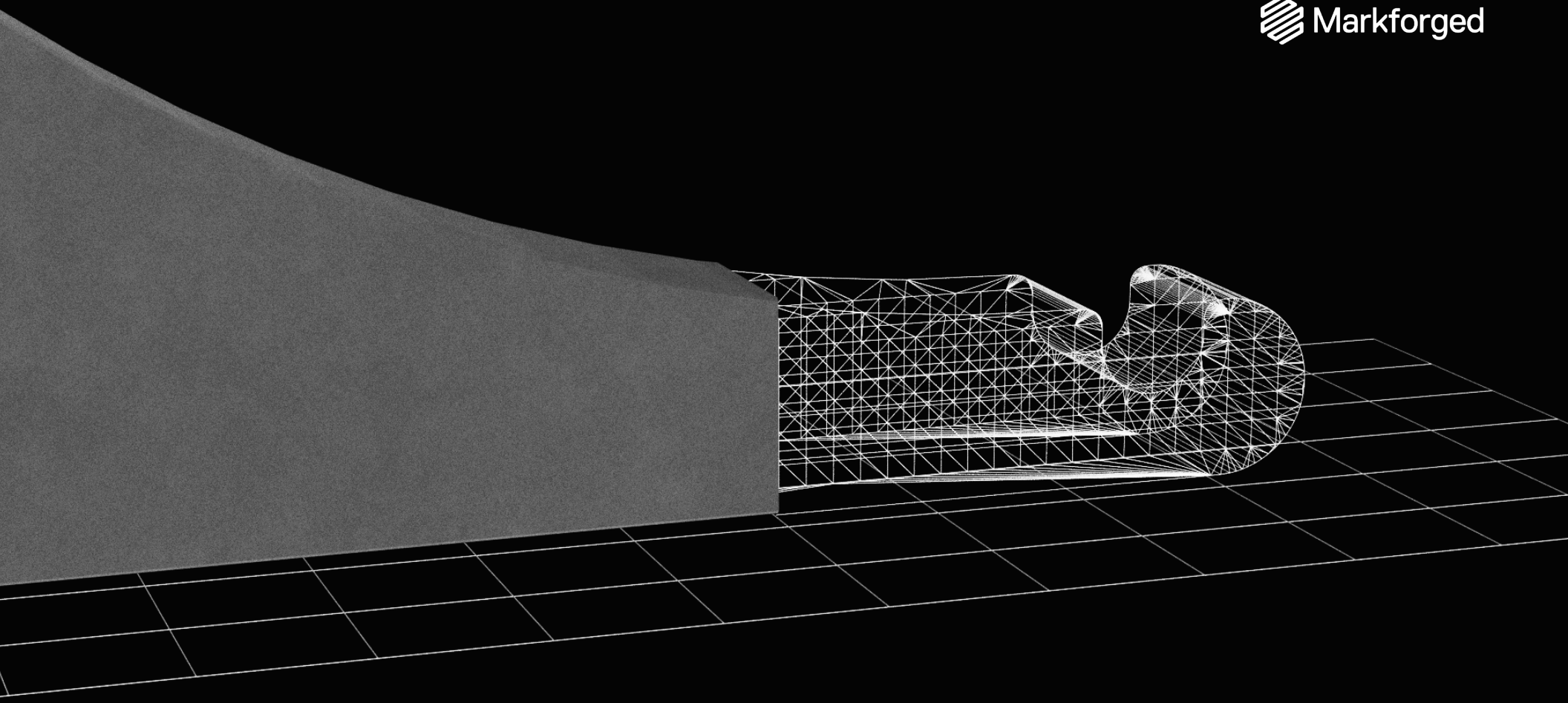
Markforged



Don’t Leave Part Performance to Chance

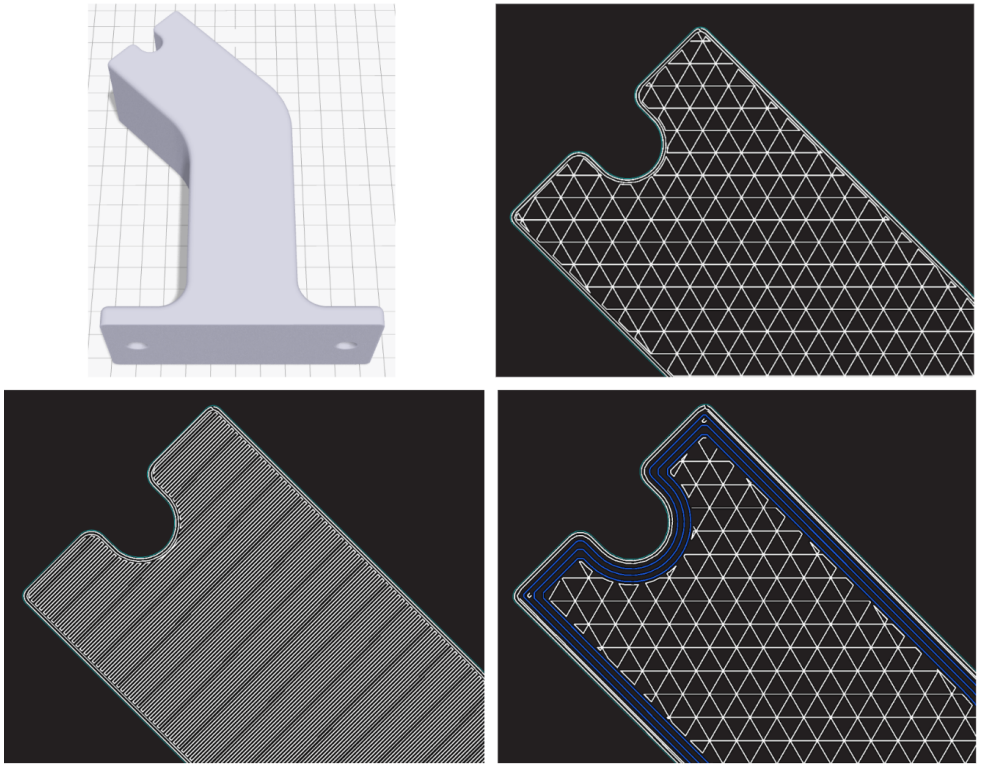
Validate and Optimize Parts with Simulation Before Pressing ‘Print’

The Challenge of Configuring Parts for Functional Applications

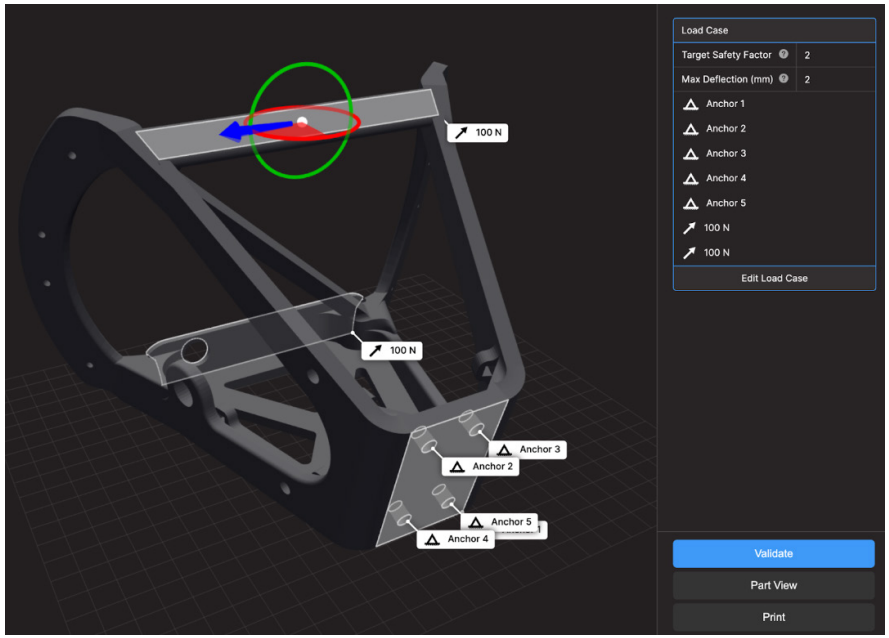
Many user-adjustable settings impact how a 3D printed part will perform — such as wall thickness, fill density, part orientation on the build plate, and Continuous Fiber Reinforcement (CFR). When functional applications carry strength and stiffness requirements, how can you know your 3D printed part will perform as needed?

Historically, users have attempted to address this challenge through guesswork: intuition, overbuilding parts, and/or multiple cycles of print-break testing. These are not efficient or reliable methods. Even when guided by experience, using intuition to determine print settings is ultimately an educated guess: the parts may or may not work. Purposely overbuilding, printing solid, or using excessive CFR leads to far higher costs and print times— and is still effectively a guess. While printing and testing measures part performance, each cycle comes at a cost. Printing, testing, and redesigning multiple iterations consumes valuable printer time, substantial material costs, and operator time.

What if there was a way to get validated and optimized parts faster?



Shown here is the exterior of a part and interior views showing three different part configurations: default, solid, and with continuous fiber. The performance of the part depends on how it is configured.



Defining a use case in Simulation is easy. Just select surfaces that are constrained and surfaces that are loaded. In this image, the use case for a jet dragster steering wheel is highlighted.

Take the Guesswork out of 3D Printing with Simulation

Our solution to this challenge is Simulation, a software tool that virtually tests and optimizes parts before they are printed. Simulation helps you identify the ideal print settings so that you can print the right part the first time. Virtual testing and easy optimization replace guesswork and trial and error. In just minutes, Simulation replaces days or even weeks of physical printing, testing, and iterating on parts. Simulation also reduces material costs substantially, lowers waste, and frees up printer bandwidth.

Performance validation —

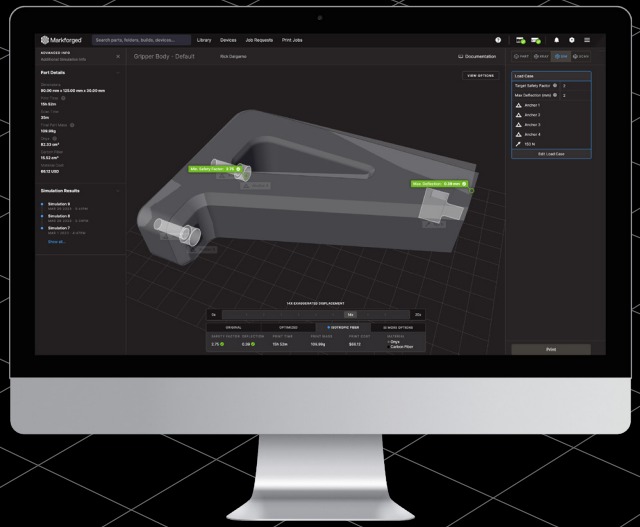
Simply configure the print settings for your part in Eiger and then define a use case — how the part will interact with other components in the real world. Simulation validates your part in seconds, providing feedback on estimated strength and stiffness along with a final thumbs up or thumbs down on whether your part is expected to meet performance requirements.

Optimize for time and cost —

Simulation optimizes your part configuration to meet performance requirements while also minimizing print time and material cost. This can be achieved by adjusting settings and running additional simulations—or with Simulation’s automatic optimization capability.

Key Features

Simulation is powered by a custom, high-fidelity Finite Element Analysis (FEA) engine built to account for the complexities of 3D printed parts. Variables that influence the simulation include material type, fill pattern, fill density, number of floor and wall layers, layer height, CFR pathing, and part orientation.



Assess part strength and stiffness —

The Safety Factor tells you the load factor corresponding to the onset of damage (material yielding) in the part. Displacement output tells you how stiff your part is.

Visualize results —

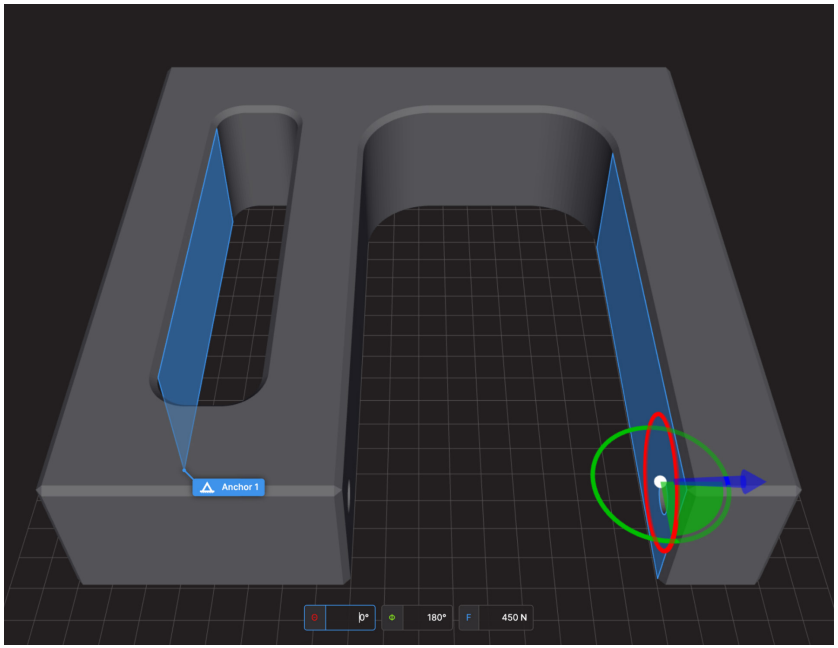
View part deformation, the location of maximum deflection, and the location of the minimum Safety Factor.

Automate the optimization process —

Press the easy button and have Simulation automatically optimize your part to satisfy performance requirements while minimizing print time and material cost.

Simple and intuitive interface —

While traditional FEA tools are notoriously complicated, Markforged Simulation is accessible and easy for non-analysts to use. Markforged Simulation automates common pain points of the traditional analysis process— such as meshing, material assignement, and material orientations.



Material handler with anchor and load surfaces highlighted.

Example Use Case

Consider the part shown here, a material handler used to lift and place raw material into a CNC machine. It needs to support about 100 lbs. of raw material when users load material with it. The handler needs to be strong enough to support the material weight, and stiff enough to ensure the load is stable and properly supported.

Consider two methods for configuring the print settings for this part:

Without Simulation —

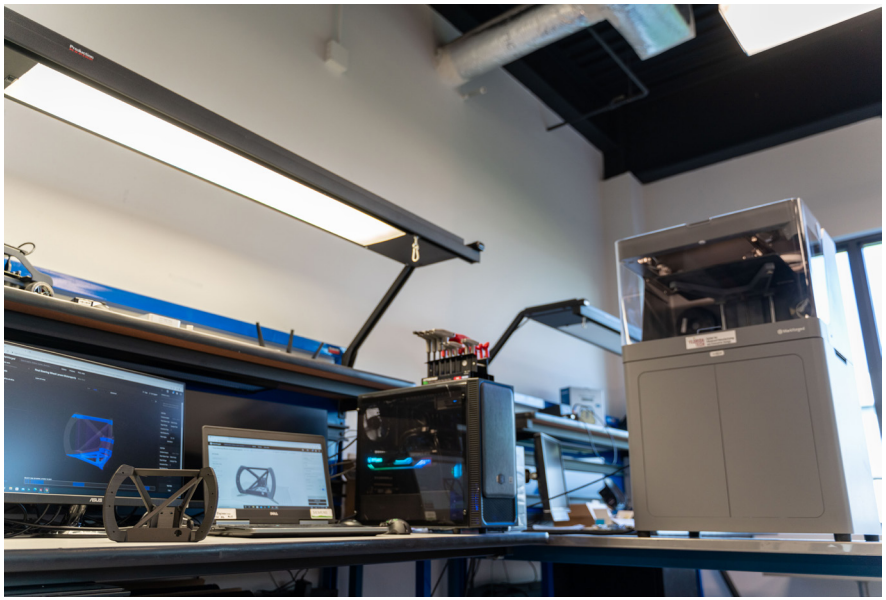
With a trial-and-error approach, a user would likely print the first part using default settings for Onyx®, which sets the fill density to 37%. If this part fails during testing, the user might try and print a part with solid fill. This part might also fail, so the user could decide to add continuous carbon fiber to the part. After printing and testing the part with continuous fiber, the user might discover that the part works — but is much stronger than it needs to be. Due to the cost of carbon fiber, optimizing fiber usage is important for streamlining operational costs. This could lead to additional iterations where they print and test a part with less carbon fiber.

With Simulation —

Contrast this trial-and-error methodology with an efficient workflow that takes advantage of modern software. Using Simulation, the load case is set up in seconds and the optimization feature automatically identifies the optimal print configuration in minutes.

Comparing the two methods reveals significant savings. Without Simulation, the print time and material cost for the 4 part configurations discussed can easily be over 16 days and $1,668. Using Simulation, one only needs to print and test the optimized design to confirm that it works, which takes about 3 days with a material cost of $282. The net savings with Simulation for this single application are over 13 days of print time and $1,386 of material. Not only does this speed up the part development cycle — it frees up time on the printer for other parts.

	Without Simulation	Simulation	Savings
Print Time	16d 5h	2d 19h	13d 10h
Cost	$1,668	$282	$1,386



Showcased above is Larsen Motorsport’s set up, featuring their jet engine dragster steering wheel and X7.

See how Customers are using Simulation

Larsen Motorsports trusts parts validated with Simulation to protect their drivers on jet engine dragsters reaching speeds up to 280 mph.

PUNCH Torino, an R&D and engineering facility, used Simulation for a 3D printed camshaft locking tool, reducing eight iterations down to just one.

Siemens Energy uses Simulation to minimize Carbon Fiber material costs and print times for a gas turbine vane fixture.

Simulation is available in the Advanced Digital Forge Complete plan. Learn more about the Advanced plan offering:

https://markforged.com/plans
Minute with Simulation video