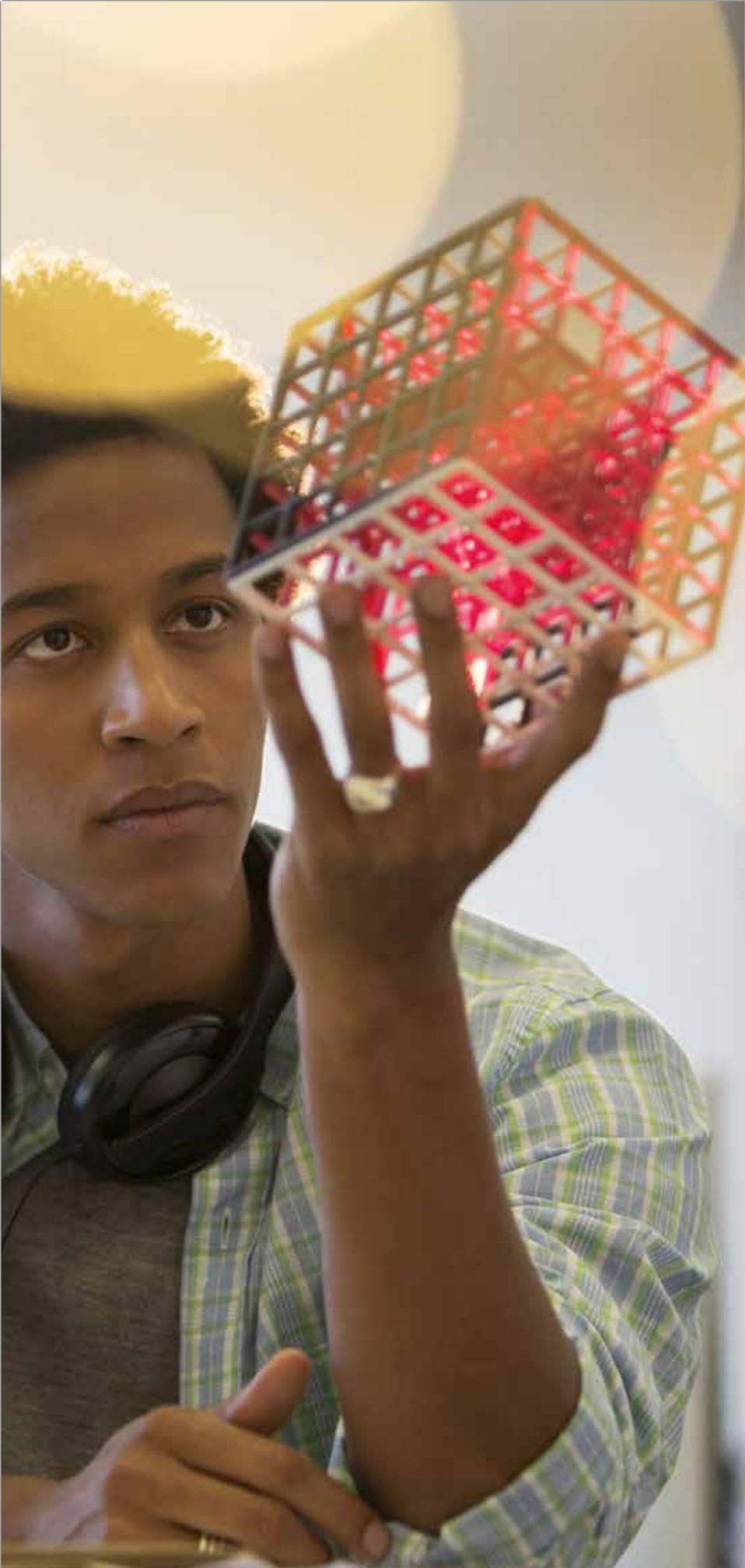


3D printing: moving into the mainstream

As a transformative technology, 3D printing has had a long gestation, but its perception as one of the most significant inventions ever is about to become much more widespread. With fast-evolving techniques, applications and printed materials, including metals, 3D printing is becoming a critical tool from prototyping to final production across industries.



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3D printing is not in itself a new technology, but a new EY survey¹ of 900 global companies shows it's evolving faster than ever and being adopted by an increasing number of major companies – 36% are already applying or intend to apply 3D printing. In a still emerging industry landscape, aerospace, defense and automotive are the most mature industries to apply 3D printing, but it has vast potential for prototyping and manufacturing finished products in other industries, including resources, retail and even food.

Why 3D printing needs to be on the strategic agenda today

3D printing is, without doubt, a disruptive technology, but one that can be harnessed actively rather than reacted to hastily. The forthcoming report *If 3D printing has changed the industries of tomorrow, how can your organization get ready today?* explains how business leaders have now become more open to exploring how 3D printing can be embedded into existing manufacturing processes, or used to create entirely new ones. Combined with the arrival of 3D printing design and engineering specialists, there are many more opportunities for organizations to create complex designs that outstrip the limitations of traditional manufacturing.



1. How will 3D printing make your company the strongest link in the value chain? EY's Global 3D printing report 2016, EY, 2016, <http://www.de.ey.com/3DPrinting>, accessed July 2016.

For businesses, simply buying a printer is not going to unlock the full potential of 3D printing; instead, they need to consider the reasons for adopting 3D printing and how best to integrate it.



There is also a wider set of materials and material providers than in the past, giving companies more options for production. Many manufacturers are collaborating with material suppliers to create their own bespoke materials to solve specific problems, with an increase in quality and throughput. Printers, too, increasingly feature quality assurance tools to validate the printed product's tolerances, layer by layer.

For these reasons alone, 3D printing should be high on the strategic agenda – and there are still more potential benefits that can be realized, including:

- ▶ Product development – reduced time to market and shortened product development design cycles
- ▶ Manufacturing – reduced process time via improved tools, less waste, fewer production or assembly steps and reduced lead time via functional integration of parts
- ▶ Engineering and maintenance – more flexible maintenance processes, lower maintenance costs and cost-efficient industrial engineering
- ▶ Logistics and warehousing – reduced inventory and reduced logistics handling, transportation and related costs
- ▶ After market – increased flexibility in delivery of spare parts, reduced costs of spare parts production and after-market care

Business trends driving the wider uptake of 3D printing

For businesses, simply buying a printer is not going to unlock the full potential of 3D

printing; instead, they need to consider the reasons for adopting 3D printing and how best to integrate it. There are some key trends influencing these considerations:

- ▶ **Individualization – customer co-creation.** Consumers are increasingly looking for products that are tailored to their needs. The 3D printing industry has responded by printing parts as close to the time of assembly as possible, which allows for a reduction in inventory.² Dell has operated in this way for years, waiting for orders to come in before assembling bespoke units.
- ▶ **Democratization – innovation and development from the masses.** 3D printing makes it possible for individuals or collaborative teams to manufacture end products with fewer barriers to innovation. For intra-company collaboration, design teams can “fax” their part across the world to work with tangible products.
- ▶ **Sustainability – the circular economy.** There is a global movement toward sustainability among consumer corporations. 3D printing reduces transport costs when the printer is placed close to the manufacturing line or on remote operating bases where critical inventory requirements are high, and there are also operating cost efficiencies when airplanes are built with lighter materials.

2. P. Basiliere and K. Wellerstein, *3D Printing Opportunities and Uses Primer for 2016*, Gartner, 2016, <https://www.gartner.com/doc/3188132/d-printing-opportunities-uses-primer>, accessed June 2016.

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Technology trends broadening the scope of 3D printing

The range of materials that can now be used is vast and expanding all the time, including plastics, porcelain, ceramics, stainless steel, carbon, graphene, titanium and other metals. This opens up the possibilities for making an increasing variety of parts in new ways.

- ▶ **Moving beyond prototyping.** 3D printing methods such as Direct Metal Laser Sintering (DMLS), Selective Metal Sintering (SLS) and Electron Beam Melting (EBM) have advanced 3D printing into industrial applications, including final assemblies. The EY survey demonstrated that 38% of the companies are expecting 3D printing to be part of their serial production in five years' time.³ The question companies need to consider is: what network of supply chain assets, and what mix of old and new processes, will be optimal?
- ▶ **Design lightweight objects.** Honeycombing, another 3D printing method, creates especially lightweight products that are hollow or have an inner chamber that is connected in a similar structure to the interior of a bee hive. One material that is of interest for 3D printing is micro-lattice: made of a 3D open-cellular polymer structure of interconnected hollow tubes, it's extremely strong and, being 99% air, is the lightest metal ever made.
- ▶ **Using fewer components for complex geometries.** With 3D printing, more components can be integrated into a single object, which improves not only

product functionality but quality as well – with the added benefit of greater supply chain and operations efficiencies as there are fewer production steps and less interim inventory. Entirely new products, that weren't possible using traditional technologies, are now within reach too, such as objects with conformal cooling channels or bionic structures.

- ▶ **From material management to material science.** A team of researchers at Harvard University in the US has extended its micro-scale 3D printing technology to a fourth dimension: time (i.e., 4D printing).⁴ Inspired by nature, the 3D printed particles form different structures based on a reaction to environmental stimuli. This is an example of advancement in programmable materials assembly and is the ultimate agile supply chain in that the programmable material can morph into what is required.

How different sectors are exploring 3D printing

- ▶ **Aerospace and defense.** Companies of all sizes are using this technology to deliver faster, lighter (better weight-to-thrust ratio), less wasteful (more fuel-efficient) and more financially viable products. GE has stated that, from 2016, its new Leap aircraft engine will include 19 3D-printed fuel nozzles, designed to last five times longer than traditionally made components.⁵
- ▶ **Health care.** The medical field is being greatly impacted by 3D printing. For example, the entire US hearing

aid industry converted entirely to 3D printing in less than 500 days,⁶ turning a manual, labor-intensive industry into an automated one. The technology helps organizations of all kinds reduce costs while providing high-quality, patient-specific care, for example, with prosthetics, dentistry and even bio-printing, where scientists can print human-sized bones, cartilage and muscle.

- ▶ **Food.** While there may be some questions about the idea of 3D-printed food, there has nonetheless been lots of innovation, ranging from crystallized sugar cake toppers and intricate chocolate designs to cracker-like yeast structures containing seeds that sprout over time. Early adopters include German retirement homes, which serve a 3D-printed food product called Smoothfoods to elderly residents who have difficulty chewing – the EU has invested nearly €3m in this project, with the hope of improving quality of life.⁷
- ▶ **Resources (i.e., oil and gas, and metals and mining).** For suppliers, there is the potential to reduce the

3. *How will 3D printing make your company the strongest link in the value chain? EY's Global 3D printing report 2016*, EY, 2016, <http://www.de.ey.com/3DPrinting>, accessed July 2016.

4. K. McAlpine, "Novel 4D printing method blossoms from botanical inspiration," Wyss Institute Communications, 2016, <https://www.seas.harvard.edu/news/2016/01/novel-4d-printing-method-blossoms-from-botanical-inspiration>, accessed June 2016.

5. "3D Printing Creates New Parts for Aircraft Engines," GE Global Research, <http://www.geglobalresearch.com/innovation/3d-printing-creates-new-parts-aircraft-engines>, accessed June 2016.

6. R. D'Aveni, "The 3D Printing Revolution," *Harvard Business Review*, 2015, <https://hbr.org/2015/05/the-3-d-printing-revolution>, accessed June 2016.

7. K. Wiggers, "Why 3D food printing is more than just a novelty – it's the future of food," *Digital Trends*, 2015.



cost of aftercare services for major equipment as there is less need to store or produce spare parts, especially for discontinued or older products. For operators, critical spares and wider inventory storage and transport costs can be minimized, and the lead time for the shipping of spares can be reduced to the length of time it takes to print parts. It also allows lower-cost trials and prototyping of new components in existing plants and operations. Sandvik, a major supplier for many resources companies, is evaluating 3D printing through various initiatives to observe how the technology can be used in its production – advantages may include faster production, increased flexibility and being able to create components in unique shapes.⁸

► **Automotive.** With 3D printing, lightweight car components can be produced, reducing weight, and improving performance and fuel economy. Direct manufacturing applications, where 3D printing can be used for low-volume and high-customization parts, can also create significant efficiency gains in production, operations and supply chain. For example, BMW engineering developed a one-piece, light-metal 3D-printed water pump wheel that incorporates design refinements and prints the component in small batches to replace a plastic part.⁹ Taking the concept further, Local Motors has created a car using 75% 3D-printed components – traditionally, it takes thousands of components to make a

The range of materials that can now be used is vast and expanding all the time.

8. N. Rolander, "Sandvik Pushes 3D Printing to Create Fuel Tubes, Drilling Gear," *BloombergBusiness*, 2015, <http://www.bloomberg.com/news/articles/2015-01-12/sandvik-pushes-3-d-printing-to-create-fuel-tubes-drilling-gear>, accessed June 2016.

9. "Racing technology right from the 3D printer: BMW makes water pump wheel for DTM racecars using additive production method," BMW Group, 2015.

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car, whereas Local Motors has created one with just a few dozen, reducing complexity and increasing longevity.¹⁰

- ▶ **Consumer products and retail.** Rapid manufacturing using 3D printing enables mass customization, reduced time to market, and numerous efficiencies in manufacturing processes and along the supply chain. To explore new potential applications, Nike has established a design and manufacturing center in partnership with DreamWorks Animation that is capable of "nearly instantaneous digital print applications, photo-real 3D visualizations and ultra-rapid prototyping."¹¹

the process becomes "natively digital,"¹² managed by software, with a continuous outward stream of data created and available for analysis. Likewise, there is the potential to use tracking and analytics to plot the consumption of spare parts and enhance product performance, as well as predict maintenance and aftercare activities.

Certain areas of the 3D-printing industry are currently highly fragmented. This presents an opportunity for a major player to offer a standardized platform for approved, crowdsourced printing files, guaranteeing security, data privacy and stability. This fragmentation presents other challenges too: for example, understanding the tax implications of a blueprint created in one country that's then used to 3D print a

Further opportunities and considerations in the near future

There are many opportunities still to be discovered by exploring industrial applications. Data is a particularly rich area, for example: when 3D printing is used to manufacture parts, that portion of

10. Local Motors FAQ, "How much of the LM3D is 3D printed?," 2016.
 11. E. Low, "Nike Eyes 3D Printing In Manufacturing Revolution," *Investor's Business Daily*, 2015, <http://www.investors.com/news/nike-eyes-3d-printing-in-manufacturing-revolution/>, accessed June 2016.
 12. R. D'Aveni, "The 3D Printing Revolution," *Harvard Business Review*, 2015, <https://hbr.org/2015/05/the-3-d-printing-revolution>, accessed June 2016.



product in another. And it can be very difficult for organizations to source vendors that meet diverse requirements in processes and materials. There is also still work to be done to make the case for 3D printing in certain areas. For example, environmental analyses should factor in the power and heat required for 3D printing, as well as material that can or cannot be recycled, especially when comparing 3D printing with traditional prototyping and the engineering steps that may normally be required.

Intellectual property (IP) sets the stage for any discussion around 3D printing and taxation. How and where 3D IP is owned and authorized for use will be critical to business relationships and the characterization of income from them. While the OECD is rewriting tax models for electronic services and other digital intangibles, which is clearly also touching on 3D printing – as IP and cloud-based digital blueprints are shipped across borders to printers – there is little clarity about how effectively these taxes would shift to “digital tangibles.”

It's in areas such as this that EY's experience and connections are invaluable. Bringing together different competencies including strategy, supply chain, design and engineering, product development, analytics and IT, as well as tax and legal, can help manage the end-to-end process of 3D printing and accompany organizations on their journey to adoption. In an inventory of thousands, choosing which components may be best suited to 3D-printing requires a diagnosis and methodology too. EY can recommend and bring together the right vendors for a 3D-printing route and even help explore new services to run pilot 3D-printing factories as a managed service in parallel with normal operations, finetuning processes before they go live. We can also facilitate the cross-pollination of techniques developed in other industries, thereby enhancing manufacturing in new ways.

What's next?

The case for 3D printing will vary between organizations and sectors: it may be rooted in issues such as pricing pressure, increasing customer requirements or the operational challenges of responding to customer needs quickly enough. Overall, though, 3D printing can help companies to:

- ▶ Gain competitive advantage
- ▶ Improve their position in the value chain
- ▶ Achieve growth
- ▶ Increase the efficiency of their supply chain and operations

The key first steps toward these goals are to raise awareness within the organization

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of what 3D printing is capable of, then identify the areas of application and use cases that will bring the highest added value. After this, it's essential to develop a transformational road map to build capabilities and redesign the organization in a way that will enable the sustainable implementation of the 3D-printing technology into the company.

It's clear that simply buying a printer is not enough to harness the full potential of 3D printing. Nor is this a journey that can be completed successfully without experienced insight and collaboration: just as with any technology-based transformation, success depends on understanding where an organization can yield value. And that relies on asking the right questions. ■

EY's forthcoming report *If 3D printing has changed the industries of tomorrow, how can your organization get ready today?* will be available at www.ey.com/3Dprinting from mid-September 2016.