An *IndustryWeek* Manufacturing Roundup

3D PRINTING: Transforming the Industrial World

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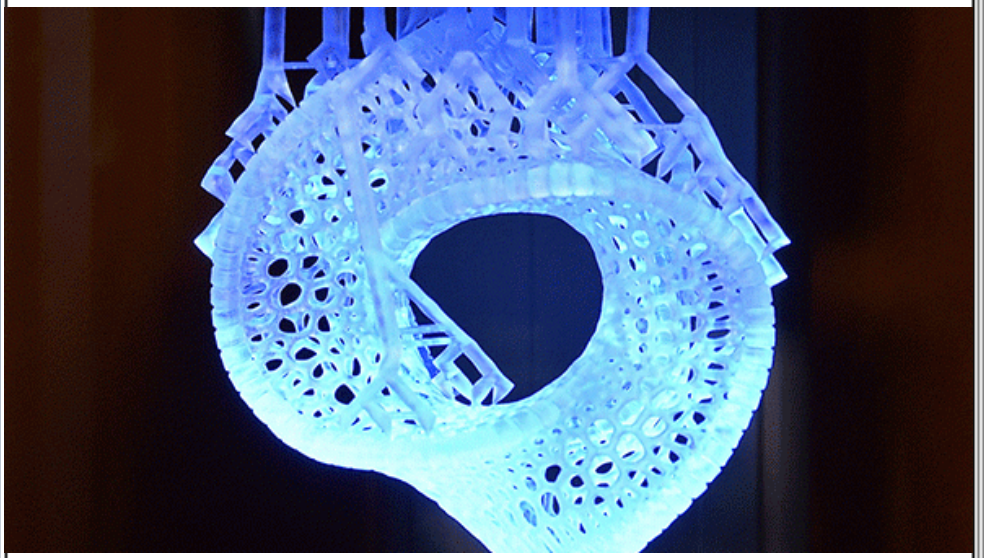
3D Printing and the Cloud: A Natural Fit for Manufacturers

By Gavin Davidson, NetSuite



The potential for 3D printing is like something out of Star Trek.

Fans of the TV and film series got a glimpse of 3D printing with the "replicator," a device that could produce spare parts, food and other necessities aboard the USS Enterprise.

A few decades later, 3D printing has leapt from science fiction into the mainstream.

For manufacturers, the disruptive implications of 3D printing are massive. Evangelists envision that manufacturers can slash lead times and net huge cost savings in materials, labor and transportation.

The global supply chain shrinks, and R&D cycles hit warp speed across collaborative design networks. Mass-personalized goods can be manufactured in a batch size of one, meeting business and consumer demand for products built to exacting specifications.

3D printing, also known as additive manufacturing, is still in its infancy, but many manufacturers are not waiting on the sidelines.

"Monolithic and inflexible on-premise ERP is distinctly at odds with the requirements of 3D printing on a significant scale. Cloud computing offers an alternative."

A survey by the global consultancy PwC found that 67% of manufacturers are adopting 3D printing in some way, most frequently in prototyping. Just 9% of manufacturers don't envision ever adopting 3D printing. The availability of 3D printers through Amazon, Home Depot, Sears and others is helping fuel momentum in the nascent industry.

"For some industries and some products, the concept of 3DP-enabled 'on-demand' manufacturing could radically change business models and supply chains," said PwC's Robert McCutcheon, partner, U.S. Industrial Products Sector.

"It holds the potential to transform some manufacturing business models—and the complex, costly supply chains and distribution networks upon which they were built."

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The Software Foundation for 3D Printing

The value that manufacturers derive from 3D printing will depend on more than the quality and performance of the 3D printers they implement.

For 3D printing to live up to its potential, manufacturers need an enterprise software foundation engineered for flexibility, global collaboration and integration with design and engineering software, such as product lifecycle management (PLM).

For decades, manufacturers have relied on enterprise resource planning (ERP) software to help manage inventory, production, logistics, partners and financials. ERP has helped manufacturers streamline processes, manage costs and better meet customer needs.

While manufacturers have realized significant value with ERP, many manufacturers continue to operate on ERP systems designed a decade or more ago.

The limitations of first-generation ERP software, typically implemented on in-house servers, are becoming more apparent as the bar is raised for greater speed and agility in global markets.

On-premise ERP can be notoriously difficult to customize as needs evolve. Data for production, distribution and inventory control can be outdated and not easy to access, especially remotely. The high costs of IT infrastructure, IT personnel and upgrades detract from the lean manufacturing ideal.

Monolithic and inflexible on-premise ERP is distinctly at odds with the requirements of 3D printing on a significant scale.

Cloud computing offers an alternative.

Cloud ERP aligns with a 3D printing environment in terms of flexibility and customizability, collaborative on-demand access and integration with design and engineering technology such as PLM.

- **Flexibility and customizability:** Many manufacturers are acutely aware of the inflexibility of on-premise ERP. Implementing a customization for a new workflow or materials needed for a 3D build could take IT developers weeks if not months. The best cloud ERP solutions put customizability into the hands of operational and business personnel to adapt the software to the needs of the business, rather than adapt the business within the constraints of the software.

  Flexibility is particularly important in 3D printing because of the dynamic, fluid, one-off nature of the practice. 3D printing requires that a manufacturer can efficiently manage and adapt requirements and workflows across design, engineering, production, quality assurance and fulfillment. The objective of shorter lead times can't be realized if it takes a month of arduous workarounds to produce a single custom product.

- **Collaborative on-demand access:** 3D printing is sometimes referred to as the "democratization" of manufacturing. In a democracy, all stakeholders can influence direction. Cloud ERP, accessible through a web browser, promotes that collaborative ideal with a single system of record to house all data associated with projects, from digital blueprints to QA documentation and case management. Global teams can "follow the sun" across time zones, each iterating by role and increasing the speed of delivery.

- **Integration with PLM:** The integration of ERP and PLM, which helps manufacturers coordinate the end-to-end product lifecycle, is emerging as a key differentiator for innovation and faster time to market in conventional manufacturing, and the 3D world as well. Product concept, design and engineering data in PLM can feed into the ERP system to assemble work orders and bills of materials (BOMs), schedule production and source components. Post-production, feedback from service and support modules associated with ERP feeds back into PLM for continuous product optimization.

From Science Fiction to Fact

These concepts are not science fiction—they're in use at manufacturers today. One example is Quirky, the revolutionary social product development business that collaborates with more than 1 million "member-inventors" and has brought about 412 innovative consumer products to market.

Based in New York City, Quirky uses 3D printing to prototype products, with large-scale production outsourced to contract manufacturers.

Quirky also uses cloud ERP.

The solution has given Quirky the agility, accessibility and scalability needed to help the company orchestrate complex

business processes across a global network of citizen inventors, suppliers, manufacturers, retailers and ecommerce.

"Velocity is the challenge for Quirky," said Tim Brindamour, Quirky Director of Systems. "[This system] allows us to really leverage our data and act on it very rapidly. It provides the flexibility we need to run an extremely agile business and outstanding data visibility to all our teams to drive the company forward."

3D printing is already beginning to reshape how some manufacturers bring products to market, and more changes are on the way as the technology continues to mature and adoption rises.

By exploring the viability of a cloud environment for 3D printing operations, manufacturers can take a first step towards future-proofing their businesses with the adaptability needed to take advantage of all that 3D printing offers.

3D Printing: In Search of the Real Thing

By Travis Hessman

Real things—break through all of the hype and all of the speculation, all of the talk about market size and industry value, all of that revolution business, and that's what we really want from 3D printing.

We want to hit print and watch a three-dimensional thing pop out—a thing that looks real and feels real: a permanent, sturdy, *real thing* customized to our specifications. We want full color, multi-material, textured object created at our whim on one machine in one pass.

That sounds like sci-fi fantasy and all of that usual hype-filled hyperbole, I know, but it is exactly where the industry is aiming with every new machine and every new upgrade. And it's what users want.

Whether it's ultra-detailed prototypes or industrial-strength finished parts, what professional 3D printers need is something real and familiar, something solid and authentic, not just monochrome toys.

And it looks like they may finally have it.

At SolidWorks World in 2014, Stratasys unveiled the latest generation of its Objet 500 series printer, the Connex3 Color Multi-Material 3D Printer.

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This bike helmet prototype was 3D printed on the Objet500 Connex3 in one print job.

It is absolutely as close as the industry has come to a real-thing printer. Far closer than I expected. And the results are pretty remarkable.

The Connex3 can print in full-color (everything from bright red to perfectly clear) in 500 different material combinations that run from rigid plastic to utterly floppy.

If off-white FDM parts revolutionized the innovation and design process, then having the ability to print something that looks and moves *exactly* like the finished product will be transforming the industry again in short order.

It's an intensely cool, intensely big step that for the industry. The potential for it is absolutely bewildering.

Mass Customization: The Modular Model

Jordan Reynolds Kalypso Consulting

Mass customization sounds new and exciting, but really it is just taking elements of our current system of production – elements that have existed for hundreds of years – and mixing them in a new and exciting way.

It has evolved concurrently both from traditional craft production techniques like the style of production that you would see during the renaissance – the pre-industrial revolution – and simultaneously from the post industrial revolution, mass production techniques.

You still see facets of each of these production techniques today and each of them comes with their own costs and benefits.

Engineer-to-Order

Craft production has evolved into something we are all very familiar with today: engineered-to-order production. With that, companies that take a project bid, do research and development, analyze to the customer specifications, go in and engineer, design and build, and then deliver the product and then do it differently for the next customer that comes around.

These companies can offer a great deal of personalization to their customers, but it comes at a very significant cost in terms of the price of the product and in terms of operational efficiency.

So those businesses' particular interest is to drive operational efficiency and be able to pass on cost reductions to their customers to make them competitive.

That's something that engineer-to-order manufacturers have looked at for years.

Mass Production

Simultaneously to this interest from engineer-to-order companies to drive operational efficiency, we see an interest from the mass production companies who already have the operational efficiency.

They already have the assembly line, the economies of scale they are using to manufacture the same good over and over again.

But mass production companies fall short in the sense that they cannot offer value to consumers aside from price. They are making very broad assumptions as to what the marketplace wants, and producing a single product meant to be a one-size-fits-all to individual customers – and that is really not viable today.

So both sides of the production spectrum are looking to break out of this dichotomy, which is that you can either produce a highly customer centric product or produce a standard product very efficiently at a low cost.

Both of these companies are looking at the costs associated with their production models and trying to find out how to do both. How can I provide products that meet unique customer needs, and do so at a high level of efficiency and low cost to the customer?

This is what I would refer to as mass customization.

Three Steps to Modular Manufacturing

The idea behind mass customization is that you should be able to take requirements and specifications from the customer and pass them directly to the assembly floor without an engineering effort.

After all, it's the engineering effort that really drives the cost of customization in the traditional engineer-to-order system.

This begs the question: Without an engineering effort, how can I ensure that the product configuration chosen by the customer is possible to build? How can I ensure that it will meet quality standards, that it will be usable, that it will be serviceable?

Really, this is the obstacle that has made mass customization an insurmountable challenge for centuries.

The solution to this problem of having to involve engineering in every order fulfillment effort, every product development effort, is a technique that is called "rules-driven product development."

Rules-driven product development involves three basic components:

1. Breaking your product architecture down into modules. You have to modularize your product so these modules can be arranged in different ways to create finished goods that meet unique customer needs.
2. Leveraging new artificial intelligence technology that creates rules for how these modules can be arranged. What can be done, what cannot be done. These types of rules define the total range of configurability.
3. Allowing customers to interface with technologies that help them arrange their own product configurations from a portfolio of modules, and choosing the way they are assembled into a final product.

It's that technology that has really driven the increased interest and increased feasibility of mass customization today.

How 3D Printing Will Transform Manufacturing

As 3D printing becomes a more broadly accepted method of manufacturing consumer-ready products, it could alter our basic standards of lead times and design all across the global supply chain.

Gavin Davidson

Toward the end of Sound City, Dave Grohl's new documentary about the famous LA recording studio, Mick Fleetwood laments the technological advances that have changed the face of music production, leading people to believe they can do it all on their own.

People are much happier, Fleetwood contends, when we work with others.

The manufacturing industry could be on the verge of the same conundrum with the advent of 3D printing.

There's been a drastic shift in manufacturing since the start of the last century – companies did their own design and manufacturing and on occasion raw production – their furthest supplier was probably on the other side of town, not the other side of the world.

But over the past few decades, global supply chains became a necessity.

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Now we are in the midst of a formidable "onshoring" movement bringing manufacturing back to North America. But why? The most common reasons we hear are:

- Closer team collaboration between design, marketing, and manufacturing
- Reduction in supply networks' lead times
- Better design integration by reducing cycle times when introducing new designs
- Ability to adapt to consumers' demands for constantly-evolving products
- Quality of relationships as well as closer collaboration between end-consumer (B2B or B2C) and manufacturing

So what part will 3D printing have in all of this?

If 3D printing is going to become a broadly-accepted method of manufacturing consumer-ready products, in what industries would it fit?

The logical answer (based on the current state of the technology) would seem to be smaller runs of custom designs where personalization would eventually lead to batch sizes of one.

Then, as design engineers start to get comfortable with the flexibility that 3D printing provides, they will design products that require components that can only be 3D printed, essentially integrating theoretical design with production engineering in sporting goods, medicine, aerospace and defense (of course) but also into consumer goods, heavy machinery, and everyday objects.

In fact, there are already directories online of ready-to-customize then ready-to-print 3D files.

So as 3D printing allows shorter manufacturing lead times (think minutes, not weeks or days), 3D printers will also be utilized throughout the supply chain.

It's not just for the designer of the end product, but imagine a global supply network where every supplier has a 3D printer that the designer can "print" to at any time.

It's almost Star Trek's replicators!

Integrate that concept back into the heart of PLM and vendors can only get on the approved list if they have a compatible 3D printer of sufficient quality that it can be commandeered to print products at will whether in resin/plastic or even metal.

This really enables not just a global network of supply – but more importantly, a global design network, bringing design expertise from all over the world right to your doorstep, or at least to the corner of your desk.

Making it Work

In NetSuite SuiteWorld in 2013, NetSuite and Autodesk presented the future of modern manufacturing leveraging both companies' respective, cloud-based products showcasing the possibility in a brief demo, redesigning a product based on customer feedback and cost analysis, through crowd sourcing with consumers voting on designs using a 3D model.

But what if we took that a step further and 3D printed a short run of prototype products for in-store display?

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The general public is much more likely to become engaged in a product / process where they can see, touch, feel the end product – and not just see it on a website.

We're not going to see 3D printers replace lathes, mills, welding machines and presses anytime soon, certainly not for volume production. But 3D printing is changing the face of collaborative design and manufacturing process, shrinking lead times, creating previously impossible to manufacture products, and leading to mass personalization.

Imagine mass manufacturing in batch sizes of one.

As the technology evolves and the material options broaden they will most definitely be more integrated into traditional manufacturing processes – imagine bearings printed with "Buckyballs" embedded in the race tracks in a variety of sizes depending on the application, or engine exhaust manifolds printed and not cast.

As a new breed of manufacturing and design engineers graduate gain experience with the flexibility and control that 3D printing provides, you can be sure they will be transforming not just design but the very objects we use in our business and personal lives.

Take a quick look around you at some of the everyday objects as you read this and ask yourself, can that be printed? I'm guessing a good percentage of them could be.

And for those that can't – there's someone going to be asking why, and looking for a way to change that.

Resources

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ATOMIC Designs Concert Sets for Top Bands with 3D Printing

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About Stratasys

Stratasys manufactures 3D printing equipment and materials that create physical objects directly from digital data. Its systems range from affordable desktop 3D printers to large, advanced 3D production systems, making 3D printing more accessible than ever. Manufacturers use Stratasys 3D Printers to create models and prototypes for new product design and testing, and to build finished goods in low volume. Educators use the technology to elevate research and learning in science, engineering, design and art. Hobbyists and entrepreneurs use Stratasys 3D Printing to expand manufacturing into the home — creating gifts, novelties, customized devices and inventions.

All Stratasys 3D Printers build parts layer-by-layer. FDM Technology (fused deposition modeling), known for its reliability and durable parts, extrudes fine lines of molten thermoplastic, which solidify as they are deposited. PolyJet technology, known for its smooth, detailed surfaces and ability to combine multiple materials in one part, employs an inkjet-style method to build parts from liquid photopolymers in fine droplets immediately cured with ultraviolet light. WDM technology (wax deposition modeling) produces finely detailed wax-ups for investment casting, particularly in dental applications.

The Stratasys portfolio of specially engineered 3D printing materials is the most comprehensive in the industry. It includes hundreds of PolyJet photopolymers and FDM thermoplastics.

MakerBot, a subsidiary of Stratasys since 2013, manufactures the company's prosumer desktop 3D printers in Brooklyn, New York. It maintains the Thingiverse design-sharing community and facilitates a wide network of user groups. Stratasys also manufactures SolidScape 3D Printers and operates Stratasys Direct Manufacturing, a digital manufacturing service.

Through its network of certified resellers, Stratasys delivers responsive, regional support around the globe. The company maintains dual headquarters in Eden Prairie, Minnesota and Rehovot, Israel. Stratasys holds nearly 500 granted or pending additive manufacturing patents worldwide. It is a public company that trades on NASDAQ under the symbol SSYS.

Learn more at Stratasys.com.

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