

# Markforged Parts Tough it Out in Battle



## Comparing the Numbers

	Cost	Time
Markforged Part	\$54.70 (material)	52 hours
Machine Shop - Aluminum	\$1,090.41	3-5 days + shipping time

## Taking a Hit

Blades spinning, blasts of fire, swinging weapons: this is the world of combat robotics. If designers want their robots to have any chance of winning, they have to design their bots to be sturdy enough to take dozens of hits, yet powerful and light enough that their robots can strike fast and hard. Many of these contraptions are built from hardened steel, heavy machined frames, and sharp edges. The designers themselves range from toughened veterans who know their way around the arena to fresh faces eager to send their bots blade-first into battle.

## Contender

Jamison Go, PhD Candidate at MIT, enters antweight fighting robots in competition

## Endeavor

Improve weight and strength of robot designs by making a unibody and 3D printed chassis

## Triumph

Go decreased frame weight by 49% and became the #2 ranked combat robot of its weight class world wide



Different Iterations  
of the DDT

One of the many designers is Jamison Go, an MIT PhD candidate researching 3D printing technologies and how to make them faster. He grew up inspired by shows like BattleBots, dreaming of one day making his mark in the world of combat robotics. One of his primary robots, DDT, is in the antweight class, meaning that the entire assembly has to weigh less than a pound. Go explains the challenge of this limitation: "In combat robotics, each robot fights in its own weight class, which means that each robot can weigh up to a certain amount. So it's really important for your parts to be effective in size and weight." Strong materials, powerful components, and a weight efficient design are crucial to performing well in a match.

## Re-Framing the Problem

His original design for the DDT was laden with a bulky, cumbersome frame: lots of fasteners, stacked plates, and plastic components. "The old chassis was manufactured using several stacks of UHMW Plastic, which were then bolted together with several long screws. This old design was cumbersome because it had so many different fasteners, it was a lot heavier, and because it was solid plastic it was actually very flexible, which isn't very good for the design," Go explained. This meant that Go had to dedicate a lot of his bot's weight just to the unwieldy frame. "The old design did...ok. It definitely won a few matches, but I had to make compromises in lighter components, less powerful components, just because of the weight of the frame...as a result, in its last competition, it was totally destroyed." Go took the opportunity after a particularly nasty battle to rethink his design: "DDT's frame was done for and I saw this opportunity to

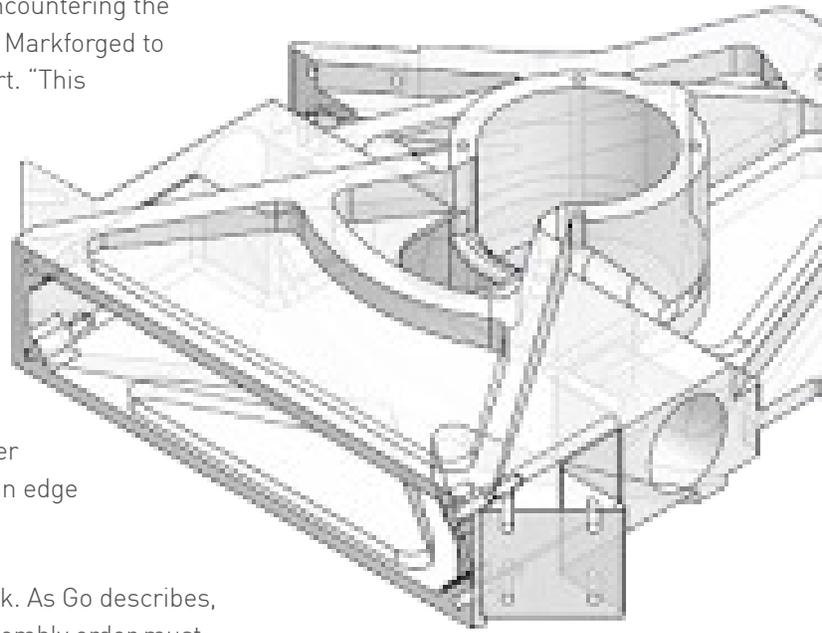
"Competitors are absolutely astounded. They can't believe that this is 3D printed, and I tell them 'this is what the Markforged printer can do.'"

-Jamison Go  
MIT PhD candidate

revisit some of the design creeds that I'd been touting for the past year... and so starting with DDT, I will evolve each robot in my fleet". Upon encountering the Markforged printer, Jamison Go saw an opportunity to use the Markforged to modify the chassis of DDT and make it a single, lightweight part. "This printer is unique because it has the ability to embed continuous strands of fiber within each layer of its print. Although it cannot place fiber in the vertical build axis, this is a monumental improvement in tensile strength... it prints nylon as its base material, which is mechanically superior to ABS in our application." Go went on to describe how he would use the Markforged in his new design. "To further demonstrate the capabilities and applications of [the Markforged] technology, I have elected to print DDT as a nylon-kevlar unibody." This would make it lighter and stronger so that he could add in heavier actuators and weapons to get an edge in the ever evolving world of combat robotics.

Reducing a multi-body assembly to a single part is no easy task. As Go describes, "many details about the parts, their connections, and their assembly order must be known ahead of time. CAD became an invaluable tool in this process; each part was modeled with excruciating detail and a detailed assembly order was developed for the rear component bay." Pursuing his passion for both combat robotics and 3D printing, Go did away with many of the plates, bolts, and other fasteners that added unwanted material weight, and he designed the structure all in one part. "I was able to incorporate a lot of intricate design features to fit my specific components to make everything smaller, more compact, and more efficient."

DDT v3 Unibody CAD



"I was able to incorporate a lot of intricate design features to fit my specific components to make everything smaller, more compact, and more efficient."

-Jamison Go  
MIT PhD candidate



Awards won with the DDT

"Some of these chassis, they can take three days to complete, and the Mark One is the only printer I trust with a part this complex, and this long," Go mentioned when describing the printing process. With the Markforged parts making the chassis even stronger and lighter than it was before, Go took DDT into battle with high hopes.

## Grand Slam

DDT performed even better than Go had expected. By printing the part on the Markforged, the chassis weight was halved even though its strength increased: "All in all, I was able to make a frame that weighed 51% of the original design, yet was much stronger."

This meant that he could use the extra weight he had to incorporate higher performance motors and electronics into DDT, making the bot even more of a threat. DDT's new, lightweight chassis made it incredibly quick on the field, striking other bots fast and hard before some could even throw a punch. "The new design has performed phenomenally thus far. I've taken it to about four different competitions, and in every single one of them, it either won first or second. It's currently the second ranked robot of its weight class in the whole world," Go explained. "When I take this guy to competitions, the competitors, bystanders, are absolutely astounded. They can't believe that this is 3D printed, and I tell them 'this is what the Markforged printer can do.'" The new DDT quickly rose in the ranks of antweight combat robots and is now second worldwide. DDT's success inspired Go to upgrade the rest of his iconic combat robots as well, designing Markforged unibody frames for all of them.

A video of DDT in action can be seen here:

<https://www.youtube.com/watch?v=RJJ1v8e0SSI>



© Markforged, Inc. 2016. All rights reserved.

Markforged's mission is to bring high strength 3D printing to everyday engineering. Offering the world's only 3D printing systems capable of automatically reinforcing engineering plastics to aluminum levels of performance and beyond, Markforged enables every business to easily manufacture parts with structural strength right on the desktop. The Mark Two Industrial Strength 3D Printer empowers professional users to affordably create workhorse 3D parts that solve real problems, as well as realize reinforced structures never before possible. Markforged technologies are delivered with thoughtful, powerful software designed for collaboration, sharing, and scaling.

For more information, visit <https://www.markforged.com>

