Additive manufacturing
The effects of 3D printing

Marc Halmes
Partner
Technology & Enterprise Application
Deloitte

Laurent Pierreu
Director
Technology & Enterprise Application
Deloitte

Additive manufacturing, or 3D printing as it is often called, is a manufacturing process that has been developing steadily since 1984. Founded by Charles Hull, the process allows three-dimensional objects to be printed from digital data.

The process begins with a 3D model of the object, usually created by Computer-Aided Design (CAD) software or a scan of an existing product. Specialised software slices this model into cross-sectional layers, creating a computer file that is sent to the 3D printer. The 3D printer then creates the object by adding layers of material on top of each other until the physical object is created. 3D printers work like inkjet printers. Instead of ink, 3D printers deposit the desired material in successive layers to create a physical object from a digital file.

The technology that supports additive manufacturing, or 3D printing, is more than 30 years old. Its recent popularity has been fuelled in part by patent expirations which are driving a wave of consumer-oriented printers. Prices have fallen, putting the technology within the reach of early adopters. 3D printing is democratising the manufacturing process and bringing a fundamental change in what we can design and what we can create.

Applications of 3D printing

Since 3D printing allows users to develop and revise products rapidly before undertaking the costly processes associated with traditional manufacturing, the applications for the technology are vast.

Due to the inimitable manufacturing processes of 3D printing, people now have the ability to innovate products from the inside out. The process cannot be mimicked using traditional manufacturing methods, since 3D printing is an additive process. This means that individuals and businesses alike can create internal skeletal structures and unique shapes within an object.

As 3D printing becomes more accessible on a global scale, consumers have begun to innovate across a diverse range of industries. As a result, the process of additive manufacturing is beginning to create industry disruptions, causing new businesses to emerge and stagnant, yet well-established businesses to fail. Navigating this disruption and embracing this new technology requires strategic foresight to profit and prosper over the next 10-20 years. The question is, *"How many businesses will be ready?"*

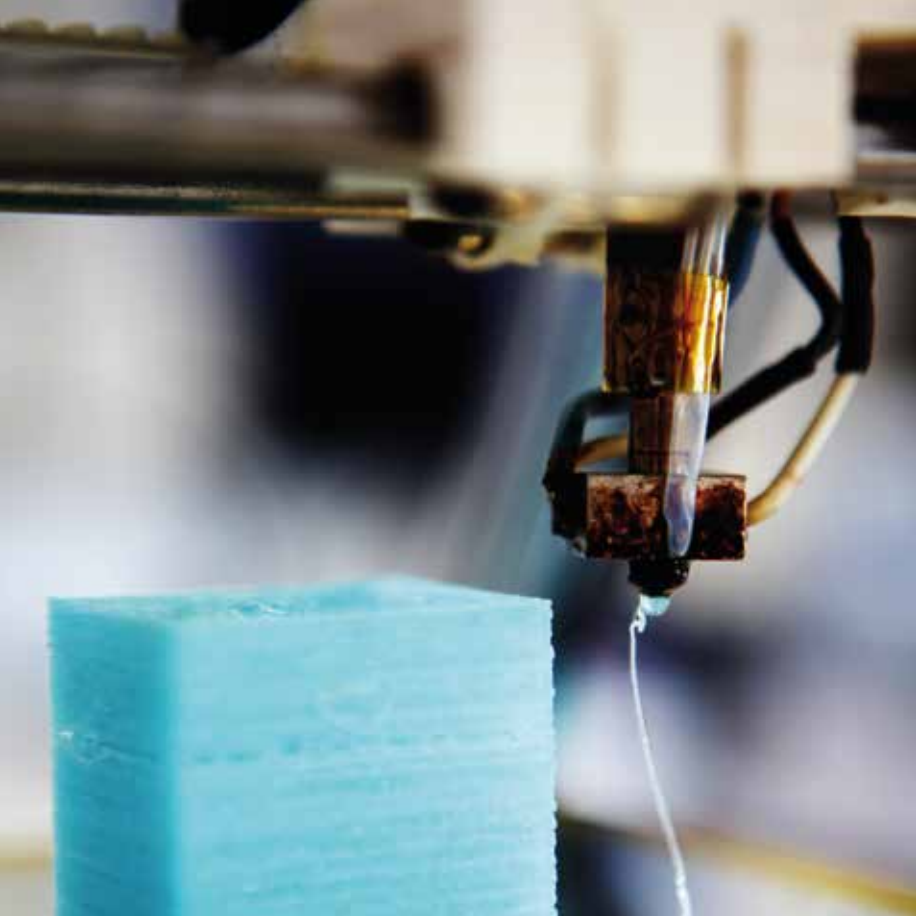
More specifically, the process of 3D printing spans many industries, including the automotive, manufacturing, aviation and medical industries. Although the capabilities of 3D printers improve exponentially each year, a diverse range of materials can already be printed using these devices.

These include urethane, metal, human tissue and even food products. As shown below, Figure 1 illustrates the global opportunities arising for 3D printing across many different industries.

Figure 1: Global opportunities: 3D printing

Target user			
	Consumer	**Small to mid-sized business**	**Corporations**
Printer readiness			
In need of further R&D		• Organ replacement, $30B	• Furniture, $20B • Consumer electronics, $289B
Nearing commercial use	• U.S. prepared food, $23B	• Bicycles, $6B • Guns and ammo, $11B • Global apparel, $1T	• Life sciences R&D, $148B • Home building and improvement, $678B • Power tools, $22B
In use	• Craft and hobby, $30B • Animation and gaming, $122B	• Medical prosthetics, $17.5B • Retail hardware, $22B • U.S. auto parts stores, $40B • Toys, $80B	• Industrial R&D (for Prototyping), $23B • Aircraft and defense R&D, $9B

Source: Forbes



Objects are built one layer at a time, depositing material as small as 100 nanometres exactly where and when needed

In essence, 3D printing makes manufacturing complexity free of charge, allowing otherwise impossible designs to be realised. Objects are built one layer at a time, depositing material as small as 100 nanometres exactly where and when needed. Mechanical items with moving parts can be printed in one step—no assembly required. Interlocking structures mimicking nature's design laws are possible with nearly unlimited geometrical freedom—no tooling, set-ups, or change-overs. Moreover, objects can be built just in time where and when they are needed. The capability unlocks business performance in a highly sustainable manner by reducing inventory, freight, and waste. 3D printing's value is not limited to complex objects. On-site creation of investment castings or construction moulds can supplement traditional manufacturing techniques.

3D printing is not just for prototypes and mock-ups. Many sectors already use the technology for finished parts and products. In the aerospace industry, jet engine parts such as manifolds require more than 20 pieces that are individually manufactured, installed, welded, grinded and tested to come a finished product. The 3D printed alternative is easier to build and service and also reduces overall system weight. Medical devices use 3D printing to customise and personalise everything from dental crowns to hearing aids to prosthetics. The potential does not end there. More fantastical use cases are starting to become a reality, such as mass customisation of consumer goods, including personalised products ranging from commodities to toys to fashion, with 'print at home' purchase options.

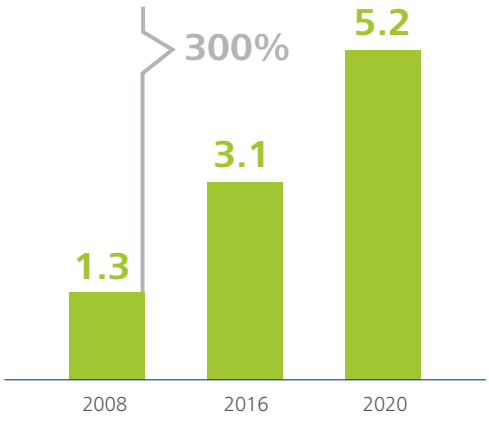
Even food printers are entering the market, starting with chocolates and other sugar and starch staples, but moving toward meats and other proteins. Organs, nerves and bones could be fully printed from human tissue, transforming healthcare from clinical practice to part replacement—and even life extension. Leading thinkers are exploring self-organising matter and materials with seemingly magical properties. One example is already here: a plane built of composites with the ability to morph and change shape, ending the need for traditional flaps and their associated hydraulic systems and controls.

Industry growth

Since the mid-1980s, 3D printing has changed drastically. As the Consumer Electronics Association noted, *"Sales of 3D printers will approach $5 billion in 2017, up from $1.7 billion in 2011, as demand expands for everything from consumer applications to markets such as automotive, aerospace, industrial and healthcare."*

As Figure 2 shows, 3D printing is forecasted to grow by 300% from 2012 to 2020. As stated by the website On 3D Printing, *"The 3D printing industry is expected to change nearly every industry it touches, completely disrupting the traditional manufacturing process. As a result, the projected value of the industry is expected to explode in the near future."*

Figure 2: Growth of 3D printing in US$ billion



Source: On 3D Printing

Embracing 3D printing: a new medium for innovation

Benefits and challenges of 3D printing

Although 3D printing offers many benefits, there are also challenges associated with using this technology, as compared to traditional manufacturing.

These benefits and challenges arise in relation to the uses and applications 3D printing offers for consumers and businesses across many industries. These include rapid prototyping, rapid manufacturing, mass customisation and mass production, among others.

	Benefits of 3D printing	Challenges of 3D printing
Rapid prototyping	Single items can be produced inexpensively without incurring the mould and tooling costs of traditional manufacturing	Entry-level 3D printers produce goods that are often inferior to those produced using traditional methods
Reduced lead times	Lead times can be reduced as a result of being able to produce goods relatively quickly	N/A
Rapid innovation	New innovations can be created and revised quickly since 3D printing is an iterative process	N/A
Rapid manufacturing	Just-in-time inventory can be easily managed and created	Depending on the type of printer, it can be slow to produce large volumes of products
Reduced overhead	Overhead required to invest in inventory, and warehouse, is reduced since items can be printed as needed. Traditional manufacturing methods typically require larger volumes of inventory to be produced and warehoused at one time	N/A
Mass customisation	Products can be customised for a single purpose or created in small and economical production runs	Limited materials can be printed through 3D printers for commercial production
Mass production	Unique products that cannot be made using traditional manufacturing methods can be produced for mass production	While traditional manufacturing can produce extremely large products, such as pipelines for transporting natural resources, most 3D printers cannot
Use of unique materials	Materials, such as human tissue, can be printed using 3D printers	N/A
Economies of scale	N/A	The cost of producing large volumes of some products can be high using 3D printers

Cost of using 3D printing to produce a product
The cost of producing large volumes of goods through 3D printing is not always economical. However, depending on the materials used to print an object, it can be inexpensive to produce low volumes of goods when economies of scale are not required.

Since 3D printing is still foreign to many businesses, it can be difficult to align all the elements required for programme success, such as strategy and operations, human capital, technology and financial advisory. To avoid missteps, it is important to adopt a well thought-out 3D printing framework.

Establishing a 3D printing initiative: creating value through innovation

Adopting a 3D printing framework

Before businesses can capitalise on these emerging opportunities for innovation, they need a framework for success.

The framework below includes five key steps:

1 Establish the initiative › **2 Invest in technology** › **3 Create a network** › **4 Change the organisation** › **5 Implement the innovation**

- How can 3D printing directly affect our company or industry?
- What are the future implications for industry disruption?
- How can we establish 3D printing within our organisation?

- What technology (harware and software) is required to set up a 3D printing initiative?
- How much should we spend on technology, based on our size and capabilities?
- Where can we source the technology?

- What key partnership should we establish to ensure 3D printing success?
- Are there any public sector grants or benefits we can access?
- Who are the key stakeholders in the 3D printing industry?
- Do we need to change any of our governance controls to protect our intellectual property?

- What key skills and abilities do we need to start and run a 3D printing initiative?
- Do we need to change our organisational structure?
- Do we need to create new business units?
- Who are the key stakeholders expected to manage our initiative and help create value for the organisation?
- What new jobs and roles must we create to manage the initiative?

- How will we take 3D printing innovations to market?
- If we need to scale up, should we produce products through 3D printing or traditional manufacturing?
- Are the innovations new products for an existing market or a new market?
- How do these products fit within our existing product range?
- Who is the target market and how will we presetn this product to the market?

Future implications of 3D printing: industry outlook moving forward

3D printing will potentially have a greater impact on the world over the next 20 years than all of the innovations from the industrial revolution combined.

3D printing has developed significantly over the past 30 years and now allows consumers and businesses to conduct rapid prototyping and even produce individual items at a profit. A new industrial revolution is coming as commercial 3D printers become smaller and more portable. As the costs for 3D printers decreased drastically in recent years, the technology has become accessible to businesses across many industries. This price decline is making high-end 3D printers accessible to the mass market. As a result, general consumers are using 3D printers to create unique items from the comfort of their own homes. In fact, consumers are even creating new innovations without financial, technological or human capital support from large organisations.

In the future, 3D printing will have a wide range of applications extending from healthcare to construction and beyond. In healthcare, for instance, 3D printing represents a truly disruptive force, particularly as costs rise and resources for transplant surgery remain scarce. Once bio-printing or the 3D printing of human organs and tissue becomes commercially viable, patients will have access to single organs, printed using the size and organic structure they need. As surgical lead times and healthcare costs drop, these innovations will be important for both emerging and developed economies.

In order to benefit from the applications and opportunities of 3D printing moving forward, companies in virtually every industry must be fast, flexible and capable to understand the implications that 3D printing will have on the nature of their businesses. Failing to do so will lead to a potential loss of market share, due to increased competition from new companies that create market changing, disruptive innovations. And competition won't stop there. As more and more individual consumers gain the ability to engineer and produce their own goods, and 3D printing becomes a more efficient and cost-effective way to produce goods, there will be an opportunity for individuals to create new innovations, disrupt industries and potentially generate new sources of wealth. As long as the technology is accessible, new businesses will continue to emerge.

Although traditional manufacturing will likely still hold a place in the competitive landscape in the years to come, the next 10 to 20 years promise to reveal a rapid increase in the innovations made possible by 3D printing. To fully capitalise on these opportunities, governments may choose to make 3D printing widely accessible within free public service locations, such as schools and libraries. For its part, the private sector will want to continue working towards embracing this technology as a platform to create new businesses, business models, products and services that push society forward by spurring the creation of new sources of global wealth.

Conclusion

3D printing is a powerful technology, but it is no panacea. To capitalise on its potential to achieve specific business and operational outcomes, business leaders need to answer these questions:

- **How can products and components be redesigned using 3D printing to reduce material and assembly costs?**
- **Can 3D printing improve product performance and/or reduce production quality issues?**
- **What supply chain challenges, such as speed to market, can 3D printing help overcome?**

The competition is certainly asking these questions. Thus, although 3D printing will not change everything right away, its impact is growing and time is of the essence.