A New Mindset in Product Design

3D printing can help bring better products to market faster

By Stratasys Inc.

What is 3D printing?
The terms "3D printing" and "additive manufacturing" refer to processes that automatically build objects layer by layer from computer data. The technology is already well-used in many sectors including transportation, health care, military and education. Uses include building concept models, functional prototypes, factory tooling (such as molds and robot-arm ends), and even finished goods (such as aircraft internal components). The aerospace and medical industries in particular have developed advanced applications for 3D printing. 3D printing is sometimes referred to as "rapid prototyping," but this term does not encompass all current uses for the technology. Materials used in 3D printing include resins, plastics and, in some cases, metal.

The earliest method, stereolithography, has been around since the late 1980s, but adoption was limited because of the toxic chemicals it required and the fragility of its models. Other technologies have evolved since then, including Fused Deposition Modeling (FDM®). FDM, introduced in the early 1990s, lays down super-thin layers of production-grade thermoplastic, yielding comparatively durable models.

Since 3D printing's inception, system reliability and model quality have increased, resulting in diverse applications. At the same time, prices have gone down to the point where some systems are affordable even for small businesses. In a 2011 report, Wohlers Associates predicted that worldwide annual sales of additive manufacturing systems will reach 15,000 units by 2015 — more than double the 2010 rate. Lower-priced professional systems will drive most of this growth.[1]

In FDM Technology™, printer software on the user's Windows network or workstation accepts computer-aided design (CAD) data in major 3D file formats, including .stl, .wrl, .ply and .sfx files. Some products also accept CT and MRI diagnostic data, protein modeling data and digitized 3D scans. The software works like a paper printer's driver, sending data to the 3D printer as a job and telling the print head where to lay down material.

Filaments of plastic modeling material and soluble support material are heated to a semi-liquid state, forced through an extrusion tip and precisely deposited in extremely fine layers. (FDM layer thickness ranges from 0.005 inch [.127 mm] to 0.013 inch [.330 mm], depending on the system.)

3D-printed models are shown with soluble support material (brown) intact, and after removal.

The print head moves in X-Y coordinates, and the modeling base moves down the Z axis as the model and its support material are built from the bottom up.

The soluble support material (brown in the example photo on this page) holds up overhanging portions while the model is being built, and allows for complex models — even nested structures and multipart assemblies with moving parts — to be 3D printed. When the print job is complete, the support material washes away and the model is ready to be used or, if desired, finished with paint or another process.

Some 3D printers are small enough and clean enough to function as office equipment inside a department or even an individual cubicle. By comparison, large rapid prototyping systems often must be centrally located and run by a dedicated staff of experts. The very cheapest class of 3D printers comprises home-use devices now on the market for hobbyists. While fascinating for enthusiasts, these machines differ from small professional systems in that the resulting models often have poor resolution, are dimensionally inaccurate and unstable, and lack durability.

Trends toward affordability and ease of use are bringing professional 3D printing technology in-house for many designers and engineers. The growing expectation that a CAD drawing can become a real three-dimensional object in a matter of hours is altering how companies see the design process. It can be faster, more effective, and less costly.

Using 3D printing to accelerate design

The longer a product stays in the design cycle, the longer it takes to get to market, meaning less potential profit for the company. Time-to-market considerations were identified as the most critical daily issue facing respondents of a 2008 Product Design & Development readership poll. This group also said prototyping itself presented a time-to-market obstacle in 17 percent of product launches.[2]

With increasing pressure to get products to market quickly, companies are compelled to make quick yet accurate decisions during the conceptual stage of design. These decisions can affect the majority of total cost factors by establishing material selection, manufacturing techniques and design longevity. 3D printing can optimize design processes for greatest potential profit by speeding iterations through product testing.

Time saved prototyping with in-house 3D printing vs. other methods

Industry	Old Method	Time savings
Industrial design	Clay models	96%
Education	Outsourced machining	87%
Aerospace	2D laser cutting	75%
Automotive	Aluminum tooling	67%
Aerospace	Injection molding and CNC tooling	43%

Each example is based on a real customer experience.[4]

benefits of investing in your own machine. A highly iterative process can only happen in a feasible time frame when engineers can see quick feedback on design changes. In-house 3D printing eliminates shipping delays and reduces administrative slowdowns that can accompany sourcing prototypes from external services. With some systems now available to lease, businesses might find that as few as one in-house model per month justifies the cost of a printer versus money spent outsourcing.

For example, Graco Inc. makes paint spraying and texturing equipment for professional use. Its engineers used a 3D printer to experiment with various paint gun and nozzle combinations to create the perfect spray pattern and volume. The resulting new spray-texture gun was based on functional prototypes 3D printed in ABS plastic. Graco estimates that 3D printing helped reduce development time by as much as 75 percent.

The journey from brilliant idea to successful product is fraught with hurdles. Analysis of new product development by Greg Stevens and James Burley in their oft-cited study "3,000 Raw Ideas = 1 Commercial Success" found that in addition to 3,000 raw ideas, a single successful innovation also requires 125 small projects, four major developments and 1.7 product launches.[3] 3D printing capabilities can speed the process by which companies determine whether concepts are worthy of development resources.

While outsourcing 3D printing might result in models equal in quality to those 3D printed in-house, the Graco example illustrates the

More effective design through 3D printing

3D printing can increase the chances of a successful product launch by enabling more thorough design evaluations and a more iterative process.

At Henk and I, an industrial design firm in Johannesburg, South Africa, designers created and extensively tested a new kind of pool-cleaner motor that works well with low-flow, energy-saving filters. The high-torque design was the result of an iterative refinement process using the office 3D printer. In the functional testing stage, 30 3D-printed prototypes cleaned pools in various regions worldwide. The result was a new pool cleaner model, the MX 8, for the firm's client, Zodiac. According to Henk van der Meijden of Henk and I, the motor innovation would have been impossible without 3D printing.

Successful product design requires review and input from many sources. With in-house 3D printers, design teams can review concepts earlier with others who may provide feedback. Fast collaboration with engineering, marketing and quality assurance can empower designers

At Acist Medical Systems, medical-device designers test ideas with 3D-printed prototypes and low quantities of end-use parts.

to make adjustments throughout the design process and follow-up testing.

Faster turnaround is the only way to enable iterative discovery without lengthening the design process. 3D printing users in aerospace, automotive, industrial design and education have reported improvements of 43 to 96 percent in prototyping speed when switching from traditional methods to 3D printing.[4] Traditional prototyping methods include injection molding, CNC machining, metal machining and 2D laser cutting. In some cases, lead time required by a machine shop had been a major factor in slowing prototype creation.

As the trend toward affordable 3D printing continues to result in more decentralized machines, for example in departments or individual cubicles, opportunities to speed the design cycle are multiplying.

An optimized design process with more prototype iterations can help minimize risk of product failure. Because 3D printers can produce models with fine feature details and the strength to withstand rigorous testing, designers can be more confident in their work. Additionally, data integrity and security is paramount in a competitive environment. While sharing confidential STL files with trusted vendors is generally safe, having a 3D printer in-house removes any worry that might stem from sending intellectual property offsite.

Making needed changes as early as possible saves money and time. 3D-printed models can give designers and engineers a thorough understanding of potential products earlier in the design process than other methods, minimizing the risk that problems will go unnoticed until it's too late.

Acist Medical Systems designs and manufactures contrast-injection devices for cardiologists and radiologists. The company uses 3D printed parts in functional testing, fixtures and end-use parts. In complex assemblies, Acist uses 3D printing to design plastic parts as efficiently as possible around machined parts, circuit boards and integrated circuits. In one display unit, Acist reduced part count from 15 to seven because of 3D printing's ability to help evaluate complex geometries. The company even tests functional 3D-printed units in customer settings, working out design problems and incorporating real customer feedback before committing to large-scale tooling.

Adopting 3D Printing to Reduce Product-Design Costs

The acquisition cost of a professional 3D printing system can be as little as $10,000 (USD), which may surprise engineers and designers who've priced larger 3D production systems. Annual operating costs are generally lower too, partly because 3D printers require no dedicated facility or special expertise to run. Leasing options can mitigate the cost barriers that may have restricted adoption of 3D printing technology in the past. Other costs to consider are printer maintenance and material costs, which vary depending on use. When evaluating 3D printing systems, consider facilities requirements; expertise needed to run the system; accuracy, durability and size of models; available materials; speed; and, of course, cost.

Your desired application will help you determine the best system for you, but keep in mind that many users report discovering diverse uses after acquiring a 3D printing system. For example, a system purchased for functional prototypes might prove useful for building manufacturing tools.

At Leptron, a developer of remotely piloted helicopters for law-enforcement, military and civilian use, engineers used a 3D printer to design, test and build a tiny surveillance drone. The RDASS 4 has eight modular fuselage components that can combine for various uses. Designing the complex drone and testing it to withstand crash landings required an iterative approach involving 200 design changes, including structural reinforcements and aerodynamic improvements. In-house 3D printing cut product-development costs for the RDASS 4 by 60 percent over injection molding. Further, the project may not have been commercially feasible without the 6-month head start that 3D printing offered in getting the drone to market.

3D printing provides a highly cost-efficient means of producing numerous design iterations and gaining immediate feedback throughout the critical beginning stages of the development process. The ability to refine form, fit and function quickly can significantly improve production costs and time to market. This can create a distinct competitive advantage for those companies who include 3D printing as an integral part of their design process.

Lower costs will continue to expand the 3D printing market, especially in small to medium-sized businesses and schools. The speed, consistency, accuracy and low cost of these printers will help companies reduce time-to-market and maintain a competitive edge.

1. Terry Wohlers, "Wohlers Report 2011: Additive manufacturing and 3D printing state of the industry" (Wohlers Associates, May 2011)
2. David Mantey, "Smaller, Cheaper, Faster" (Product Design & Development, June 2008)
3. James Burley and Greg Stevens, "3,000 Raw Ideas = 1 Commercial Success," (Research Technology Management, May-June 1997, 16-27)
4. Stratasys; "Bringing Imaginative Products to Market" (2011), "Rapid Learners" (2011), "Trial and Air" (2012), "3D Printing Wins Prototyping Time Trial" (2010), "Bird's Eye View" (2011)

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