

# Additive Manufacturing for the U.S. Navy



# Introduction

The U.S. Navy and its partners leverage additive manufacturing to mitigate the risk of rapidly shifting supply chains to maintain combat readiness. Through programs such as AFLOAT, the Markforged X7 printer is used shipboard to produce strong parts at the point of need. 3D printing improves battlefield logistics by allowing warfighters to create rapid prototypes, and on-demand spare parts, while also pushing technological boundaries by lightweighting complex designs for vehicles, drones, and weapon systems.

Fabricate Navy strong parts using high-performance thermoplastics with continuous fiber reinforcement or metal. Skip multi-week lead times for composite or metal prototypes, tools, fixtures, and replacement parts. With material traceability and an expanding portfolio of materials, you can print a wide variety of mission-critical parts at the point of need.

Markforged parts' high strength and durability withstand rigorous environments, and printer repeatability and reliability ensure parts are produced accurately and efficiently every time. Combined with best-in-class software, training, and support, The Digital Forge platform makes it easy to train new warfighters at scale and ensure you always have the parts you need when you need them.

Please review the key applications below and contact your rep to learn more!

# Print Replacement Parts

📍 U.S. Army, Fort Irwin

Fort Irwin is a major training base for the U.S. Army that provides realistic joint and combined arms training to develop the U.S. Army's soldiers and leaders for the battlefield. They train soldiers for upcoming deployments, wherever that may be in the world. By using additive manufacturing technology, the Army is able to create readiness factors that decrease downtime.

The regiment needed durability, functionality, and versatility — and Markforged machines' Continuous Fiber Reinforcement (CFR) printing process gives them the ability to print with continuous carbon fiber, fiberglass, and Kevlar®. The U.S. Army's Markforged composite printers have been used for personal protective equipment (PPE), window wiper brackets for military vehicles, tools, and low-volume production parts.

The regiment has also started to 3D print a critical low-volume replacement part for a component that is no longer available: a hatch plug that sits on top of a vehicle used in low-light scenarios. The hatch plug helps the driver see at night, giving the driver the ability to tell the soldiers to engage. Unfortunately, this part is not in production anymore and would cost roughly \$10,000 to reproduce, not to mention the 3-month lead time. With Markforged, the regiment printed the hatch plug in Markforged Onyx material for \$230, and then another using 17-4PH Stainless Steel on the Metal X for \$800. This application alone has saved the regiment \$244,000.



**Further Reading:**  
[United States Army - Fort Irwin Training Center](#)

# Print Lighter Equipment

📍 U.S. Air Force, Cannon Air Force Base

Cannon Air Force Base, home of the 27th Special Operations Wing (27 SOW), lies in the high plains of eastern New Mexico, near the Texas Panhandle. The 27 SOW employs specialized aircraft and highly trained airmen to execute and support special ops missions around the world. Within the 27 SOW, the 27th Special Operations Support Squadron (27 SOSS) supports deployment, employment, planning, and combat training for specific squadrons and other flying operations.

Airmen typically carry packs of 80 lbs or more in combat training scenarios. Under those circumstances, any load weight reduction goes a long way towards improving airman stamina and agility. The combat training unit decided to 3D print many of the tools used by airmen in the field. The tools, printed with Onyx — a carbon fiber-filled nylon material — were more durable and lighter than their conventional counterparts.

Simulated combat, like real combat, can happen at any time of day — or night. That's why most training kits include night vision goggles (NVGs). The goggles are held in place by NVG mounts affixed to the top-front of airmen's tactical helmets. Unfortunately, NVG mounts are vulnerable to damage due to user error and impact. A single replacement mount can range from \$100 to several hundred dollars with a shipping time of a few weeks or more. Lejay Colborn, 27 SOSS Range Support Planning and Operations Specialist, realized he could solve this issue with the unit's Markforged industrial X7 3D printer. The team 3D printed replacement mounts with built-in spacers to accommodate multiple helmets including those used in force-on-force scenarios for less than \$5 in just a few hours. According to Colborn, his 3D printed NVG mounts are "just as strong as the commercial, off-the-shelf aluminum ones."



**Further Reading:**  
[U.S. Air Force: Cannon Air Force Base](#)

# Print Assistive Technology

📍 U.S. Department of Veterans Affairs, Central Virginia

The Central Virginia VA Health Care System seeks to improve the lives of military heroes through innovation. For eligible veterans and active duty service members impacted by disabilities, the Assistive Technology team aims to offset the impact of disability and improve quality of life through services including evaluation, clinical intervention, and training.

The team employs assisted technologies such as electronic cognitive devices, adapted automobile equipment, adapted sports and recreation equipment, electronic aids to daily living, augmentative and alternative communication equipment, and adaptive computer access tools. The Central Virginia VA Healthcare System has used Markforged composite printers to successfully print rigid prosthetics with Onyx material, a Nylon filled with micro-carbon fibers, and flexible prosthetics with Smooth TPU 95A.

“Markforged technology has given us the capability to successfully collaborate with medical professionals and veterans to deliver a high-quality solution,” said Brian Burkhardt, Clinical Rehabilitation Engineer. “These printers just work, and enable us to deliver an elegant, high-quality end product for our patients.”

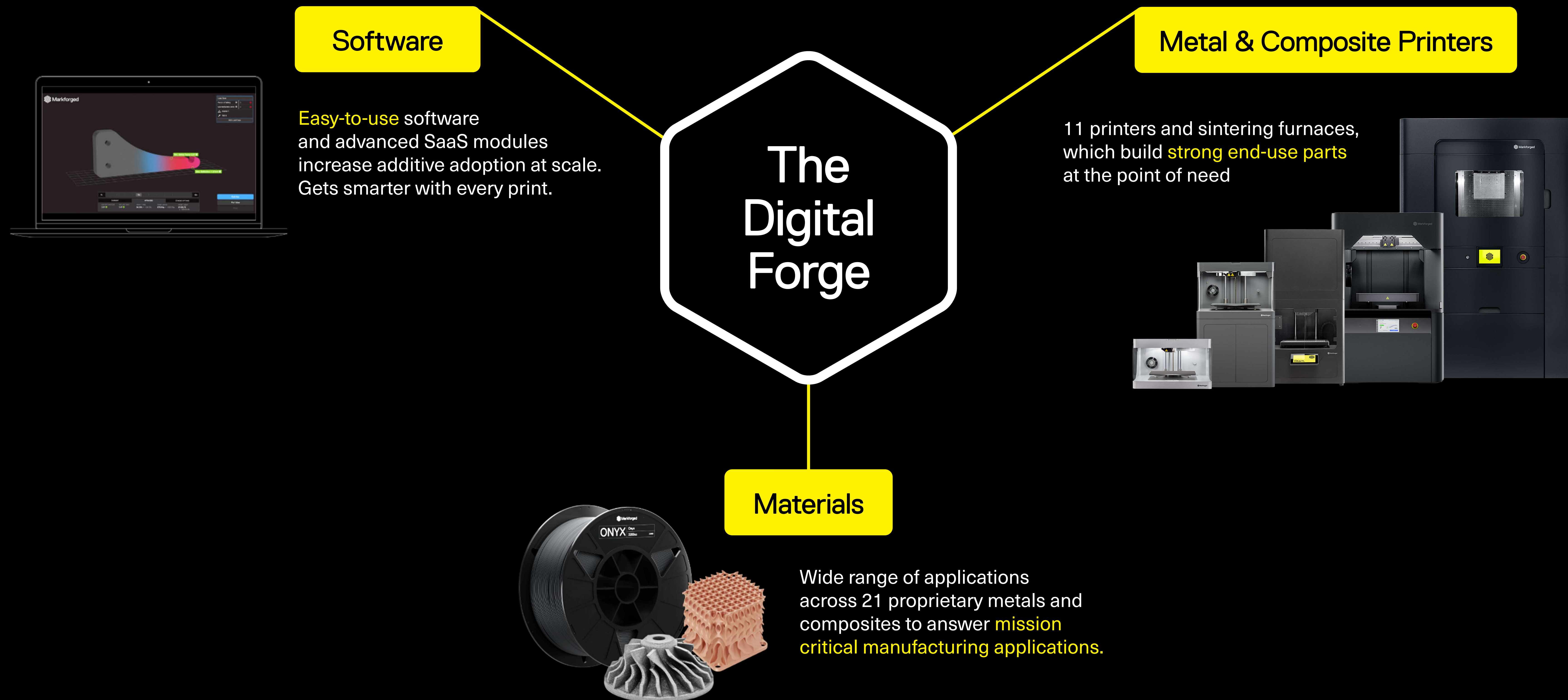


**Further Reading:**

[The U.S. Department of Veterans Affairs \(VA\)](#)

# Markforged's platform, **The Digital Forge**, brings resiliency to the field.

The Digital Forge is the reliable, easy-to-use and intelligent Additive Platform.



# Defense Printer Lineup



## X7FE

### MOBILE ADVANCED COMPOSITES

Portable, rugged, 3D printer for tactical solutions in remote locations.



## FX20

### HIGH-TEMP COMPOSITES

Large scale printer for strong, durable parts that withstand some of the harshest environments - from sea to air.



## FX10

### ADVANCED COMPOSITES & METALS

The world's first industrial metal & composite 3D printer. Reliable, low-touch user experience that mitigates the need for dedicated operators.



# X7FE™

X7 Field Edition (FE) is a rugged, field-deployable carbon fiber 3D printer built for tactical response to supply chain challenges in remote locations. Increase supply chain resilience by printing tools, adapters, and replacement parts for equipment at the point of need. Recover faster when parts break, operate with less on-hand inventory, and minimize equipment downtime with flexible manufacturing, all while using less than 300 watts. Allow warfighters to solve problems during deployment— instead of expediting parts from across the globe — at a fraction of the cost, time, and effort.

# X7FE Details



## All-in-One System

Printer pack with all the materials, replacement parts, and tools needed for months of deployment in the harshest environments.

## Quick Deployment

Go from packaged to printing in under three minutes. The fully loaded system weight of 188 lbs is designed for two-person lift.

## Mobile Power Source Compatibility

Solar panels can be used to ensure you'll always have the power required to print parts, no matter where you are in the world.

# FX20™

FX20 is a high-temperature, large format 3D printer that utilizes composite and Continuous Fiber Reinforcement (CFR) technology to produce parts that thrive in some of the most demanding environments— from sea to air. FX20 prints bigger and hotter than any other Markforged 3D printer. Whether your needs are high-temp tooling or mission-critical parts, FX20 can deliver quality, high performance solutions quickly.



# FX20 Details

## Massive Builds, Fast

The FX20 pairs size and throughput to print huge builds at incredible speeds, enabling users to get large, functional parts in hand next day.

## Functional Parts from Factory to Flight

Built for everything from performance tooling and fixtures to flight-ready production parts — the FX20 can print with both high temperature materials and continuous fibers.

## Production Ready Performance

A precision-designed, sensor-driven machine delivers breakthrough reliability and performance with a simple user experience.





# FX10™

FX10 is the first industrial metal and composite 3D printer — the product of years of engineering innovation and technological advancement. Built on the success of the Markforged X7 and Metal X, FX10 quickly delivers strong, accurate tools and fixtures for your operation.

FX10 features a modular print system that enables users to swap between metal and composite print engines quickly. All FX10s have composite and Continuous Fiber Reinforcement (CFR) technology, with metal capability as a purchasable add-on. Printhead-mounted optical sensors can verify the dimensional accuracy of parts and assess device health and performance. FX10 utilizes automatic calibration and material changeover, yielding a simple, low-touch user experience that mitigates the need for dedicated operators.

# FX10 Details

## Unlock strong parts on demand

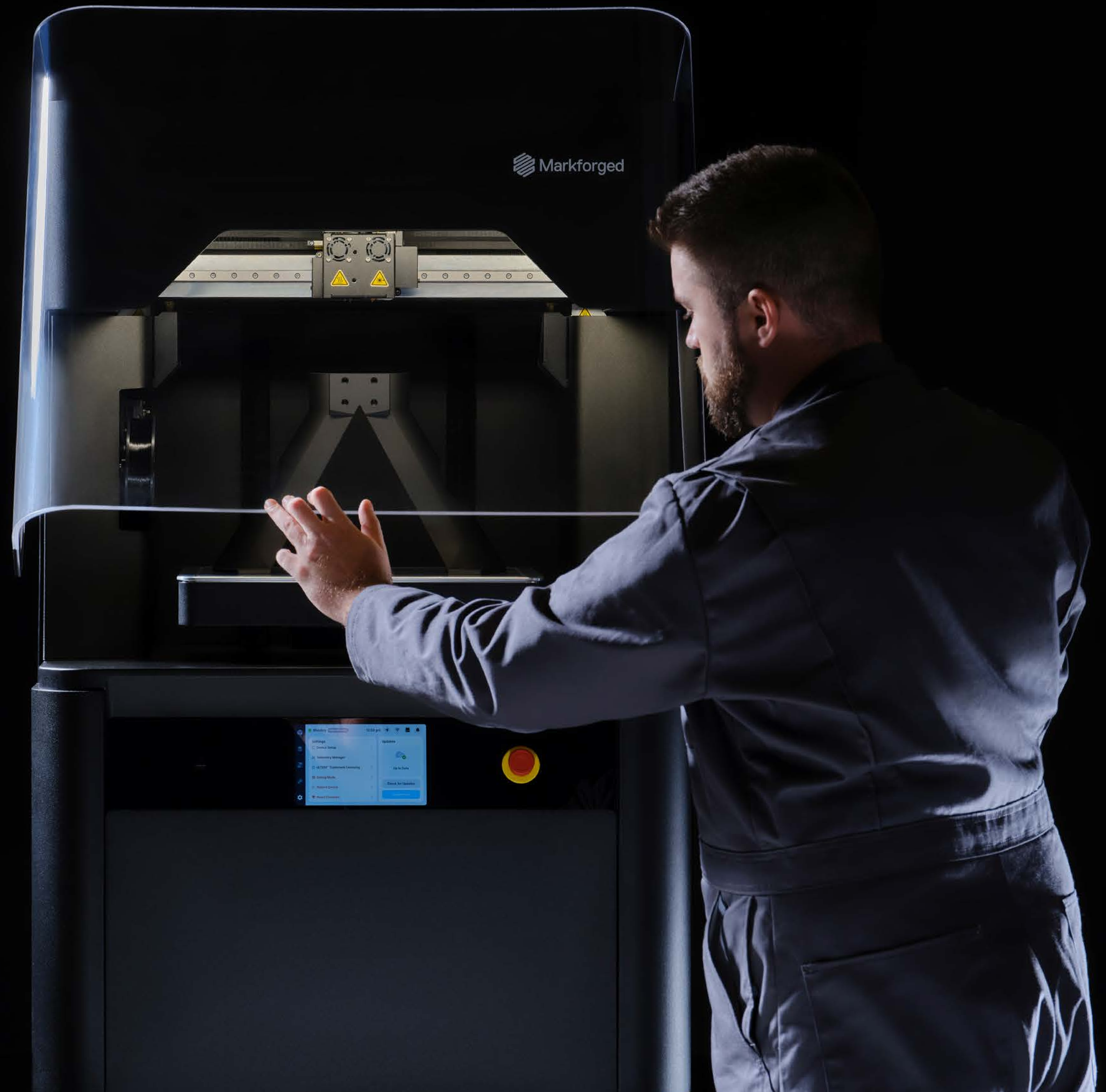
FX10 prints both metal and continuous carbon fiber reinforced parts for a wide range of defense applications — helping users get essential parts faster, reducing the cost of replacement parts from manufacturers and de-risking downtime events.

## Print the right part every time

We designed every aspect of FX10 — from its motion system to the software that powers it — around delivering accurate, strong parts, reliably. It's a printer you count on when it matters most.

## Drive usage fast, then scale

FX10 operates on the Digital Forge: Markforged's additive platform that features intuitive device and desktop software, training, and built-in cost calculation. New warfighters can adopt quickly, and effortlessly scale machines to more units and bases.



# Navy Strong Parts, made possible by CFR

## What is Continuous Fiber Reinforcement (CFR)?

CFR is a proprietary Markforged process that enables 3D printers to reinforce Fused Filament Fabrication (FFF) parts with continuous fibers. A CFR capable machine uses two extrusion systems: one for conventional FFF filament, and a second for long strand continuous fibers.

Continuous fibers are laid down in-layer, replacing FFF infill. Resulting parts are significantly stronger (up to 10 times stronger than any FFF material), and can replace aluminum parts in-application.

Continuous fiber-reinforced parts boast high stiffness and tensile strength at a far lower relative density than steel and aluminum. Due to the very high strength-to-weight ratio, CFR is often used for defense, aerospace, and other demanding applications.

## Benefits of using Continuous Fiber Reinforcement include...

### **Stronger Parts**

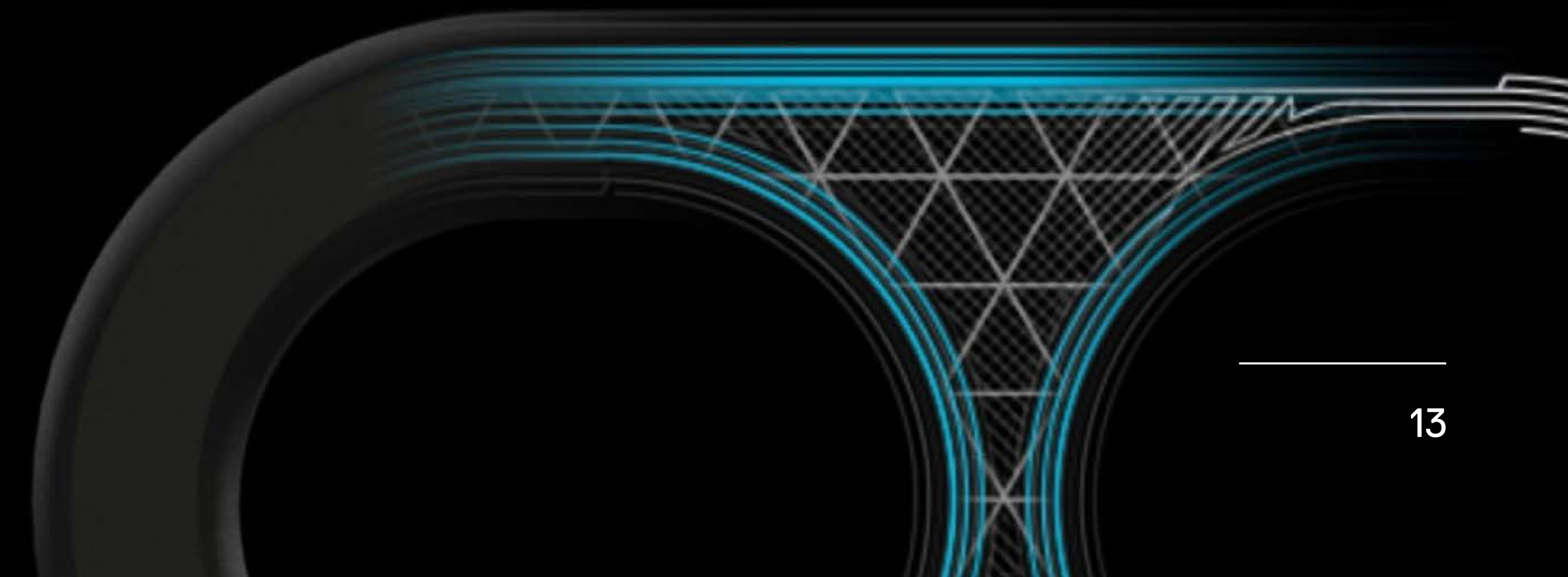
CFR enables you to dynamically alter the strength of parts from plastic strength to aluminum strength. This enables users to design and 3D print parts as strong as needed.

### **Durability**

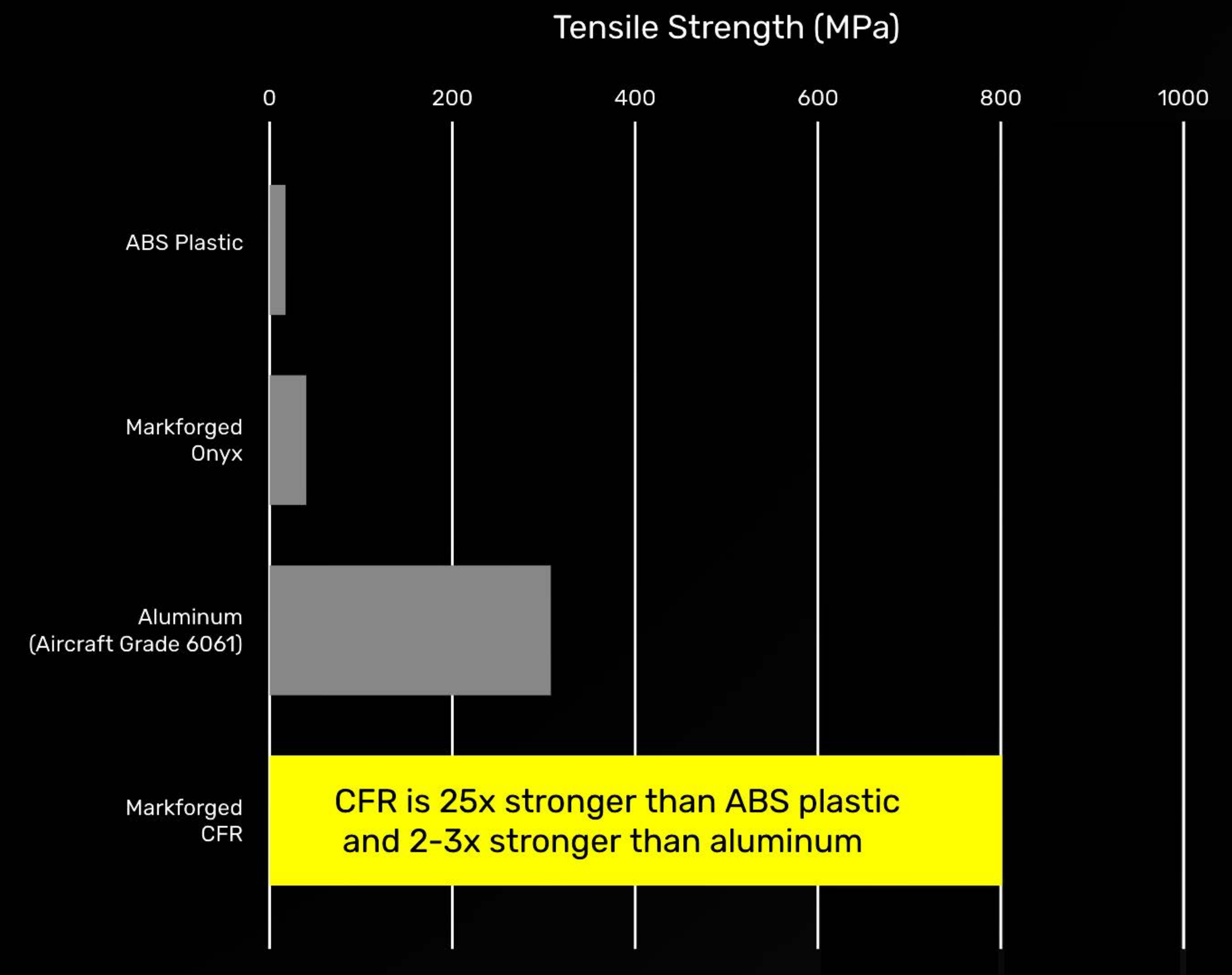
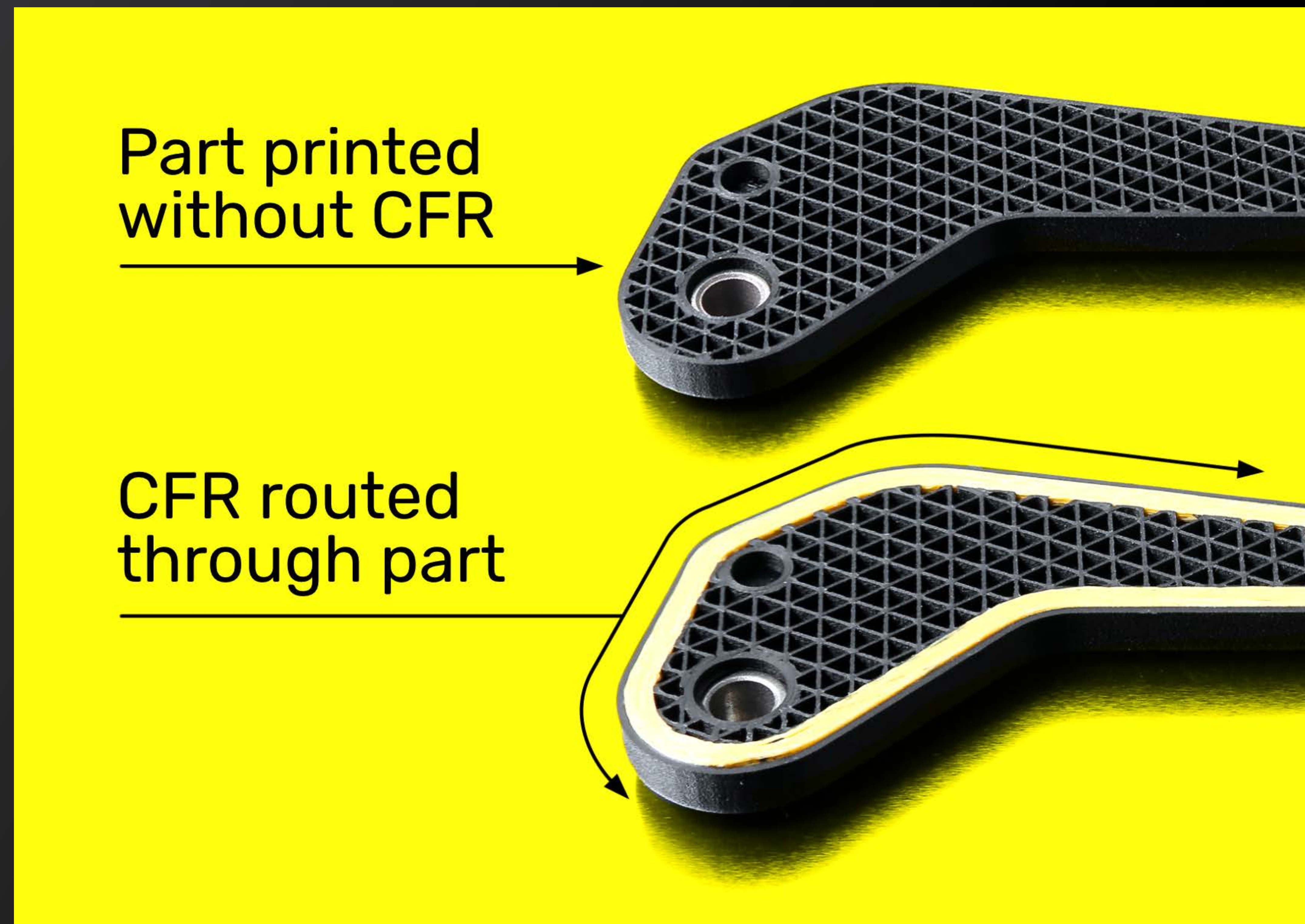
CFR parts last longer than any other FFF 3D printed parts in application due to the strength, stiffness, and durability of the continuous fibers. In addition, filled plastics boast high wear resistance and toughness.

### **Resistance to Heat and Chemicals**

CFR parts can resist ambient heat in most environments, and the short fiber filled filaments they reinforce are extremely chemically resistant.



Patented Continuous Fiber Reinforcement (CFR) technology enables users to replace metal with our solution.



# High Temp Composites

## ULTEM™ 9085 Filament

ULTEM™ 9085 Filament is an ultra high-performance PEI thermoplastic. A well-known material in aerospace & defense, ULTEM™ Filament is an extremely durable thermoplastic that exhibits excellent flame, smoke, and toxicity (FST) characteristics.

## Vega™

Vega is Markforged's first engineered high temperature plastic — an ultra high-performance carbon fiber filled PEKK for 3D printing aerospace & defense parts. It is compatible with high temp continuous fiber reinforcement (CFR) to achieve aluminum strength for replacing structural, non-critical components. It exhibits a smooth black matte surface finish that is excellent for production parts with minimal post processing.

Designed specifically for the FX20, Vega offers high flame, smoke, and toxicity (FST) resistance as well as chemical and solvent resistance, and low outgassing. Vega offers exceptional stiffness and strength, bringing substantial advantages in weight reduction and production time.



# High Temperature Material Properties

Physical Properties	Unit	Test	Ultem 9085™ Filament XZ Orientation	Test (ASTM)	Vega XZ Orientation	Test	Carbon Fiber HT-A
Tensile Strength	MPa (ksi)	D638	68 (9.9)	D638	88 (13)	D3039	800 (116)
Tensile Modulus	GPa (ksi)	D638	2.52 (365)	D638	5.2 (725)	D3039	69 (10,005)
Elongation at Break	%	D638	5.5	D638	3	D3039	1.6
Flexural Strength	MPa (ksi)	D790	105 (15.2)	D790	140 (20)	D790	529.7 (76.8)
Flexural Modulus	GPa (ksi)	D790	2.45 (355)	D790	4.7 (681)	D790	53.3 (7,730.5)
Flexural Extension at Break	%	D790	—	D790	5.2	D790	1.1
Compressive Strength	MPa	D695	—	D695	221	D695	300 (43.5)
Compressive Modulus	GPa	D695	—	D695	4.1	D695	59 (8,557)
Notched Izod Impact Resistance	J/m	D256-10 A	70 (1.3)	D256	48	D256	810 (15.2)
Density	g/cm <sup>3</sup>	—	1.27	—	1.27	—	1.2
HDT (1.8 MPa)	deg C (deg F)	D648 B	175 (347)	D648	157 (315)	—	190 (374)
HDT (0.45 MPa)	deg C (Deg F)	D648 B	173 (346)	D648	164 (327)	—	190 (374)

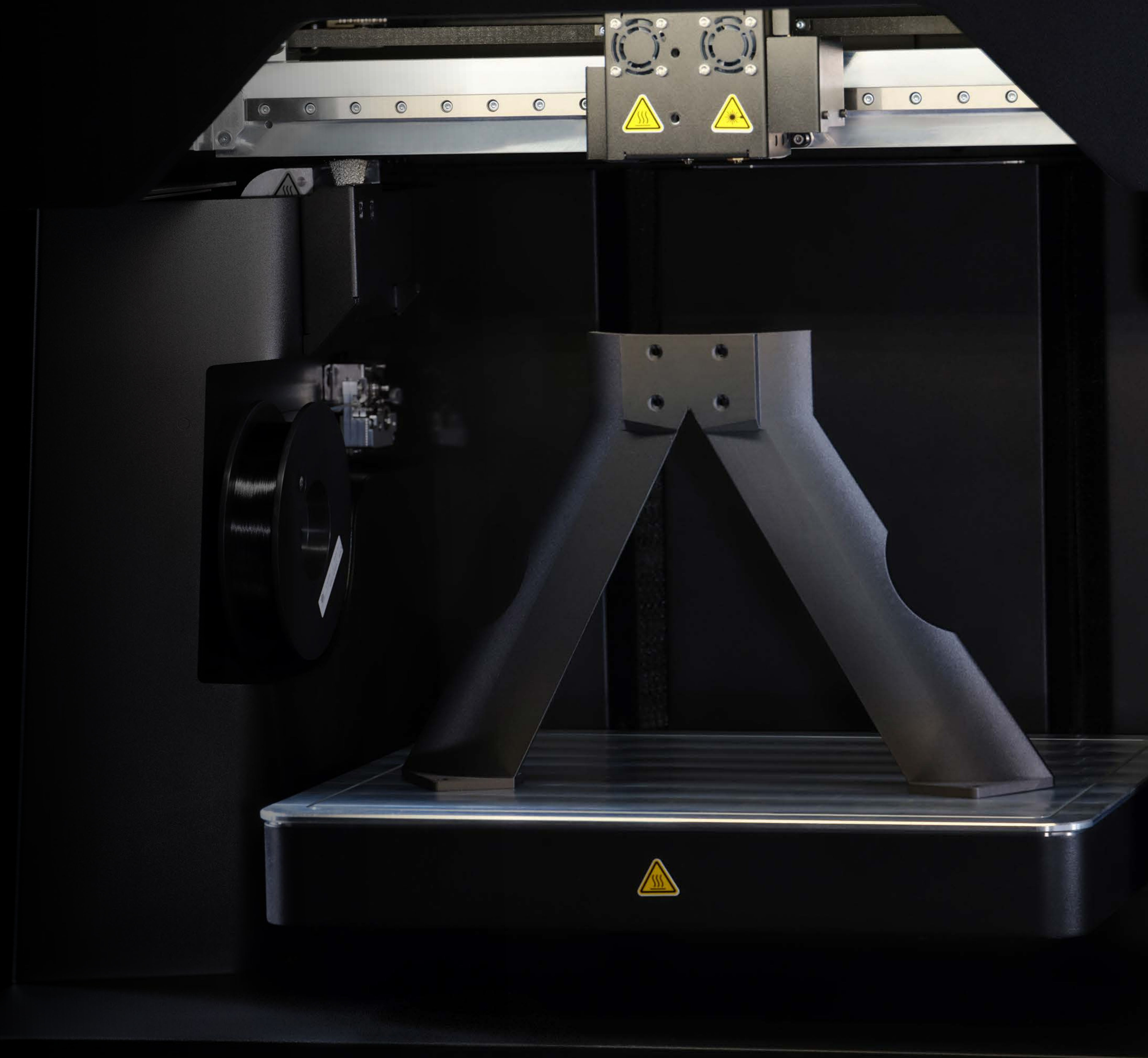
# FX10 Metals

## 316L Stainless Steel

316L is a low-carbon stainless steel widely used across manufacturing. Possessing good strength and toughness paired with excellent corrosion resistance, 316L is commonly used for naval and marine applications, aircraft parts, and medical gear. Markforged 316L is only available on FX10.

## 17-4 Stainless Steel

17-4PH Stainless Steel is a multipurpose steel used for specialized tooling, armored vehicle parts, and military-grade fasteners. Heat-treatable to 36 HRC and possessing 95% wrought strength, Markforged 17-4PH enables you to print high-strength, robust metal parts for a wide variety of applications.



# Security Focus

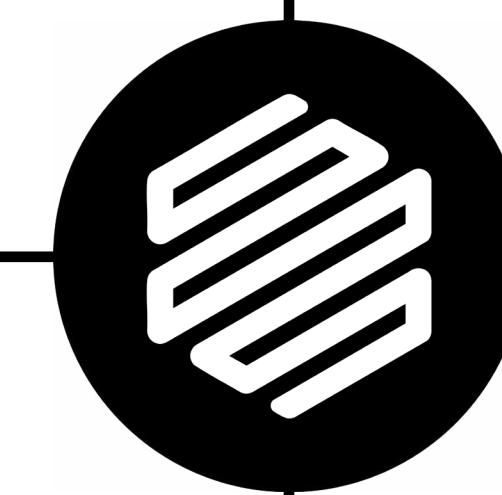


## ISO 27001 Certified

First AM vendor to achieve certification for ISO/IEC standards-based information security policies and practices backed by a dedicated security team to ensure customer data privacy, confidentiality, integrity and availability.

## Strict Data Security

Encryption of customer part data at rest and in transit and encryption and tamper resistant protection of print files to prevent unauthorized access and changes to and printing of print files.



## Secure Online or Offline Operation

Secure part slicing, storage and printing to connected printers using cloud-based Eiger or Offline Eiger software operating on private systems and networks without cloud connection.

## STIG-Compliant OS

All printers feature a STIG-compliant operating system that adheres to strict government security guidelines for use in DoD and similar environments.

# Markforged University

Like the Navy, Markforged understands the importance of training. Markforged University is a comprehensive training program that accelerates mastery of Markforged Composite and Metal 3D printing technology, enabling you to realize the full potential of your technology investment and ensure successful adoption.

## Maximize Impact

Learn how to identify which high risk parts can be printed to improve operational readiness.

## Accelerate Additive Adoption

Realize the full potential of your investment faster and shorten the amount of time it takes to get new warfighters up and running.

## Built On Experience

Advanced design for additive manufacturing techniques based on field knowledge and proven workflows for best outcomes.



The logo consists of a stylized, white, three-dimensional-looking symbol on the left, composed of several parallel, slightly curved lines that form a shape reminiscent of a gear or a stack of plates. To the right of this symbol is the word "Markforged" in a clean, white, sans-serif typeface. The entire logo is set against a dark, gradient background that transitions from black on the left to a light blue on the right.

Markforged