology is amplified when it is used in conjunction with a lean design model which incorporates both a 'Design for Manufacturing' (DFM) and a 'Design for Assembly' (DFA) component. Both of these are aimed at reducing complexity while increasing the flexibility of the design. Together DFMA reduces labor costs by decreasing the number and complexity of parts involved in a product design and the number of steps in the manufacturing process itself.

A high profile example of a company which has embraced this approach is GE, who in 2012 opened their first new assembly plant at Appliance Park, Kentucky for 55 years. Investing in lean manufacturing enabled GE to reduce the number of parts in their GeoSpring water heater appliance by 20%; material costs by 25%; investment in equipment by 30%, and reduced development time in half. This allowed the company to reduce the price to consumers by 20% over the one produced under contact overseas.

Companies of the scale of GE can manufacture anywhere in the world, however significantly they chose to open their plant in Kentucky. This provides several advantages. First, close proximity between the designer and manufacturing reduces cycle times through rapid iterate prototyping. This is especially beneficial in creating new products for customers within rapidly changing market spaces as well as for gaining early mover advantage in emerging market categories. Second, bespoke manufacturing can be undertaken at relatively low cost. Third, it allows companies such as GE to manufacture close to their target market benefiting from the reduced delivery times and logistics costs.

We studied over 70 companies who have moved their manufacturing closer to their domestic markets and over 400 meeting groups to identify the creative mechanisms through which firms transformed themselves to leverage 3D technology systems and lean manufacturing models.

Three stages were found to be keys in the transformation process and provide a useful guide for companies embarking on this journey.

Stage 1: Change your Mindset:

Change won't happen unless your culture changes, this requires two actions:

Establish a Design Leadership Mindset

In order to establish a design mindset, the leadership of the firm needs to embrace it and verbalize this strategic intent. For example, Jeff Immelt, GE's chairman and CEO made it clear 3D printing "makes unique shapes with high tech material, in a quick period of time. That is worth my time and a lot of investment," he illustrates the point by indicating that by 2020 there will be over 100,000 printed parts inside their jet engines. This sends a clear directive of intent to shareholders and throughout the firm with respect to the importance of additive manufacturing and the need to think about design in that context.

Establish a Hackerspace Designer Mindset

The move to a design innovation mindset requires the adoption of an adaptive; 'question everything' and innovate design focus. This philosophy of development has been championed by innovators such as Mark Zuckerberg, who actively discouraged his employees from using traditional linear, formalized development methods, where managers take a long period of time to specify every aspect of the 'perfect' product in the hope of reducing risk to zero; instead he encouraged the Hacker Way:

"The Hacker Way is an approach to building that involves continuous improvement and iteration. Hackers believe that something can always be better, and that nothing is ever complete. They just have to go fix it – often in the face of people who say it's impossible or are content with the status quo. Instead of debating for days whether a new idea is possible or what the best way to build something is, hackers would rather just prototype something and see what works"

The hacker mindset can be developed and flourish through the creation of what are termed 'Hackerspaces.' These are locations, where employees can work, 'play,' and experiment with new technologies in order to explore their capabilities, and develop their ideas. Hackerspaces can even be placed within administrative offices with the 3D printer next to the photocopier, in essence providing a 'desktop factory' within a nontraditional context.

Several factors contribute to the success of these hackerspace facilities at driving innovation and creativity. Hackerspaces bring together their members heterogeneous skill sets to bear upon a problem, groups include engineers, technologists, artists, woodworkers, etc. This promotes a sense of collaboration and creativity through a cross fertilization of skills, techniques, and ideas. Additionally, teams enjoy searching for answers to problems via their human networks. The innovation even leads to new equipment being modified out of the box, nothing is sacred, and old equipment is 'evolved' to solve new and interesting problems.

Companies may also support local hackerspaces, where members of the wider community come together to work on projects.

This was the strategy embraced by the Ford Motor Company and Autodesk, a world leader in 3D design software; who in Detroit partnered with TechShop, a company that creates, owns, and manages Hackerspace styled workshops. Autodesk, who is also an investor in TechShop provided the membership with professional grade software and staff to with technology expertise; while Ford, also keen to drive innovation, provided $750,000 worth of laser cutters, 3D-Printers, CNC machine tools and "Dream Consultants" to help teams build their projects in a 38,000 square foot workspace.

Bill Coughlin, CEO of Ford Global Technologies, has noticed a discernible shift in corporate culture and attitude towards innovation, commenting "there was a time not so long ago in this business where outside ideas were not readily considered." The impact of the initiative has yielded positive outcomes, Coughlin notes, "since TechShop memberships were added to help enhance Ford's invention incentive program, invention disclosures have increased by more than 50 percent." Ford provides three months free membership to any employee whose innovation leads to a patentable product for Ford.

Stage 2: Change your Design Philosophy

The second stage in cultural change requires a shift to a philosophy that stresses "flexibility without complexity" rather than "volume and repetition." This also requires two actions:

Establish a Design Center

Key to understanding the potential for any new technology is actually using it. For additive manufacturing this can be achieved through the establishment of a prototyping center in the corporate R&D Lab. For example, GE has created a new Rapid Prototyping Center in Louisville, Kentucky where they experiment with 3D printers to create and assess the viability of potential new products.

One prototype GE recently developed was a fabric softener dispenser for a new top loading washing machine; another is a grate for a gas range. These prototypes can then be immediately presented to focus groups. Previously, in order to achieve the optimum design for the best performance, GE found that a part development process would require as many as 20 prototypes, each requiring the creation of a new tool and taking eight to 10 weeks from a computer-generated 3D drawing to the completion for each new prototype to test. Now, with additive manufacturing, the development of each prototype can be condensed from months to days, drastically reducing the overall development cycle by as much as 80 percent and significantly reducing the costs associated with the product development.

Establish a 'Design for Manufacture' and 'Design for Assembly' perspective

A principal aspect of the successful reshoring movement by firms in the United States has been the adoption of 'Design for Manufacturing and Assembly' (DFMA) lean manufacturing principals which aim to reduce design complexity. DFMA has been embraced by leading companies including DELL; Boeing; OTIS, and Whirlpool who through this approach reduced the number of parts in its most popular microwave oven by 29% and assembly time by 26%. The power of 3D manufacturing is precisely its flexibility to produce experimental designs, prototype materials, and test assembly options iteratively. Integration of the 3D platform with DFMA methods enables the product business case to be refined and the options understood before a design is presented to customers.

Stage 3: Change your Delivery Model

The third stage requires recognition of the need to change the delivery model for products. This also requires two actions:

Establish an IP Repository & Design Store

The R&D prototyping center not only enables production knowledge for new products to be developed. It can also act as the location for an Intellectual Property (IP) "knowledge" repository on existing products and additive manufacturing. Since the 1990's, many firms have created digital models for their products through systems such as Autodesk. These provide a rich 'back catalogue' of digital product specifications and data. In the music industry, the long tail of back catalogue was considered dormant and un-economic from a production perspective until the advent of digital markets, such as those of iTunes and Amazon, facilitated a viable reseller model.

The IP can be leveraged in a variety of ways. It can be provided to previous clients so that they can manufacture components on their 3D systems at the new points of manufacture; it can be provided to third party OEM manufacturers for manufacture under license, and to innovators who wish to take an old product then revitalize or modified it for enhanced performance.

An innovative approach is to create an "IP Design Store" or online exchange where individuals or companies can buy and sell design models for 3D systems. One such exchange is the venture capital funded GrabCAD, located in Boston, whose aim is 'helping engineers get products to market faster by connecting people, content and technology.' They do so by providing an environment where members can share CAD files collaboratively or privately. A second form of IP Design Store is the Corporate IP Design Store where firms can provide IP for their end consumers. For example, GE Industrial Solutions provides CAD drawings for use by engineers who wish to integrate GE components into their designs.

Establish Manufacturing as a Service (MaaS) Capabilities

With the advent of IP Design Stores, independent pure 3D-Manufacturers are starting to emerge. These are firms who are able to produce components on demand, performing Manufacturing as a Service (MaaS). These 3D-manufacturers are located in the country or area of consumption and act as independent third parties. These firms can be used to produce and deliver parts designed anywhere in the world. However, the originators of the design IP will need to undertake quality assurance oversight of the final part, vital in the case of a component such as a jet engine nozzle. To do so firms have three options. They can contract with a 3D manufacturer capable of meeting their quality requirements; work directly with the end user's 3D manufacturing group, or establish in-country 3D manufacturing capabilities in the form of MaaS centers.

Manufacturing firms today need to be more nimble than ever. This requires a shift towards a new business model, one that integrates design and manufacture to a point where anything can be produced anywhere at any time. Those firms who embrace the technologies of 3D and incorporate the lean manufacturing philosophy will reap the early mover rewards, build a knowledge-base and be recognized as pioneering and innovative. Companies that fail to embrace the changes risk being left behind defending static business models as the world rapidly changes around them.