Project Breakthrough

Disruptive Technology Executive Briefs

ADDITIVE MANUFACTURING

The rise of the makers

At its simplest, additive manufacturing is the process of building up a three dimensional object layer by layer from a digital file, adding material only where it is needed. This contrasts with traditional manufacturing methods that start with a raw material that is then reduced to its desired size and shape. The full applications of this technology are being seen as it moves from prototypes to full scale industrial production, in areas ranging from food, to aerospace and healthcare.

The technology

Additive manufacturing (or 3D printing) has developed from a number of technologies that emerged over the past 20 years, including software, automation, materials science and post-processing. The technology is now available through off-the-shelf printers and is increasingly being integrated with conventional production technologies for industrial applications.

The potential

Additive manufacturing can reduce waste, challenge global supply chains (through localised manufacturing) and offers flexibility in the manufacturing process. Although the equipment required can still be quite expensive, new business models, such as Fab Labs, are increasing its accessibility. With the business case for using additive manufacturing in small scale and customised production already clear, we can expect to see rapid expansion of the technology's applications in both industrial and consumer uses.

The barriers

Slow print times, the quality of surface finish and high raw material costs (materials are often specific to brands of printers) will impede adoption in mass production environments. However, in certain areas, such as food, the choice and accessibility of materials makes it use more attractive.

Concerns over how the technology could be used for illegal activity, such as 3D printing of guns, as well as fears over potential unemployment resulting from the disruption of current business models have captured headlines and are likely to remain issues as the technology develops.

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Some Example Applications...

Medical implants

One of the early adopters of additive manufacturing has been the medical industry. Despite the fact that everyone is unique, medical products, such as, artificial joints have for a long time only been available in a range of standard shapes and sizes, with minimal customisation. Additive manufacturing can address this through far greater personalisation of products. Renishaw used their additive manufacturing technology to recreate parts of a motorcycle crash victim's skull – allowing for reconstructive surgery that would not have otherwise been possible.

Flying high

GE is developing its biggest ever engine using 19 3D-printed fuel nozzles that spray fuel inside the combustion chamber. The conventional nozzles they replaced had more than a dozen welded parts but the new nozzles do not need these. This has helped reduce the engine's weight by 25%, increase fuel efficiency, and make it quieter.

Bioprinting

Organovo Inc. have demonstrated that it is possible to print models of human organs and tissues, such as liver kidney and skin.

Plastic waste used as feedstock

Indian company Protoprint have partnered with a Pune based waste picker co-operative to set up a low cost 3D printer filament production facility. They are able to offer a price an order of magnitude higher to the pickers for the collected waste HDPE, and still make a profit of 600%.

Key Numbers

$21 bn

Estimated additive manufacturing market size in 2020

Source: Statista

6.7 mn

Estimated global shipments of 3D printers in 2020

Source: Statista

30,000+

Number of 3D printing patent applications to date

Source: 3D Printing Industry

Advancing the Sustainable Development Goals (SDGs)

Additive manufacturing has the potential to advance many of the SDGs. Below are some examples of areas of application across a wide variety of sectors.

SDG 1 No poverty

- Reduce the cost of making or buying advanced products and components.
- Enable cheaper and easier repair, through production of spare parts – even when they might have been discontinued.

SDG 2 Zero hunger

- Reduce the quantity of food that is wasted during production, helping to lower costs and increase availability.

SDG 3 Good health and well-being

- Provide access to customised medical devices and prosthetics, improving quality and comfort for users while reducing cost.
- Manufacture body parts that currently rely primarily on donors, such as internal organs.

SDG 8 Decent work and economic growth

- Increase global resource efficiency in consumption and production.
- Support increases in economic productivity.
- Enable new, localised production - with access to the required feedstocks (such as plastics) a whole product range can be manufactured in dispersed sites, reducing shipping and logistics costs, and allowing products to get to places where they would not normally be available.

SDG 9 Industry, innovation and infrastructure

- Improve the share of gross domestic product that comes from industry by allowing more economies access to the tools and capabilities to manufacture complex products.
- Increase access for small scale producers through the lower capital cost of manufacturing complex products.
- More flexible manufacturing as there is no need for expensive moulds, multiple/different production lines or time consuming tool changes.
- Innovation through precise placing of ingredients allows the production of new forms, intricate designs, and targeting of functionality and active ingredients.

SDG 11 Sustainable cities and communities

- More localised production would reduce transport needs and the resulting congestion/pollution.

SDG 12 Responsible consumption and production

- By adding, rather than reducing / removing, additive manufacturing reduces the amount of waste during production.

Potential Negative Impacts and Barriers

As additive manufacturing proliferates, its accessibility and affordability have the potential to be a risk and benefit in equal measure:

Illicit goods

The widely publicised manufacture of a 3D printed gun demonstrated the ability of additive manufacturing to produce firearms. While it is already possible to make a rudimentary firearm with many tools available from a local hardware store, additive manufacturing removes the skill required - making it easier and more accessible and raising concerns about its misuse.

Intellectual property

Safeguarding the intellectual property of additive manufacturing designs may become a key legal battleground. As the designs will be digital, they can be shared and this means they can be more easily copied. This may allow rapid distribution, but authors may not receive recognition for their design. How this is addressed may aid, or inhibit, the transformative power of additive manufacturing.

Access

Ethical concerns will play a key role in relation to the availability of additive manufacturing. The ability to bioprint new organs or body parts can bring huge benefits but its usage and availability risks widening the gap between the medical options available to the rich and poor.

Case for change

If localised production becomes the norm, this will disrupt traditional manufacturing industries and their supply networks. This would be a shift rather than a replacement, however, the short term effects could be disruptive, resulting in potential job reductions.

Development costs

While 3D printing can appear cheap for low volume items, because of the reduced set up costs, at present it is not economical for high volume production. The cost of some materials (especially plastic and metal powders) is a lot more expensive than material stock for conventional manufacturing. However, in food production there is increasing research into ways additive manufacturing can produce items quicker and more economically than the traditional approaches.

Technical Considerations

There are still some technical barriers to overcome before additive manufacturing can be adopted on a large scale .

Materials science

Materials science is key to the new developments in printing. Currently materials require varying levels of pre-treatment to prepare them for the printing process. This is often expensive and proprietary technology. The feedstocks also have varying levels of sustainability which need to be addressed. Investing in research and technology to increase the range of materials and their availability whilst reducing their cost will be key to more wider adoption.

Production speed

In most additive manufacturing applications, both print time and the time required for post processing (completing surface finishes) are not as fast as for traditional manufacturing techniques. This is not an issue for small volume, specialist components. However, focussing on technologies to overcome this will be the key to unlocking the full potential of this technology.

Design challenges

Today's products are not designed with additive manufacturing in mind. For complex parts it is often down to the skill of a designer to set the printer to maximise the chance of success. Increasingly advanced software is being developed to overcome this, though there is plenty of scope for continued development.

Enabling New Business Models

Additive manufacturing has the potential to impact manufacturing and distribution across a range of sectors, particularly where small-run applications and customisation is valuable

Much as digital computers unleashed a wave of innovation in the 1970s which is still felt today, additive manufacturing could lead to similar disruption to business models. The breadth of materials, and range of scales it can use means it has potential to disrupt a large number of established sectors e.g. food, consumer products, pharmaceuticals, industrial, healthcare, infrastructure, and transport. It also avoids the need to hold spare inventory, reducing warehousing costs, and overstocking. The impacts will be felt across value chains from extraction to servicing including:

- More efficient production to reduce demand for raw materials
- Democratising product design
- Development of new transformative products through rapid prototyping and new functionality
- New flexible production techniques, responsive to local needs. Local flexible production capabilities (fabrication labs)
- Reduced need for global distribution and supply chains due to local production
- Servicing through local repair and refurbishment.

Additive manufacturing potentially changes the economies of scale equation, affecting incumbent businesses, and creating opportunities for small-scale providers which could better serve niche and local markets.

Additive manufacturing will enable a number of the disruptive business model levers identified on the Project Breakthrough website, specifically:

A more personalised product or service

Additive manufacturing enables businesses to design, produce and offer unique personalised products in cost effective ways.

A closed-loop process

Additive manufacturing produces less waste by its very nature, it is additive rather than reductive. By enabling local production and use of local feed-stocks such as plastics, it helps accelerate the shift towards closed-loop production and consumption.

Agility

The inherent flexibility in additive manufacturing equipment means that organisations can rapidly prototype during development, and then reconfigure existing equipment to manufacture new products.

More Examples…

NASA funds 3D food printer

http://inhabitat.com/nasa-funded-food-3d-printer-gets-its-first-prototype-3d-prints-an-entire-pizza/

3D printing used in construction

http://www.economist.com/news/science-and-technology/21722820-think-spiderweb-floors-denser-skyscrapers-and-ultra-thin-bridges-3d-printing-and

Daimler uses 3D printing for spare parts

http://fortune.com/2016/07/13/daimler-trucks-3d-printing-spare/

United Nations Global Compact

The United Nations Global Compact is a call to companies everywhere to align their operations and strategies with ten universally accepted principles in the areas of human rights, labour, environment and anti-corruption, and to take action in support of UN goals and issues embodied in the Sustainable Development Goals.

The UN Global Compact is a leadership platform for the development, implementation and disclosure of responsible corporate practices. It is the largest corporate sustainability initiative in the world, with more than 9,000 companies and 3,000 non-business signatories globally.

Project Breakthrough

Project Breakthrough – a collaboration between UN Global Compact, Volans and partners – spotlights the best thinking in sustainable innovation. It showcases innovators across mainstream companies and next generation entrepreneurs who are developing solutions with the potential to achieve exponential impact. It features analysis and resources designed to help leaders understand the new business models and technologies that will be crucial in achieving the SDGs, catalysing action amongst today's businesses to meet the needs of tomorrow's world.

PA

The Disruptive Technology Executive Briefs are produced in collaboration with PA Consulting Group, combining cross sector technology, innovation and business design expertise. The briefs are intended as an easy to digest introduction to disruptive technologies, to help organisations understand how they could advance the Sustainable Development Goals and business performance. These overviews explore key features, examples of applications, potential positive and negative impacts, and how they may enable the new business models.

Visit www.projectbreakthrough.io for more information, or contact projectbreakthrough@unglobalcompact.org