WHITE PAPER

3D PRINTING

Marching into the Future with 3D Printing

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1. Introduction

3D printing was created in 1984 by Chuck Hull of 3D Systems Corp., but it wasn't until the early 2010's that 3D printers became widely available to consumers. Giving users the ability to produce any object from a computer-aided design (CAD) file, thus cutting out large chunks of the traditional supply chain, 3D printing has the potential to revolutionise the manufacturing industry.

To begin with, 3D printing was used by manufacturing companies to reduce the time and cost associated with developing prototypes, but recent advances in 3D printing technology mean it's being used more and more at the production end of manufacturing.

GE Aviation has been using 3D printing to rapidly prototype parts, but has announced plans to begin using the technology to mass-manufacture end use parts for its gas turbines. There has also been significant growth in consumer use, with Stratasys, a leading manufacturer of 3D printers, now producing 3D printing systems for as little as $2000, which previously retailed for as much as $40,000.

Several websites dedicated to 3D printing make design files and instructions freely available to users, meaning an abundance of objects can be created in one's own home, with the cost of the 3D printing offset by avoiding costs associated with purchasing commercial products.

3D printing is not only time and cost saving, but has also led to innovative and creative solutions to problems. The technology has been applied in industrial design, engineering, medicine, aerospace, automotive, biotech, fashion, education and food industries, to name a few.

This whitepaper will outline the technology behind 3D printing, and how leading manufacturers, start-up companies and consumers alike are using it to their advantage.

3D printing at a glance

- 3D printing (also known as 'additive manufacturing') is a method for making solid 3D objects by successively 'printing' layers of material on top of each other.
- Recent advances in 3D printing technology, and its increased availability, mean its use in both professional manufacturing and domestic environments is on the rise.
- There are several types and sizes of 3D printers available, each used to carry out different processes and to work with different materials, meaning there isn't much that can't be done with 3D printing technology.

2. What Exactly is 3D Printing?

Traditional 'subtractive' manufacturing techniques like drilling or cutting involve the removal of material from a solid block or sheet to produce an object. Off-cut material is often thrown away, or damaged while in storage and no longer fit for use.

3D printing, on the other hand, is an 'additive' manufacturing process where an object is fabricated through the successive addition of layers of material.

An advanced CAD program is used to mathematically slice a 3D model of an object into thin layers. The 3D printer then builds the object layer by layer, starting with the bottom layer and working its way up until the object is completed.

3D printing techniques present users with a versatile set of production methods, and can be used to produce:

- Car parts
- Smartphone cases
- Architectural models
- Artificial organs
- Replacement parts for household machines
- Household objects like doorknobs and coat hangers
- Fashion accessories
- Ornamental objects
- And many more...

3. How Does 3D Printing Work?

A 3D printer has two major parts:

1. **Build box** – contains a bed of finely ground material, e.g. pulverised stainless steel or powdered plastic, from which the object will be made.
2. **Printing head** – depending on the type of 3D printer, the head contains a heat source (such as a laser or an electron beam), or jets that spray binder over the powder.

The 3D printing process

Step 1 – The process begins on a computer, where CAD software is used to format the object into a 3D model that serves as a blueprint for the printer to refer to.

Step 2 – The printer head moves back and forth across the build box, spraying binder or applying heat to the powder until a very thin layer is produced.

Step 3 – Once the first layer has been completed, the machine deposits more powder on top of it and the process is repeated to produce the second layer.

Step 4 – This lamination process is repeated until the object is complete, and can take several hours depending on the size of the object.

Step 5 – At this stage, the production process will be complete for most plastic items.

Step 6 – Some metal objects will undergo heat treatment to strengthen them for use. Metal objects that are held together with binder are infused with other metals in a furnace.

Step 7 – Metal objects are left to cool, becoming denser and stronger and able to withstand any additional machining and finishing work that has to be done.

Step 8 – Post production (e.g. finishing)

To see a desktop 3D printer in action please click here.

4. Business Benefits of 3D Printing

3D printers give businesses the opportunity to boost their productivity.

With the addition of a 3D printer, companies already using CAD software in their office environment could rapidly produce 3D concept models to help visualise and communicate early product design, thus speeding up the design process and improving time-to-market. The ability to produce prototypes on premises also cuts costs associated with the use of third party manufacturers.

5. Using 3D Printing

There are several shops in Australia offering 3D printing services, as well as 3D scanning, which involves the use of 3D scanners to produce CAD models of customer submitted objects. These CAD models can then be made print ready and the item 3D printed, or the design file returned to the customer for later use.

There are also web-based services that 3D print objects from customer submitted CAD files. Designers can sell their own designs to be 3D printed on demand for customers.

Community operated workspaces in Australia offer access to 3D printing systems in exchange for a membership fee, plus it's also worth checking if your local TAFE institution or university has a 3D printer.

6. Adoption of 3D Printing

At this stage, 3D printing is generally viewed by large manufacturers as a prototyping tool because its speed can't yet match that of traditional fabrication methods. Indian research firm MarketsandMarkets forecasts a compound annual growth rate of 23% for 3D printing over the next 7 years, with this growth motivated by the adoption of 3D printing at the production end.

Reductions in price mean 3D printers are becoming increasingly accessible to home users, with lower end models starting from

around $1500. Personal and small business 3D printing use is set to become a mass market, where the cost of the hardware and printing process would be offset by the avoidance of costs incurred when purchasing commercial products.

The technology is also being used increasingly by marketers as a part of direct mail campaigns. With 3D printing, small volume production costs only a small fraction more than mass production, meaning it's a valuable tool in the world of personalised, on-demand marketing communications.

7. Innovative 3D Printing

With increasing accessibility to additive manufacturing techniques, and the growing versatility of systems, it's no wonder that big and small companies alike are adopting 3D printing as part of their business model. From surgery to sports shoes, the use of 3D printing has not only helped companies save time and money, it's led to the development of new and creative solutions.

Organovo

Organovo has used 3D printing technology to create small organ-like structures for use in drug development. Previously, in medical research, single layers of cells in petri dishes were exposed to drugs to gauge how organs would respond to them in vivo. Organovo has created a more accurate way to test candidate chemotherapy drugs, producing tissues that emulate actual blood flow through organs. They aim to eventually create fully functional livers, hearts and kidneys for transplantation.

To learn more about Organovo please click here.

Dyo

A team of designers, engineers and scientists at the Massachusetts Institute of Technology has launched a service that offers customised, 3D printed jewellery. Dyo, short for 'design your own', uses a range of 3D printing techniques to produce jewellery in silver, metal or plastic materials. Using 3D printing, every item that comes off the production line can be personalised to meet the wants of customers, at little to no extra cost. While existing services 3D print customer submitted design files, not all consumers are capable of working with complex CAD modelling software. Dyo has made the benefit of 3D printing more accessible to the consumer by creating a web-based user-friendly design tool that customers use to customise jewellery before purchase.

New Balance

New Balance is currently piloting a 3D printing process for making customised shoes for elite runners. At the New Balance Sports Research Lab, a force plate, in-shoe sensors and a motion capture system are used to collect data about the way a runner's feet behave inside shoes. Advanced algorithms and software are then used to convert the biomechanical data into custom 3D printed spike designs. Elite runners using the custom-made shoes have reported that they give a much more natural feel. New Balance has expressed hope to move away from mass manufacturing, towards custom, on-demand production, and 3D printing is giving them the opportunity to do so.

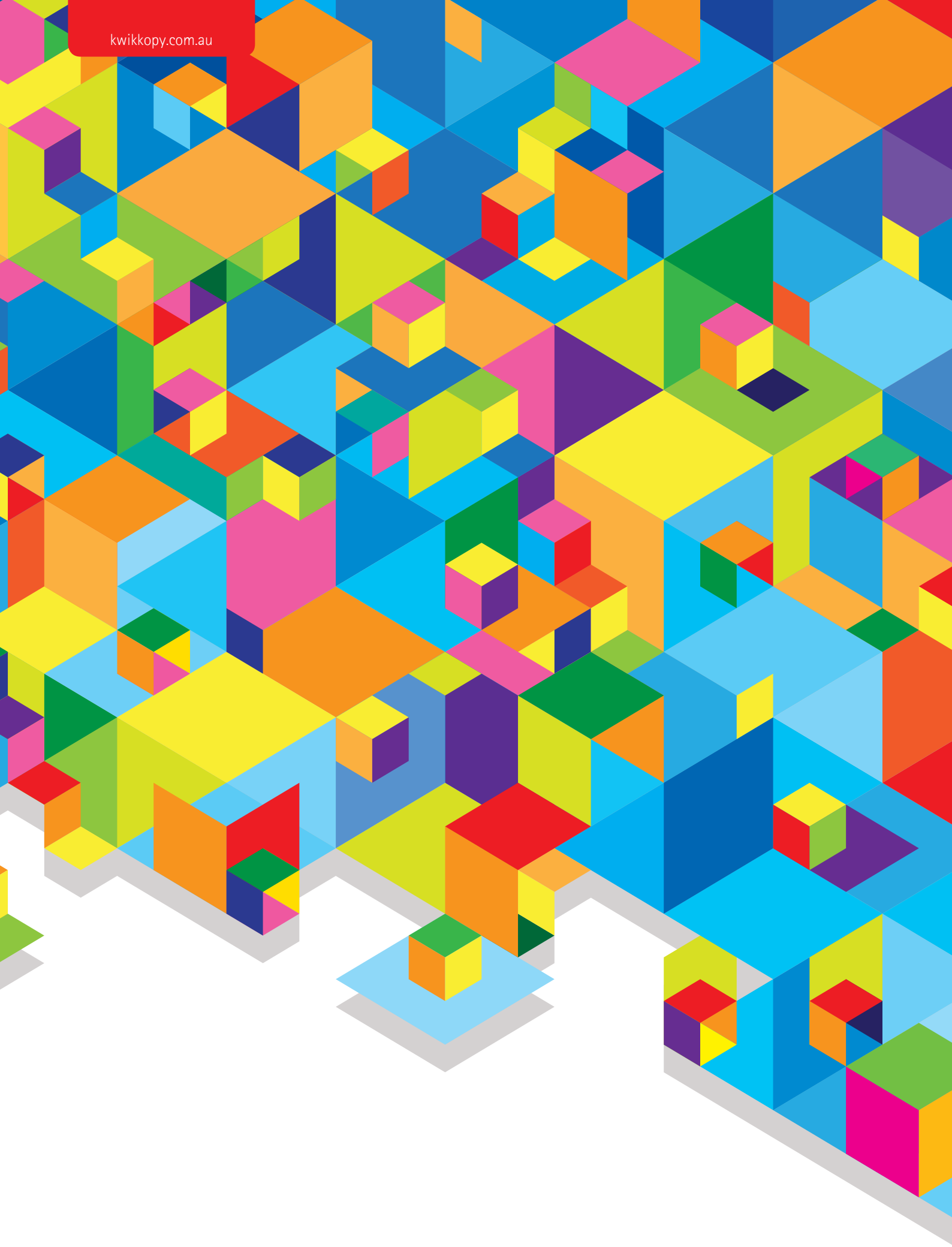
To learn more about New Balance's 3D printing innovation please click here.

8. The Future of 3D Printing

The future of 3D printing depends on broadened appeal by further expanding the versatility of systems. Stratasys has recently announced the launch of its multi-colour, multi-material 3D printer, the Objet500 Connex3. It's capable of producing rubber and plastic parts in a range of colours, using three different colour materials.

Items produced with the Connex3 match the quality of conventionally manufactured items, without the need for assembly or post-production processes like painting. While this technology may initially be adopted only for custom or low volume production, 3D printing is set to be used for more and more parts of the manufacturing process as systems become more versatile.

To find out more about the world's first multi-colour, multi-material 3D printer please click here.



9. Case Studies

CS Yahoo! Hands on Search

Yahoo! Japan is working with the creative agency Hakuhodo Kettle to help children with visual disabilities. Combining their search function with a 3D printer, they developed the "Hands on Search" machine, which produces solid objects in response to searches for items.

The Hands on Search machine resembles a cloud with a built in MakerBot 3D printer. Using voice recognition to search for an item, the machine finds the corresponding design file in the Hands on Search database and 3D prints the object instantly.

Hands on Search has been introduced to the Special Needs Education School for the Visually Impaired, Tsukuba, where the sense of touch is being used to help visually disabled children overcome learning impairments.

Anyone can contribute to the project by submitting design files for items that aren't in the Hands on Search database yet.

To see Yahoo! Hands on Search in action please click here.

CS Wilmington Robotic Exoskeleton

When she was born, Emma Lavelle's legs were folded up by her ears and her shoulders were internally rotated due to the genetic disorder arthrogryposis multiplex congenita (AMC). Following surgery, she was able to move around with the help of a walker. However, at the age of 2, she still couldn't lift her arms and would become frustrated that she couldn't play with toys, eat without assistance or brush her teeth.

At a conference for AMC families, her parents found out about the Wilmington Robotic Exoskeleton (WREX). The device was demonstrated by an 8 year old AMC patient who was able to lift his arms and move them in all directions with the help of the WREX.

Emma's mother met with the presenters, researchers at the Nemours Foundation, who had been working on making the WREX progressively smaller, to serve younger patients. Emma's arms were strapped into a small trial WREX and she immediately began moving her hands around and playing.

However the parts for Emma's WREX would be too small to create with the workshop's usual fabrication methods. Instead, it was 3D printed in plastic and proved durable enough for everyday use. Since then, more than fifteen young AMC patients have started to wear custom 3D printed WREX devices.

To learn more about Emma's story please click here.

CS URBEE 2

Jim Kor, the founder of KOR EcoLogic, has created the world's first 3D printed car. With the first prototype launched in 2010, the current version URBEE 2 is comprised of 40 large plastic 3D printed parts. Carrying two passengers, URBEE 2 has a hybrid engine and can reach speeds of up to 109 km/h.

Because URBEE 2 is made from lightweight ABS plastic, it causes much less drag and requires less fuel. It also runs on biofuels like ethanol, making it much more eco-friendly than your typical car.

For eco-conscious car manufacturers, the focus is often on developing increasingly efficient motors for heavy steel bodied cars. However, 3D printing technology is particularly well suited to the construction of lightweight parts. This has enabled the team at KOR EcoLogic to focus on developing more optimal automobile physics, which subsequently require much less horsepower to move. It's a win-win situation where the use of less materials at the production stage leads to the use of less materials at the use stage.

3D printing has also allowed Kor to combine what would usually be sets of several parts, requiring further assembly, into simpler unibody shapes. With less space between parts, the URBEE has significantly increased aerodynamics.

URBEE 2 is expected to be commercially available within two years.

To find out more about URBEE 2 please click here.

CS Aki Inomata

The Japanese artist Aki Inomata has harnessed the precision of 3D printing technology to create a series of crystalline shells for hermit crabs. She used a high accuracy 3D printer to produce the shells, which feature the skylines of Greece, New York and Thailand.

Inomata used a computed tomography (CT) scanner to produce a highly detailed image of the interior of a snail shell that one of the hermit crabs had been inhabiting. From this she produced a CAD model, resized it to suit the hermit crabs then created several shell designs featuring the skylines of different cities. It was only with the use of a high accuracy 3D printer that she could then print the intricate shells in a crystalline material.

Inomata's sculptures were inspired by a real estate transaction between the governments of France and Japan. They had been negotiating the rights to an embassy, eventually coming to the agreement that control of the embassy would change hands every 50 years. Consequently, Inomata got thinking about globalisation, ownership and nationality, eventually materialising her ideas in the form of her hermit crab shells and their inhabitants.

To see Inomata's 3D printed hermit crab shells please click here.

CS Honda

Honda Motor Company has recently released an archive of 3D design files of some of its concept cars, which consumers can download and 3D print from the comfort of their own homes.

The archive includes 3D models of Honda's Puyo and Fuya-Jo car designs from 2007 and 1999, respectively, as well as the new hybrid NSX supercar concept.

With Honda 3D Design Archives, consumers with access to 3D printing can have a close up look at the exterior design of the NSX supercar before it begins production in 2015.

This will give prospective customers the opportunity to better assess whether they're interested in purchasing the car, long before it becomes available.

To learn more about Honda's 3D Design Archives please click here.

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10. About Kwik Kopy

Kwik Kopy has a longstanding history as a leading provider of print and design services to the Australian small & medium business market. We've recently begun to offer a range of digital services and with over 100 centres operating throughout Australia, you can count on us.

While we do not provide 3D printing services, at Kwik Kopy we are always paying attention to new developments in technology, taking into account the changing business environment while working with our customers.

We know that not all businesses are the same, that's why we work with our customers in a consultative process to ensure that we are delivering against their business goals, whilst providing practical advice and superior communication products that enhance their business presence and assist in achieving their goals.

Speak to us today to see how we can help you with your print, design & digital needs.

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