formlabs

Rapid SLS Production of High Performance Parts with the New Fuse 1+ 30W

SPEAKER

Linus Häggblom

Agenda

1. **Introduction**
   - Who is Formlabs?
   - What is SLS?

2. **Fuse 1+ 30W**
   - Product Overview
   - Additional Features
   - Use Cases & ROI

3. **Materials**
   - Overview
   - Material Properties & Applications
   - Workflow & Safety

4. **SLS Case Studies**

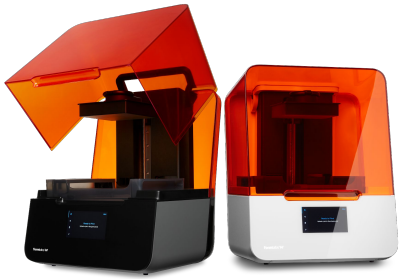
5. **Q & A**

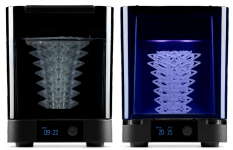
Introduction


We create reliable, accessible 3D printing
systems for professionals.

Formlabs Products

Formlabs designs and manufactures professional 3D printing **hardware**, **software** and **materials** for prototyping and production. Below is Formlabs current hardware lineup.





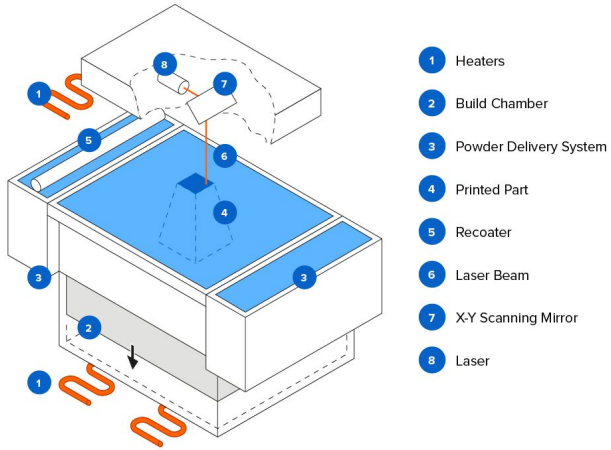
Stereolithography (SLA)

Selective Laser Sintering (SLS)

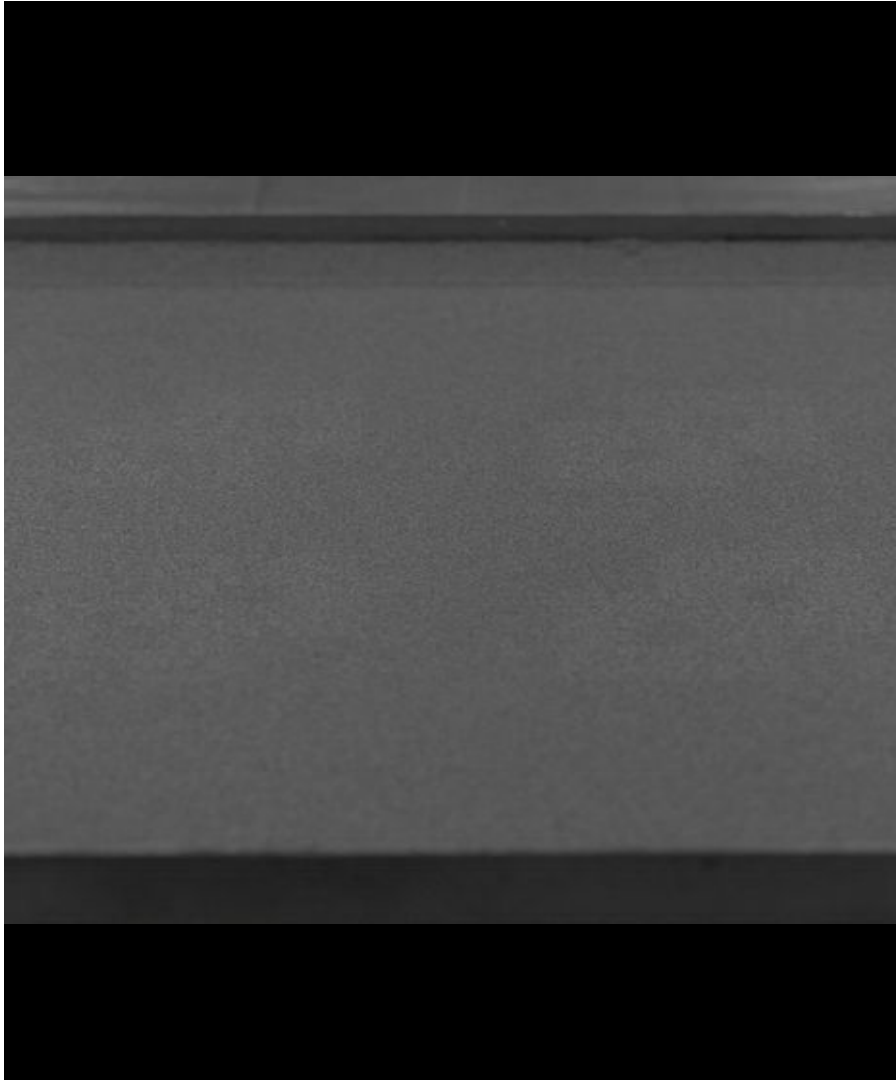
What is SLS?

Selective Laser Sintering (SLS)

An additive manufacturing process that uses a high-powered laser to precisely fuse together nylon powder into lightweight, robust parts.



1. Heaters
2. Build Chamber
3. Powder Delivery System
4. Printed Part
5. Recoater
6. Laser Beam
7. X-Y Scanning Mirror
8. Laser



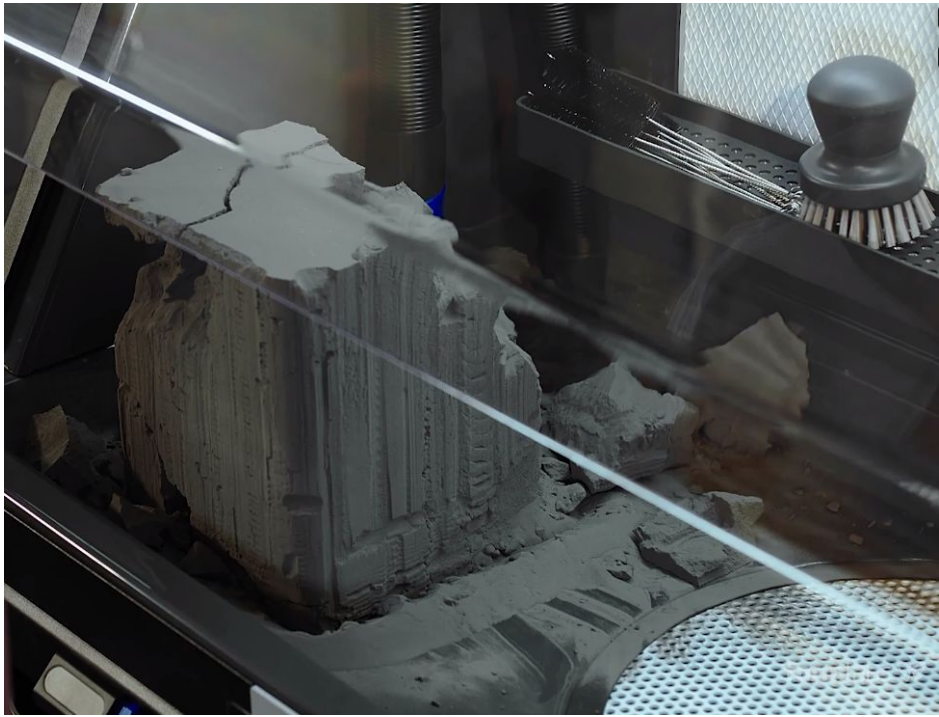
SLS Benefits

1. **Proven, end-use materials.**
   Nylon and its composites are proven, high-quality thermoplastics with mechanical properties comparable to those created with conventional manufacturing methods like injection molding.

SLS Benefits

2. Design freedom.

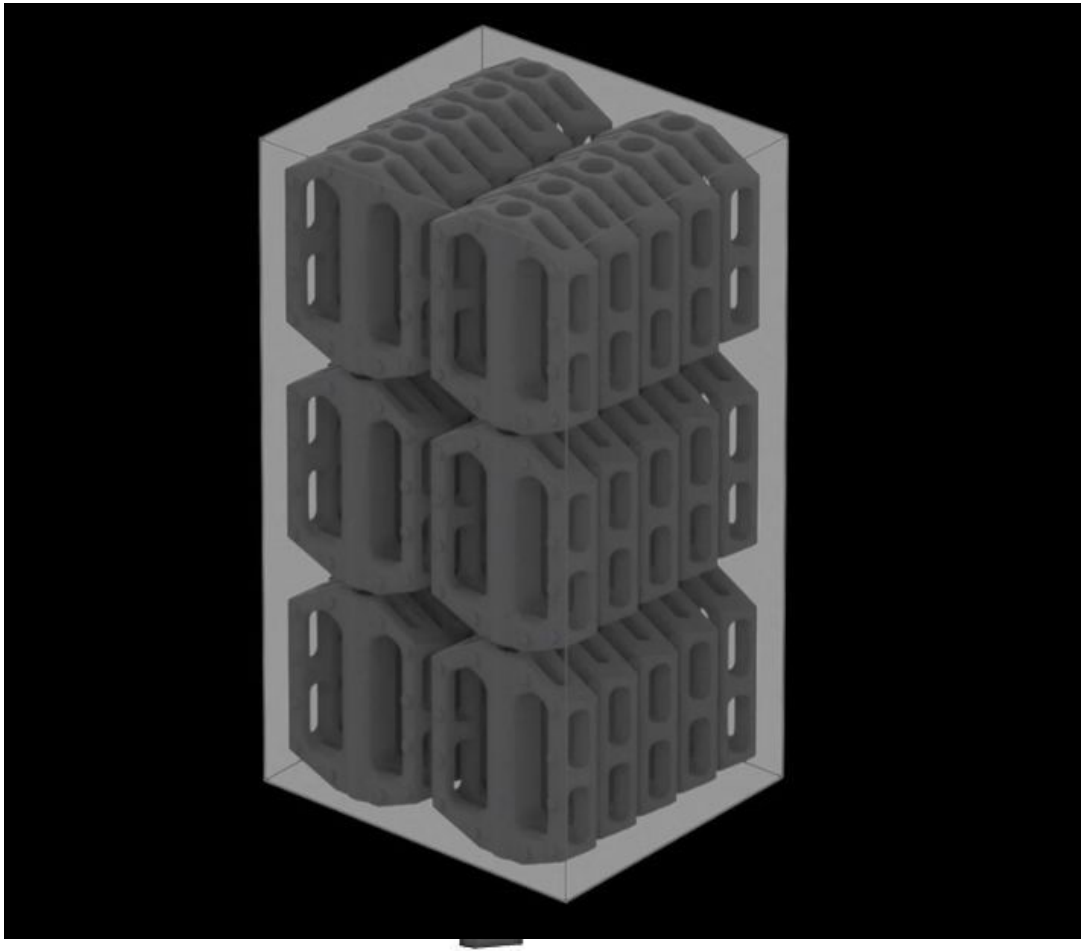
Parts are supported by the powder, so no supports are required, allowing for easy printing of overhanging features, intricate geometries, interlocking parts, interior channels, and other complex designs.



SLS Benefits

3. High productivity and throughput.

SLS printing is the fastest additive manufacturing technology for functional, durable prototypes and end-use parts. Many parts can be tightly arranged during printing to maximize the available build space.



SLS Benefits

4. Low material costs.

Nylon is an affordable material, and most SLS systems allow for printing with recycled powder to minimize waste.

SLS Use Cases

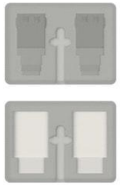
IDEA ..... **PROTOTYPING** ..... **PRODUCTION**

Hobby applications

Basic prototypes

Dental models and indications

Castable patterns



Molds

Jigs and fixtures

Medical models

Enclosures

Functional prototypes

Production parts

FDM

SLA

SLS

Fuse

Fuse Series Product Line

HIGH PERFORMANCE SLS 3D PRINTERS FOR ALL NEEDS

Fuse 1

Our first professional SLS 3D printing solution.

Fuse 1+ 30W

Even greater capability than the existing Fuse 1.

Users with **high utilization**, need for **rapid turnaround**, or those with **greater material requirements**.

Fuse 1+ 30W

Product Overview

Truly Rapid SLS, For High-Performance Parts in Hours, Not Days.

SUPERIOR PRINT SPEEDS

INDUSTRIAL GRADE MATERIALS

STREAMLINED WORKFLOW

Superior Print Speeds

HARDWARE

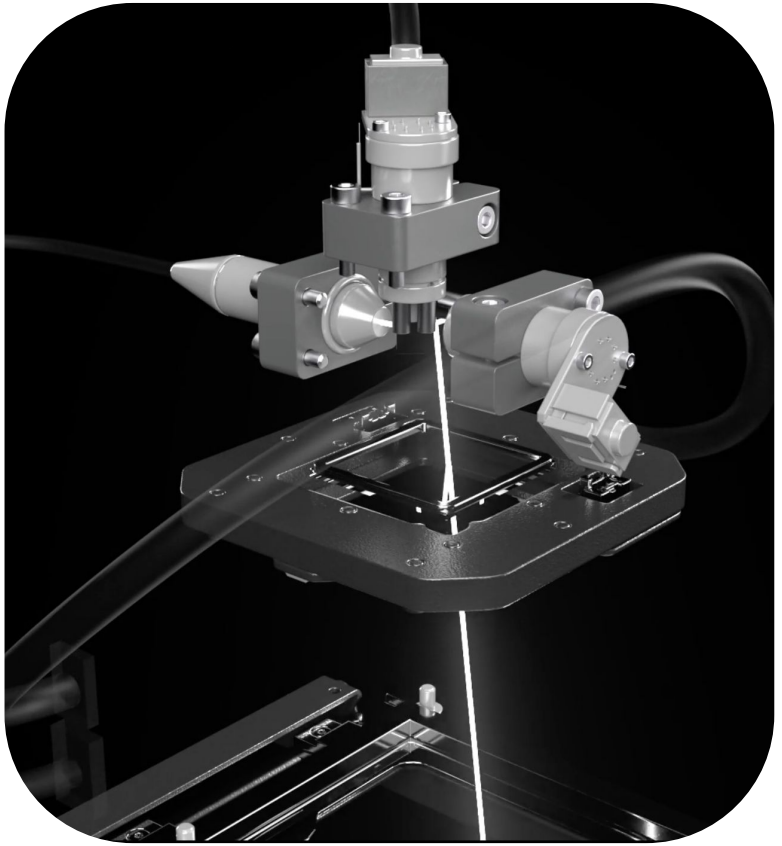
- 30W Ytterbium Fiber Laser
- Re-engineered Galvanometer System

ADVANTAGES

- Faster lasing for short layer times
- Scan speeds of up to 12.5 meters per second
- Print up to 2x faster than Fuse 1 with Nylon 12
- Future material and settings in development

VALUE

- Quick turnaround time for prototypes
- Higher-throughput for small series
- Most prints complete under 24 hours



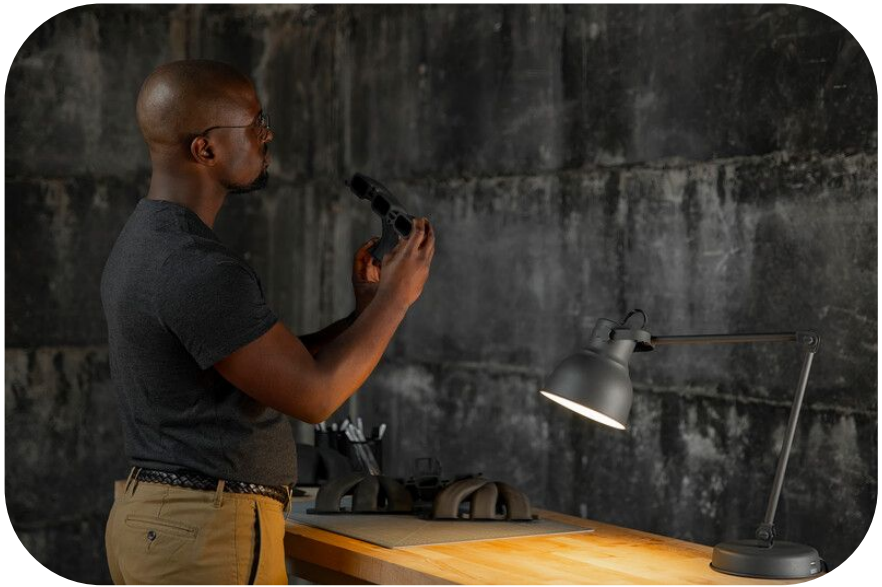
Industrial Grade Materials

NEW MATERIALS

- Exclusive access to Nylon 11 CF Powder
  - Composite carbon fiber filled powder
  - Our higher-performance SLS material
- Enabled by active powder handling
- More to come

ENHANCED MECHANICAL PROPERTIES

- Enhanced properties on existing materials
- Better ductility, decreased brittleness
- Most noticeable on Nylon 11-based materials
- Enabled by the nitrogen atmosphere



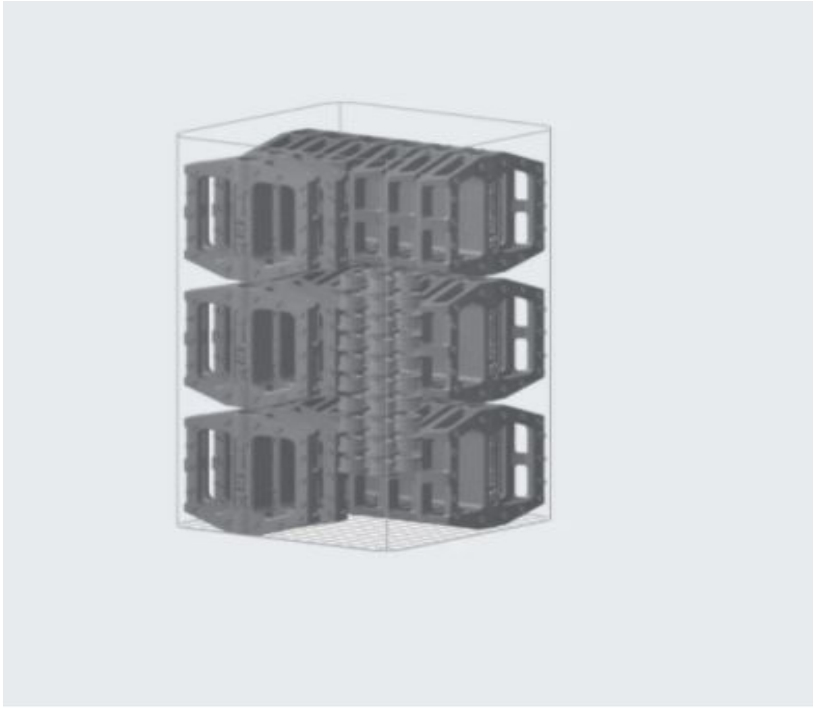
Reduce Waste When Printing

HIGH POWDER RECYCLABILITY

- Most materials print with only 30% fresh powder
- Improved recyclability on Nylon 11-based materials
- Enabled by the nitrogen atmosphere

HIGH PACKING DENSITY FOR FUSE SERIES

- Powerful packing algorithm
- Unrestricted packing density
- Maximization of the build volume



Product Comparison

FUSE 1 Accessible Benchtop SLS 3D Printer	FUSE 1+ 30W Rapid Benchtop SLS 3D Printer
Laser Type **10W Ytterbium Fiber** Reliable in-house capabilities	Laser Type **30W Ytterbium Fiber** Fast print speeds for same-day delivery
Material Compatibility **Core Material Range** Nylon 12, Nylon 11, Nylon 12 GF Powders	Material Compatibility **Full Material Range** Core Powders + Nylon 11 CF Powder
Print Environment **Air** One option, easy set-up.	Print Environment **Inert gas or Air** Enhanced material performance and recyclability
Efficiency **Low Waste Printing** High packing density	Efficiency **Zero Waste Printing** High packing density and improved recyclability

Additional Features

Powder Management

ACTIVE POWDER HANDLING

- Agitator at the bottom of the hopper
- Precise application during inter-layer recoating
- New materials

Inert Gas Atmosphere

NITROGEN ENVIRONMENT

- Optional: Fuse 1+ 30W can print with or without a nitrogen supply
- Exclusive to Fuse 1+ 30W
- Prevents material oxidation during printing

ADVANTAGES

- Superior and more consistent mechanical properties
- Low refresh rates and cost per part
- Most noticeable on Nylon 11-based materials

Nitrogen Recommendations

NITROGEN GENERATOR

We recommend using a nitrogen generator to supply Fuse 1+ 30W with nitrogen flow.

- **UX**: split nitrogen out of the air directly, no moving bottles in / out regularly
- **Plug-and-play**: generally only need a compressed air supply to operate
- **Safety**: No tip-over hazards like bottled nitrogen

BOTTLED NITROGEN

Suitable for limited use, but **not recommended for regular use.**

- **Print requirements:** A full build volume print may use over 2 x 50 liter cylinders of compressed nitrogen gas
- **Setup:** Requires nitrogen manifold and gas management system accommodating multiple cylinders to provide sufficient nitrogen supply for regular printing

Nitrogen Supply

REQUIREMENTS

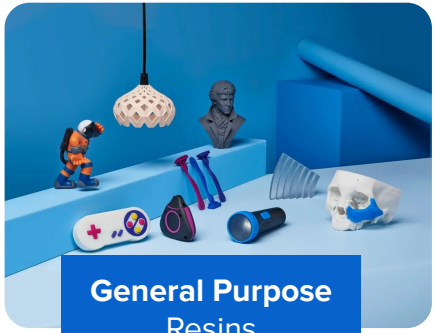
Need to accommodate the following requirements:

- **Concentration:** >=99.5%
- **Flow:** 0.5 SCFM
- **Pressure range:** 60-120 PSI
- **Gas temperature at machine inlet:** 18°C

Materials

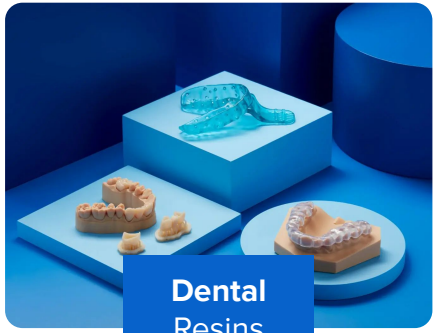
Materials Properties & Applications

Formlabs Material Library

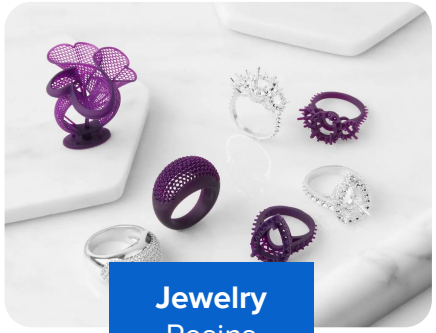


General Purpose Resins

Engineering Resins

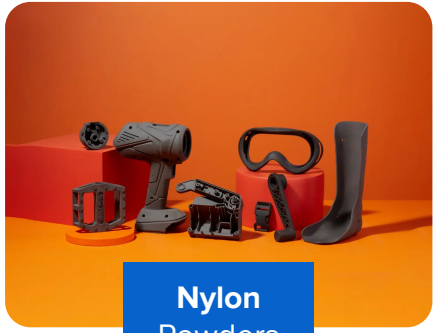


Dental Resins



Jewelry Resins

Medical Resins



Nylon Powders

SLA Material Library

GENERAL PURPOSE RESINS

White, Clear, Black, Grey

Color

Draft

Grey Pro

RIGID RESINS

Rigid 4000

Rigid 10K

TOUGH & DURABLE RESINS

Tough 2000

Tough 1500

Durable

FLEXIBLE & ELASTIC RESINS

Flexible 80A

Elastic 50A

SPECIALTY RESINS

High Temp

ESD

Ceramic

MEDICAL RESINS

BioMed Amber

BioMed Clear

DENTAL RESINS

Surgical Guide

Model

Permanent Crown

LT Clear

IBT

Denture

Custom Tray

Temporary CB

JEWELRY RESINS

Castable Wax

Castable Wax 40

Nylon 12
Powder

A Material That Does It All

Balancing strength and detail, Nylon 12 is our most easy to use, versatile SLS material.

Nylon 12: Applications

- High performance prototyping
- Small batch manufacturing
- Permanent jigs, fixtures, and tooling
- Biocompatible, sterilizable parts*

* Material properties may vary based on part design and manufacturing practices. It is the manufacturer's responsibility to validate the suitability of the printed parts for the intended use.

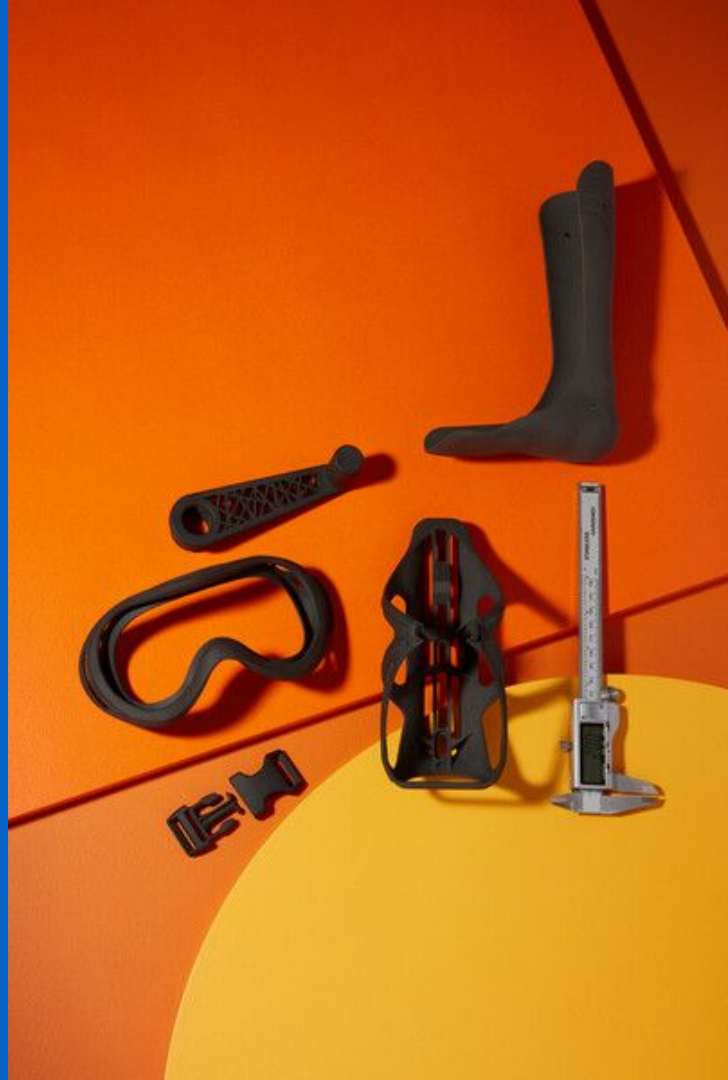
Nylon 11
Powder

High Performance, High Impact

Robust, ductile material for parts that need to bend or take impact.

Nylon 11: Applications

- Impact-resistant prototypes, jigs, and fixtures
- Thin-walled ducts and enclosures
- Snaps, clips, and hinges
- Orthotics and prosthetics*



* Material properties may vary based on part design and manufacturing practices. It is the manufacturer's responsibility to validate the suitability of the printed parts for the intended use.

Nylon 12 GF
Powder

For stiff, stable, functional parts.

High rigidity, dimensional
accurate, and thermally stable.

Nylon 12 GF: Applications

- Robust jigs and fixtures and replacement parts
- Parts undergoing sustained loading
- Threads and sockets
- Parts subjected to high temperatures

* Material properties may vary based on part design and manufacturing practices. It is the manufacturer's responsibility to validate the suitability of the printed parts for the intended use.

Nylon 11 CF Powder

Carbon Fiber SLS, For Strong And Lightweight Parts

- Chopped carbon fiber
- Superior strength to weight ratio
- High stiffness and stability
- Impact/vibration resistant
- Perfect for end-use applications

Nylon 11 CF Powder

Product Details

Compatibility	Fuse 1+ 30W only
Layer height	110 microns
Refresh rate	30% (Nitrogen)
Pricing	£849 (6KG Package)

Nylon 11 CF Powder Material Properties

Property	Value
Ultimate Tensile Strength (X/Y/Z)	69 / 52 / 38 MPa
Tensile Modulus (X/Y/Z)	5.3 / 2.8 / 1.6 GPa
Elongation at Break (X/Y/Z)	9 / 15 / 5 %
HDT @ 1.8 MPa	178 °C
HDT @ 0.45 MPa	188°C
Vicat	~190 C
Refresh Rate	30% in N2, 50% in Air
Flexural Modulus	4.2 GPA
Flexural Strength	110 MPa

Nylon 11 CF Powder Properties

USE THIS MATERIAL FOR PARTS THAT NEED TO BE

- Dimensionally stable parts under load
- High-impact or vibration resistant
- Stable at high temperature
- Strong and lightweight

Nylon 11 CF Powder Applications

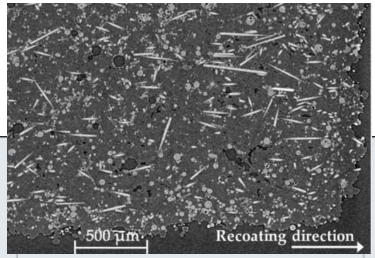
EXAMPLES

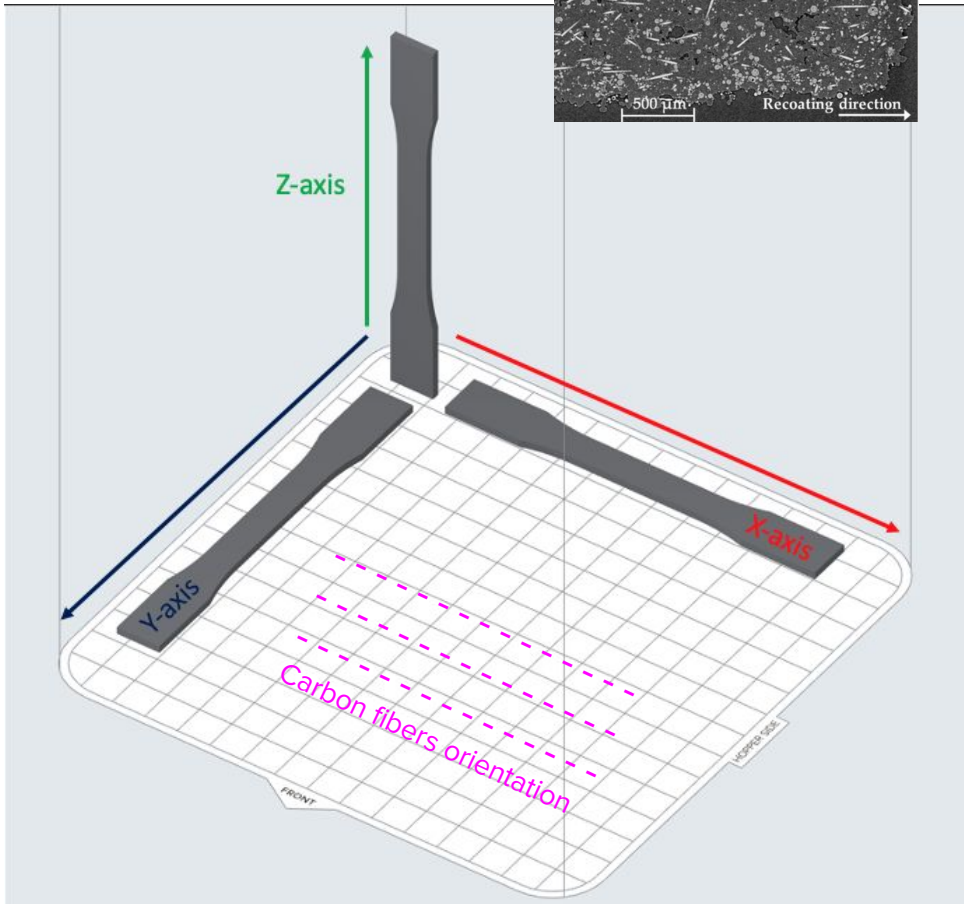
- Tooling, jigs, fixtures
- Casings, housings and enclosures
- Manifolds, aerodynamic components
- Composite prototypes
- Impellers, connectors
- Metal replacement parts

Orientation and Mechanical Properties

- Mechanical properties are directional and differ in each axis
- Carbon fibers aligned by the recoater, primarily along the x-axis

Materials	X	Y	Z
Tensile Modulus (MPa)	5300	2800	1600
Ultimate Tensile Strength (MPa)	69	52	38
Elongation at Break, (%)	9	15	5





Nylon 11 CF Workflow Sift 300 Sieve

NEW PRODUCT

300-micron sieve for the Fuse Sift

HOW TO USE IT

- Replaces the 150 micron sieve
- Required with Nylon 11 CF Powder
- User replaceable: simply unscrew the current sieve and screw the new one in

PRICE

$89.00 | €89.00 | £79.00 | 99.00 CHF

Safety with Nylon 11 CF Powder

Nylon 11 CF Powder pauses a risk of irritation for skin and mucous membranes.

We recommend users wear PPE to prevent skin contact:

- Gloves
- Long sleeves and pants or lab coat (ideally with elastic cuffs)
- Respiratory protection
- Safety glasses

Additional recommendations:

- Manage dust generation with adequate ventilation such as updraft, air-handling, and vacuum during pouring / mixing / unpacking.
- Ensure that contaminated surfaces are cleaned to prevent accidental skin contact.

Refer to the Nylon 11 CF Powder SDS for safety requirements

Formlabs Product Comparison: Nylon Powders

Nylon 11 CF Powder

- High stiffness and dimensional stability
- Vibration / Impact Resistance
- Great strength-to-weight ratio
- High thermal stability

Nylon 12 GF Powder

- High stiffness for static applications
- Thermal Stability
- High dimensional accuracy and low warpage

Nylon 12 Powder

- Great printability
- Balanced stiffness/ductility
- Good surface finish
- High dimensional accuracy
- Biocompatibility

Nylon 11 Powder

- High Ductility
- Robustness for impact/vibration
- Biocompatibility

Stiff **Ductile**

Overview SLS Powders

Property	Nylon 11 CF	Nylon 12 GF	Nylon 12	Nylon 11
Stiffness	★★★★★	★★★★☆	★★☆☆☆	★☆☆☆☆
Ductility	★★☆☆☆	★☆☆☆☆	★★★☆☆	★★★★★
Thermal Stability	★★★★★	★★★★☆	★★★☆☆	★★☆☆☆
Impact Resistance	★★★☆☆	★☆☆☆☆	★★☆☆☆	★★★★★
Refresh Rate	30% (N2) 50% (air)	30-50% (air)	30% (air)	30% (N2) 50% (air)
Price	$999	$649	$599	$699

Workflow

PRINTING NYLON 11 CF POWDER WITH THE FUSE SERIES WORKFLOW

Preparation

CAD Design
PreForm

Setup

Prepare Printer
PPE

Printing

Sensors and video
feed monitoring

Depowdering

Fuse Sift
300-micron sieve

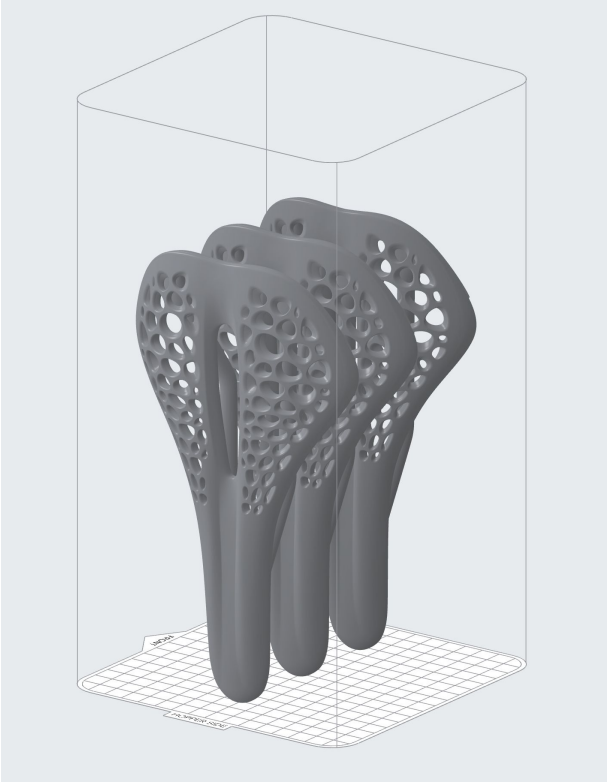
Post-processing

Media Blast
Paint, Coat

Print Times

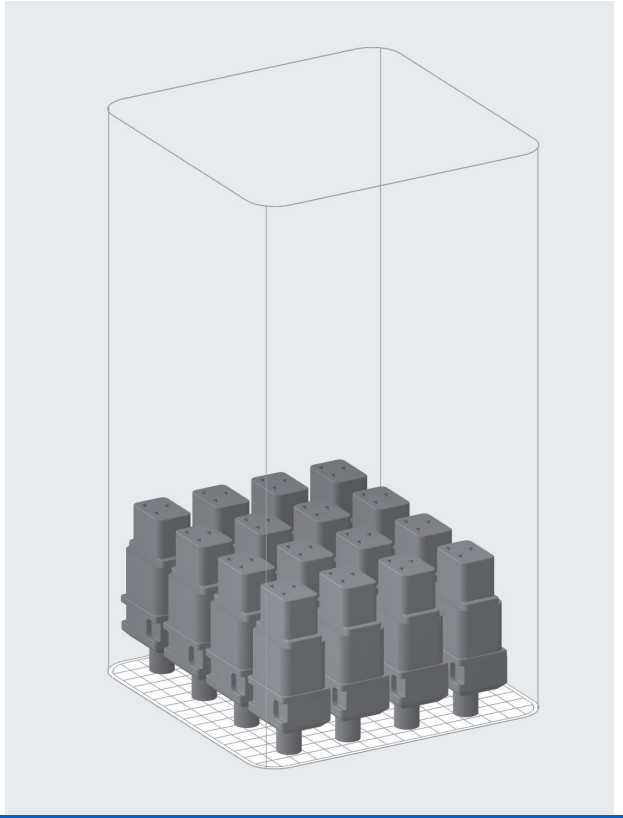
Bike Seat

	FUSE 1	FUSE 1+ 30W	
Material	Nylon 12		
Packing Density	9%		
Model Material	0.35 kg		
Layers	2101		
Print Time	18 hr 22 min	14 hr 1 min	-24%



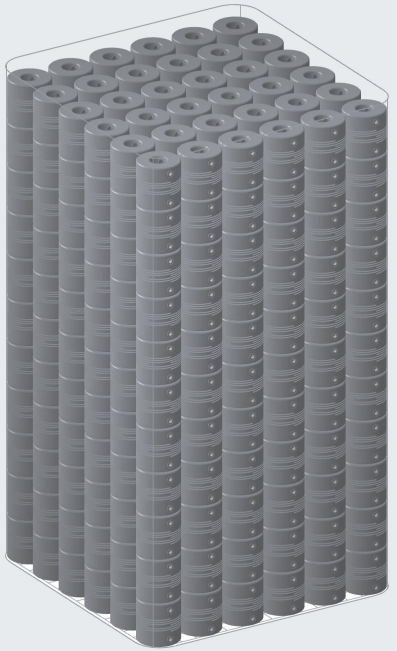
IEC Connector

	FUSE 1	FUSE 1+ 30W	
Material	Nylon 12		
Packing Density	49%		0 waste printing
Model Material	0.93 kg		
Layers	780		
Print Time	14h 16mn	8h 42mn	-39%



Shaft Coupling

	FUSE 1	FUSE 1+ 30W	
Material	Nylon 12		
Packing Density	58%		0 waste printing
Model Material	3.96 kg		
Layers	2669		
Print Time	66h 19 mn	32h 59mn	-50.2%



Thank you!

Use Cases

Vital Auto

Concept Cars

Vital Auto leads in **custom car development**, benefitting from the design freedom, compressed turnaround times and high throughput available with cost-effective 3D printing. Interior auto parts are printed using the **Form 3L** for material versatility and scale while structural mechanical parts with complex geometries are built quickly and flawlessly in the **Fuse** 1.

3D printing is attracting new business for Vital Auto as well, as customers want access to the newest technologies and have their parts fabricated using the latest cutting edge materials.

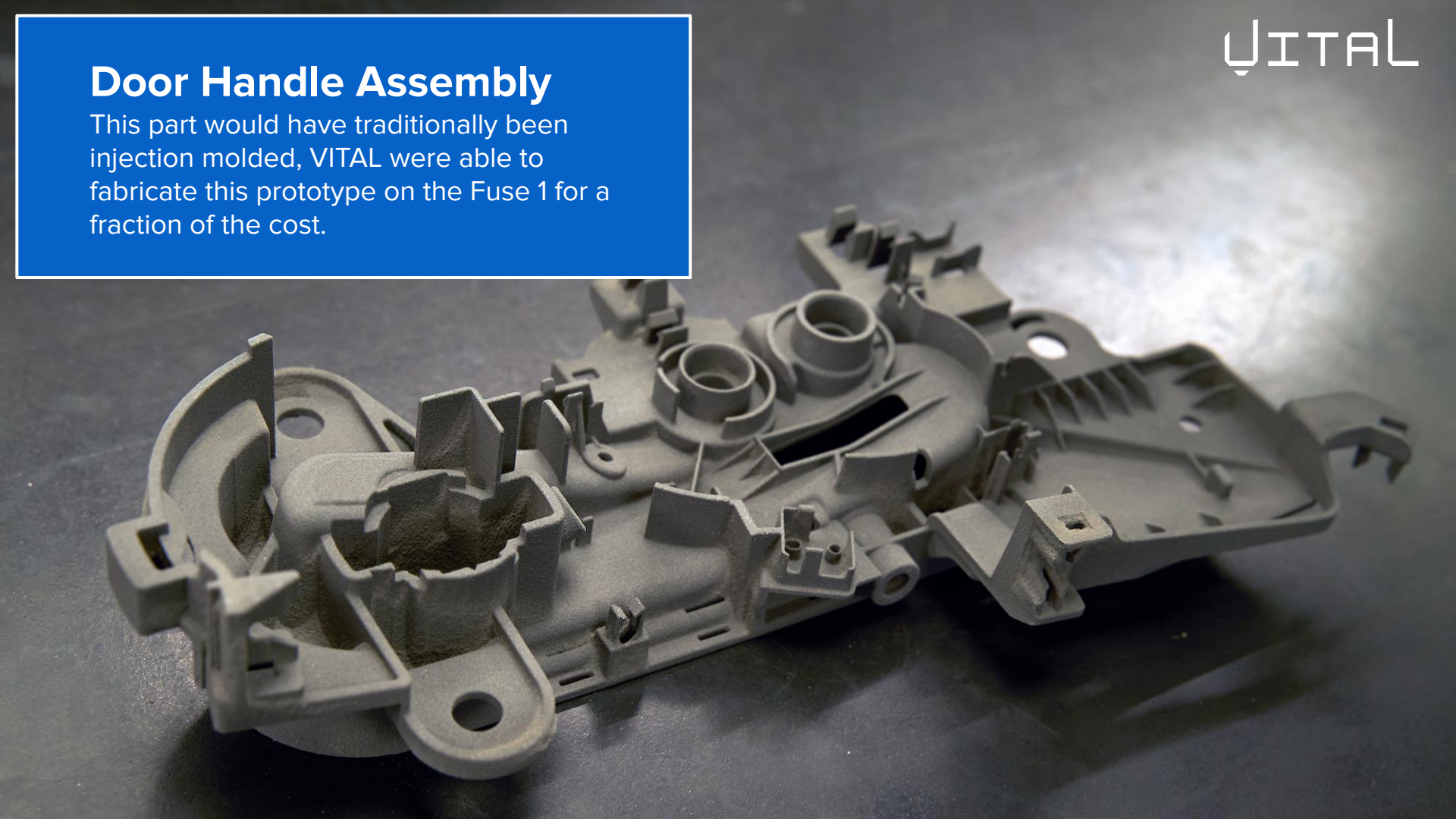





VITAL

Door Handle Assembly

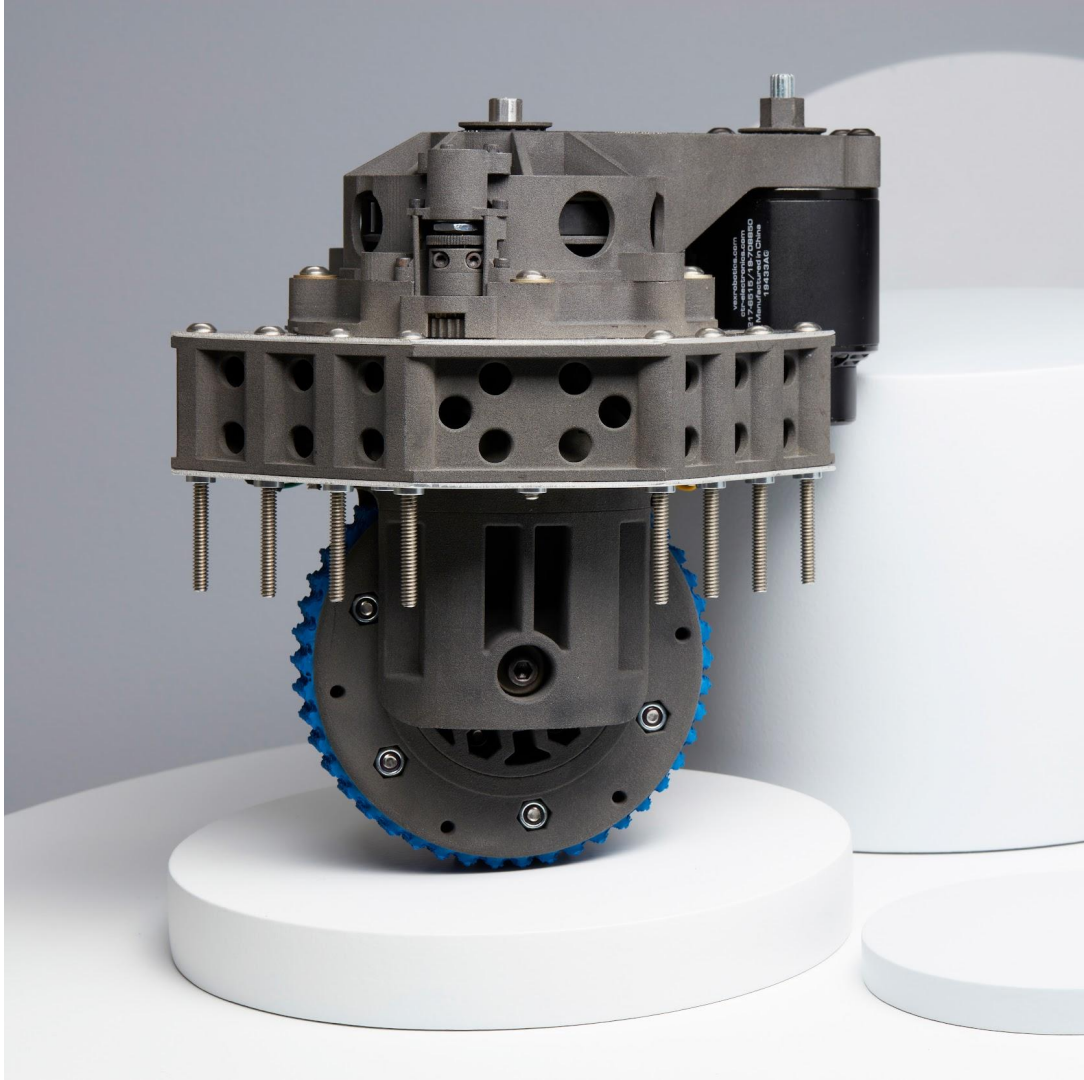
This part would have traditionally been injection molded, VITAL were able to fabricate this prototype on the Fuse 1 for a fraction of the cost.



Engineering

Take control of your entire product development process, from iterating on your first concept design to **manufacturing ready-to-use products.**

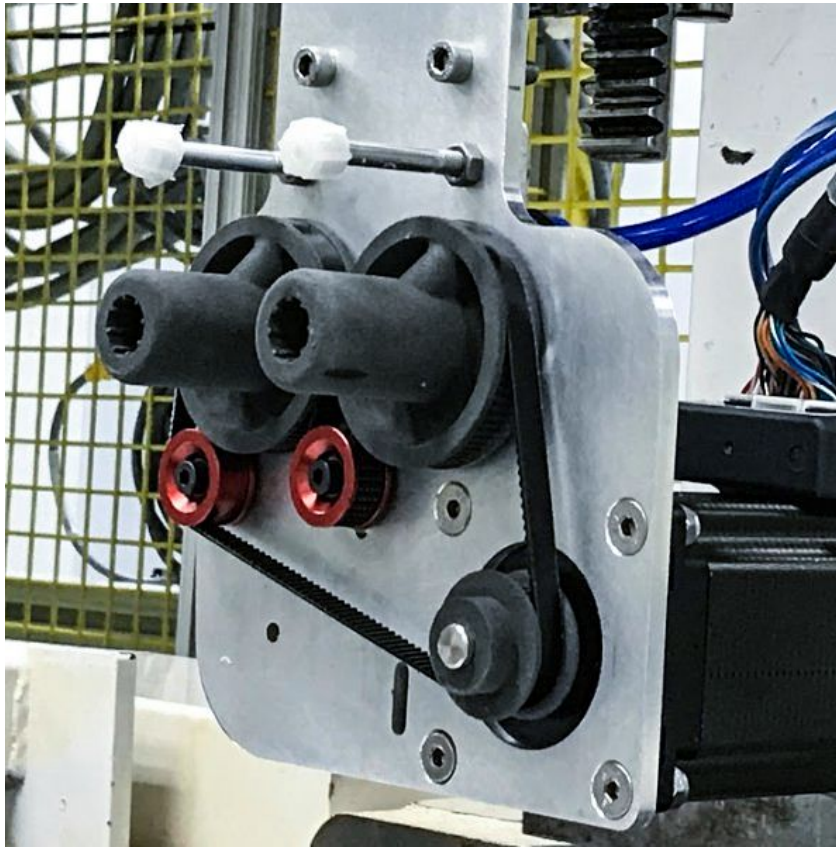
- Functional prototyping
- Rigorous functional testing of products (e.g: ductwork, brackets)



“ The custom pulleys printed last week are working well in production as functional parts. They have very delicate splines on the inside of the vacuum tooling that are holding up well unscrewing molded parts from the core. ”

Brian Anderson

“ Accuracy and durability on the pulley was impressive. ” →



brose
Excellence in Mechatronics

“In automotive, it is important that you deliver the highest possible quality at the best price possible. The Fuse 1 is the only small factor machine that actually works, as far as I know”

Christian Kleylein

Medical

Ready-to-use, patient-specific medical models and devices in-house

Medical

- Medical Device Prototyping
- Orthotic and Prosthetic Devices
- Biocompatible, sterilizable parts

Ankle Foot Orthosis →

Prothesia

Mexico + Massachusetts

“ Prothesia was born the day we met a kid that lost the chance of walking because his family couldn't afford ankle braces. **Combined with low-cost 3D scanning and design software, Fuse 1 enabled us to prototype incredibly fast and to bring the first orthotic devices to patients. The parts are lightweight, robust, and durable,** something very hard to achieve when designs are complex. **For the first time, patients can have personalized orthotic devices at a lower price than traditional orthoses.** ”

Francisco Valencia, Cofounder/CEO
Guillermo Herrera-Arcos, Cofounder

Partial Hand
SOLUTIONS, LLC

Partial Hand Solutions

Holliston, MA

Partial Hand Solutions is dedicated to advancing technology for amputees of all ages. Since the company's inception in 2007, they've provided functional solutions for many active soldiers and individuals with partial hand and finger amputations, along with children with more extensive prosthetic requirements.