



## 3D Printing Super Strong Robots With Carbon Fibre

Robo Challenge is a creative engineering company that pushes design and materials to the absolute edge. A small family outfit based in Birmingham, brothers Grant and James along with dad Nick, have built a reputation for building some of the toughest and most creative robots in the World.

From designing the house robots for TV series Robot Wars to building the world's fastest chainsaw-powered vehicle and creating an autonomous football-pitch painting robot that uses GPS and vision detection to paint out the lines - Robo Challenge combines the latest technology with engineering know-how to bring ideas to life.

### Challenge

**To build Spectre:** A next-generation fighting robot equipped with a state of the art hydraulic crusher as its weapon.

As the engineering team behind BBC's Robot Wars, Robo Challenge were barred from competing themselves in the series, so they looked further afield and decided to create Spectre for the King Of Bots (KOB) World Championship in China.

James Cooper, managing director at Robo Challenge, says, "There is no other industry like fighting robots that takes materials, batteries and motors to the extremes like we do. We have to design and build a 110kg fighting machine that will go into a 110 tonne bulletproof arena with three minutes to either destroy the competition or be destroyed.

"The difference between designing for automotive or aerospace and fighting robots is that with robots, there isn't the safety implications of a robot breaking down in an arena and hurting people as there is with Formula 1 for instance. It means we can run things much harder and closer to the tolerances of material specification without the worry of something catastrophic happening."

Robo Challenge's design brief was to reinvent the robot's hydraulic crusher to take on the spinning weapon-style of robots that have recently dominated competitions. James adds, "King Of Bots is the chance to blend together the creativity of our designs in an extreme environment. We wanted to turn up with something that people thought wasn't possible - a hydraulic crusher that would jump another league in Robot Wars technology."

### Solution

**Markforged 3D Printers From Mark3D:** Robo Challenge wanted a reliable, high-strength 3D printer that would let them print end-use parts in more organic shapes with stronger materials. It approached Mark3D, an award-winning reseller of Markforged 3D printers in the UK. Mark3D supply, support and install Markforged printers, which use Continuous Filament Fabrication (CFF) technology to create end use parts.

Robo Challenge invested in a Mark Two printer with dual print heads; one to extrude onyx while the other reinforces the onyx with carbon fibre. The carbon fibre is 6x stronger and 18x stiffer than onyx and is designed primarily to replace aluminium parts. Using carbon fibre, the printed components are as strong as aluminium with a flexural strength of 470MPa.

“ Thanks to Markforged's Carbon Fibre 3D printers from Mark3D, we are now at the cutting edge of what is possible. By letting us push materials and their tolerances to the very limit, we are creating super strong, lightweight 3D printed components that are as strong as aluminium.

James Cooper, managing director, Robo Challenge





Markforged printers can also reinforce 3D printed components with Kevlar and Fibre Glass.

James says, "Reliability is our number one aim. It is vital to Spectre's success that when it goes into the arena, it is prepared for battle and can take the hits. The carbon fibre strands are as strong as aluminium. The filaments on the Markforged printer mean the print is more dimensionally stable than previous FDM printers we have used, and we are able to assign the angle of the carbon to ensure the printed component has the strength in the axis that we need."

Markforged's CFF technology also means Robo Challenge has greater freedom in how it designs parts. James explains, "With 3D printing, we can now spend more time designing the perfect component, rather than worrying about how our design will be compromised if we have to use steels and traditional fabrication methods. It means we no longer have the design restrictions of 3-axis machining and can start experimenting with generative design to build whatever shape we want."

### 3D Printing Stronger, Lighter Materials

Previously, Spectre's 'collar bones' had been manufactured in aluminium, weighing 1kg each. Using Markforged 3D printed carbon fibre technology, that weight was halved without compromising on strength.

"For all Spectre's internal components, carbon fibre 3D printing came into its own. We could get the stiffness and the strength without adding weight and for

us that was a huge step forward," says James. By 3D printing in carbon fibre, Robo Challenge saved on average 500g per internal component and shaved off 2.5kg from Spectre's total weight. It meant Robo Challenge could use that extra gain to add a second battery pack, which would let them run Spectre's crusher at full power.

### The Result

Spectre won the KOB World Championships 2017. Its next generation hydraulic crusher can now impart 22 tonnes of force (the last hydraulic crusher to win any major event had just nine tonnes of force).

James says, "Spectre is completely different to any other robot that has ever competed. Attention to detail has been meticulous with each component analysed to its very core. It is as much a piece of art as it is an engineering project.

"Thanks to Markforged's Carbon Fibre 3D printers from Mark3D, we are now at the cutting edge of what is possible. By letting us push materials and their tolerances to the very limit, we are creating super strong, lightweight 3D printed components that are as strong as aluminium. It means we end up with a robot that has been optimised in every way and looks better suited to being in a Formula 1 garage than a fighting robot arena."

Robo Challenge is now planning to retain the KOB World title with Spectre using generative design and 3D printed parts for the 2018 KOB hosted in China.

### AT A GLANCE

- Replacing aluminium parts with 3D printed components
- Super strong end use parts
- Lighter components by 50 per cent
- No more compromised design

“Mark3D is an amazing supplier for our MarkForged printer and materials. The dedicated team are incredibly helpful in providing us with data sheets and intricate samples of the variety of different materials available. Always fast to respond and very hands-on, they have gone above and beyond to support us when projects with tight deadlines come up - including offering to print a number of Spectre's components to ensure he would be ready for battle on time!”

**James Cooper,**  
Robo Challenge

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