Introduction to FDM 3D Printing

Agenda for Today

- Who is CAM Logic and how do we help our customers
- FDM technology and how it works
- Where does FDM fit in design/manufacturing
- How to operate and leverage a FDM 3D printer

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Who Is CAM Logic

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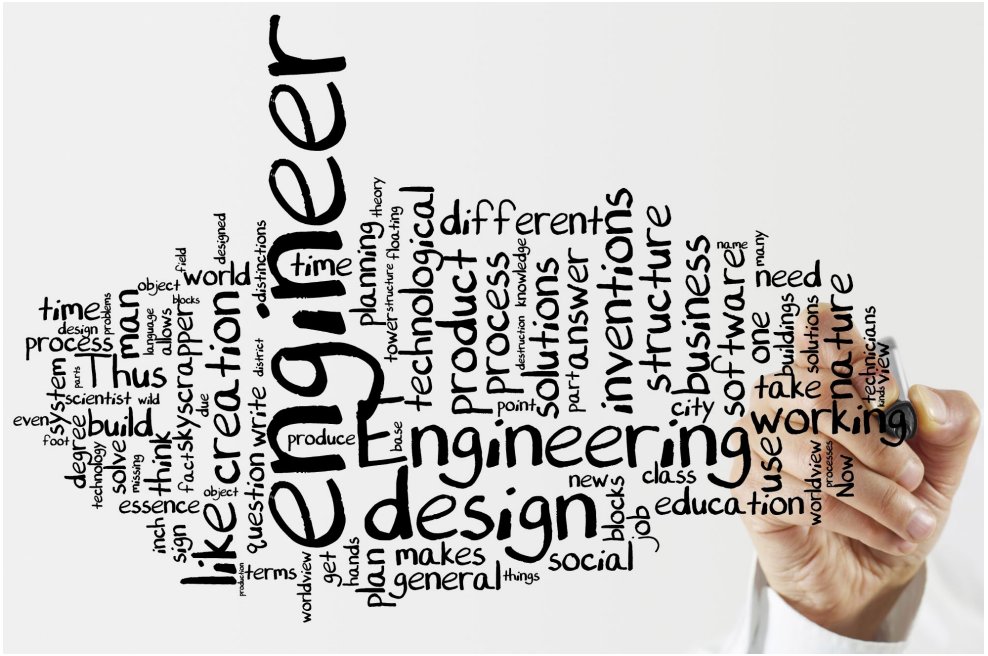
Struggles of the Manufacturing Engineer

Helping Resolving The Headaches of the Manufacturing Sector

- Will the project be done on time
- Will the project be done within cost
- What are the customers requirements
- This job has be done With Catia but we only have NX
- The job shop we send our work out to has our job delayed
- My teams not trained to do this job
- We don’t have the CAD data for this job
- We need (_____) but have no budget

Sound Familiar?



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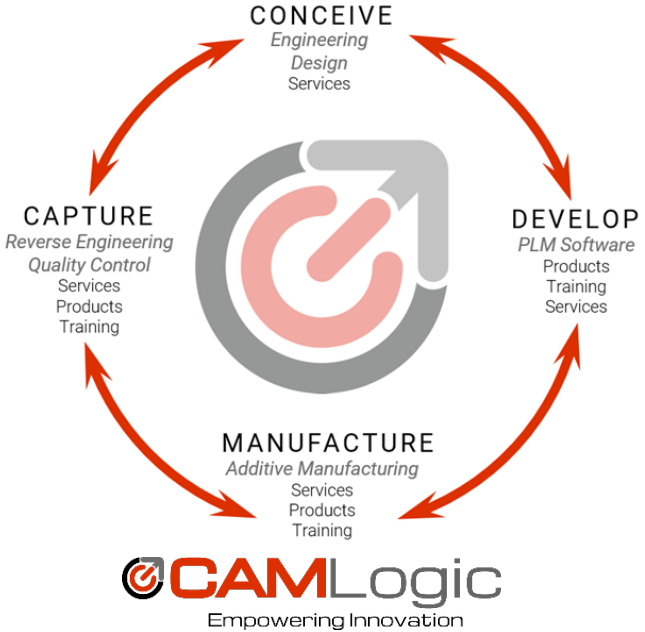
Introduction to CAM Logic

- *CAM Logic is a full services engineering solutions provider of software's and hardware's that enable our customers the ability to bring products to market in the most efficient and innovative way possible.*

PLM Software
SIEMENS
NX



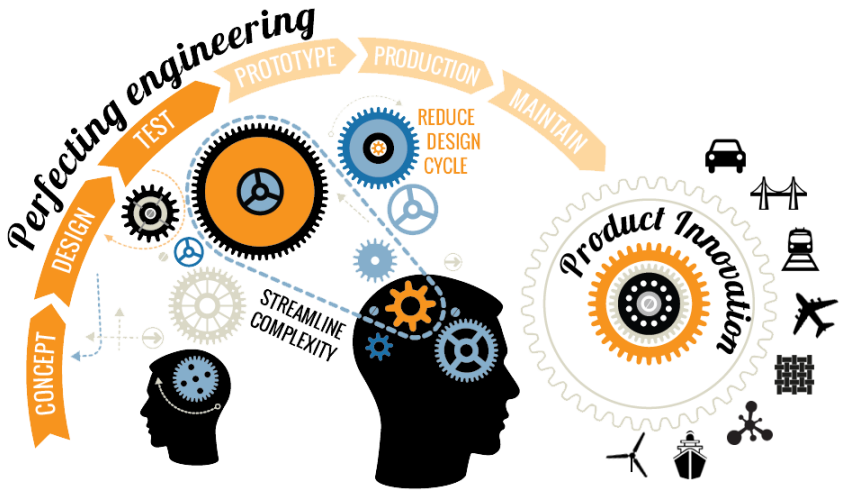
SOLID EDGE

ZEISS

Markforged

CAM Logic Supporting Manufacturing

- Headquartered in Oxford Michigan
- Siemens PLM Provider for Over 20 Years
- Additive Manufacturing Provider for Over 10 Years
- Scanning Solutions Provider for Over 10 Years
- Dedicated Applications Engineers for Each Product Line



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Additive Manufacturing

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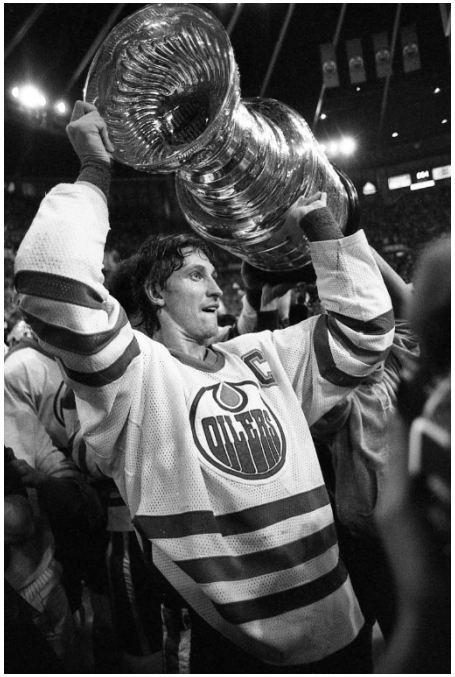
The Great One

"Skate to where the puck is going, not where it has been"

Wayne Gretzky



What does being proactive with your business mean for your bottom line?

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Traditional Manufacturing Processes

We Need to Make Something

Concept and Design

Prototype and Validate

Tooling

On to Mass Production

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Drivers for Change within Manufacturing

- Time to Delivery
- Innovation
- Cost Reduction

Results of Going Beyond Customers Expectations

Return Business from Customers

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Additive Technologies

FDM
Fused Deposition Modeling

Binder Jetting

SLA
Stereolithography

Additive manufacturing is the process of taking a CAD design and utilizing 3D printing hardware to build a part with plastic or metal material in a layer by layer process, thus “additive manufacturing”

SLS
Selective Laster Sintering

Polyjet

DLP
Digital Light Projector

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What is 3D Printing

3D printing is an additive manufacturing process that creates a physical object from a digital design. *According to 3D Hubs*

Commonly Referred As

Rapid Prototyping
Additive Manufacturing
3D Printing
Additive Fabrication
On Demand Tooling

Types of 3D Printing

Stereolithography
Polyjet
Selective Laser Sintering
Fused Deposition Modeling
Binder Jetting

Industry experts refer to 3D printing technology its self as "disruptive"

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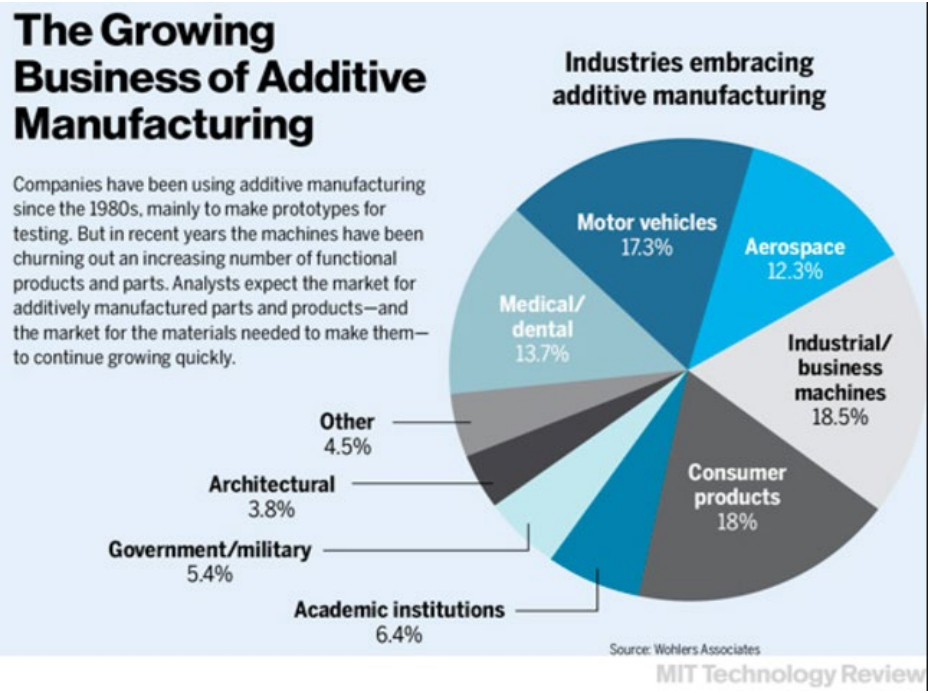
Projections in Growth



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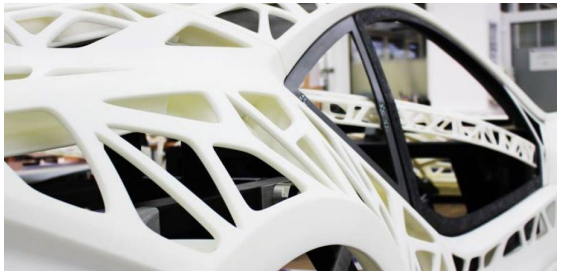
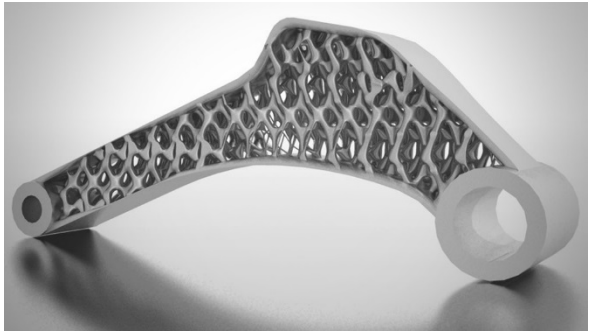
What Industries Benefit from Additive and Generative Design

- Aerospace and Automotive Large Adaptors of Technologies
  - Reduction of Weight Results in Greater Fuel Economy
  - Structural Integrity Critical to Parts
  - Lower Volume Production





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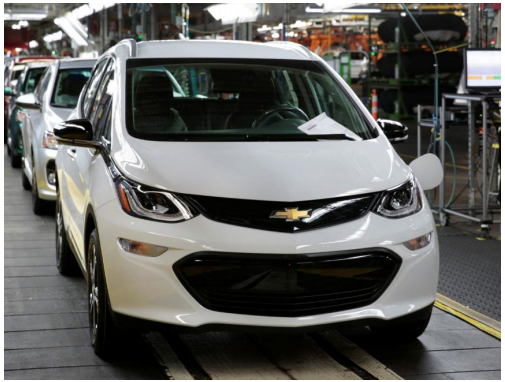
General Motor Printing lighter parts at lower costs

- Utilizing topology and generative technologies to produce lighter weight brackets in electric vehicles
- Designing for additive
- Can’t produce parts by traditional means
- Helping to meet GM plan to add 20 new electric battery and fuel cell batteries to its global lineup by 2023



Talking FDM 3D Printing

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FDM 3D Printing

Who: Scott Crump (founder of Stratasys)

When: 1989

What: A thermoplastic filament, which is heated to its melting point and then extruded, layer by layer, to create a three dimensional object*

Where: Middle School to John Deer, Ford, Boeing, & GM

Why: We are going to show you

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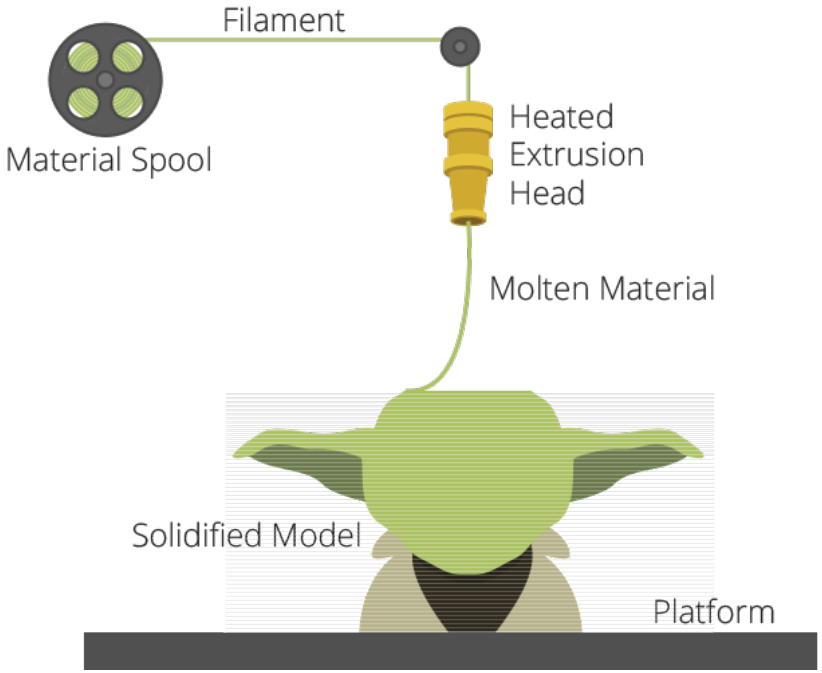
How Does FDM 3D Printing Work?

Mark II 3D Printer

Fused Filament Fabrication



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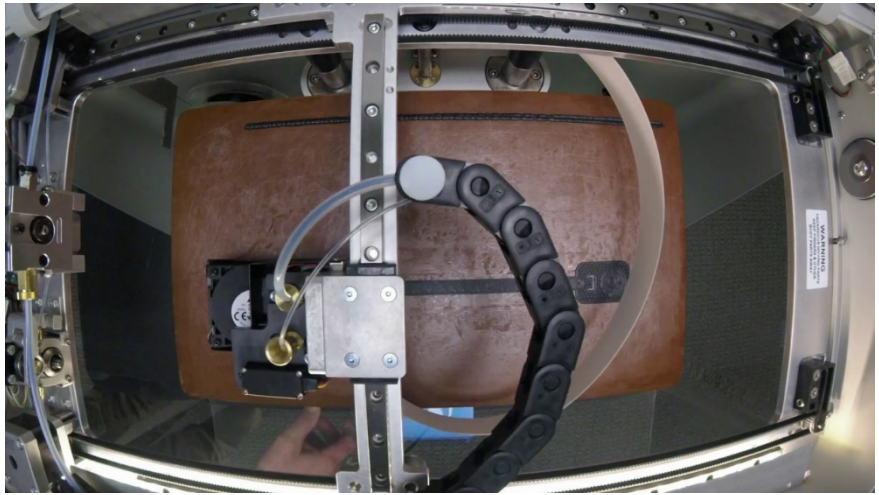
How Does FDM 3D Printing Work

Nylon | Fiber Glass | Carbon Fiber | Kevlar | Onyx



Overhead view of inside a Mark II

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Who is using 3D Printing

Type	Aerospace	Automotive & Other Transportation	Gov. & Defense	Consumer Product	Medical and Healthcare	Footwear Orthotics & Prosthetics	Academic
Customers	NASA, AIRBUS, SPACEX, GE, Cessna, Raytheon, NORTHROP GRUMMAN, BOEING, United Technologies, MOOG, ALCOA	GM, NISSAN, BMW, TOYOTA, Vespa, JOHN DEERE, DENSO, GENTEX, ARROW	U.S. AIR FORCE, NAVY, MARINES THE FEW. THE PROUD., U.S.ARMY, DRAPER LABORATORY, Honeywell, LAWRENCE LIVERMORE NATIONAL LABORATORY, IBM	GE Appliances, STANLEY, a, 3M, Google, TREK, LOWE'S	PHILIPS, GE Healthcare, SIEMENS, stryker, Brooks, Johnson & Johnson, MERCK Be well, DUPONT	NIKE, UNDER ARMOUR, adidas, GORE-TEX, ÖSSUR LIFE WITHOUT LIMITATIONS	HARVARD, MIT, UNIVERSITY OF MARYLAND, MIT Lincoln Laboratory, JOHNS HOPKINS UNIVERSITY

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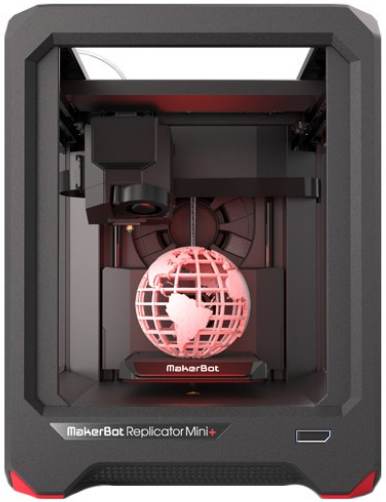
Types of Printers

Hobbyist



Both are great for the right application

Professional

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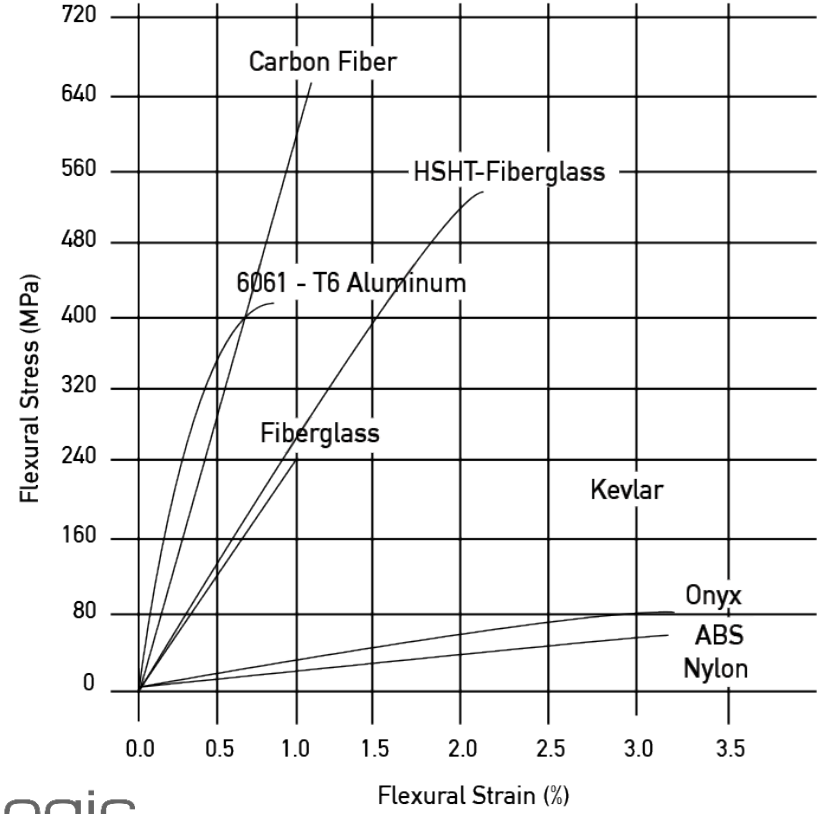
Material Characteristics

Thermoplastic Materials

- Onyx (Nylon filled chopped carbon fiber)
- Nylon

Continuous Fiber Materials

- Carbon Fiber
- Fiberglass
- Kevlar
- HST Fiberglass



*CAM Logic can provide published mechanical properties if anyone wants a copy

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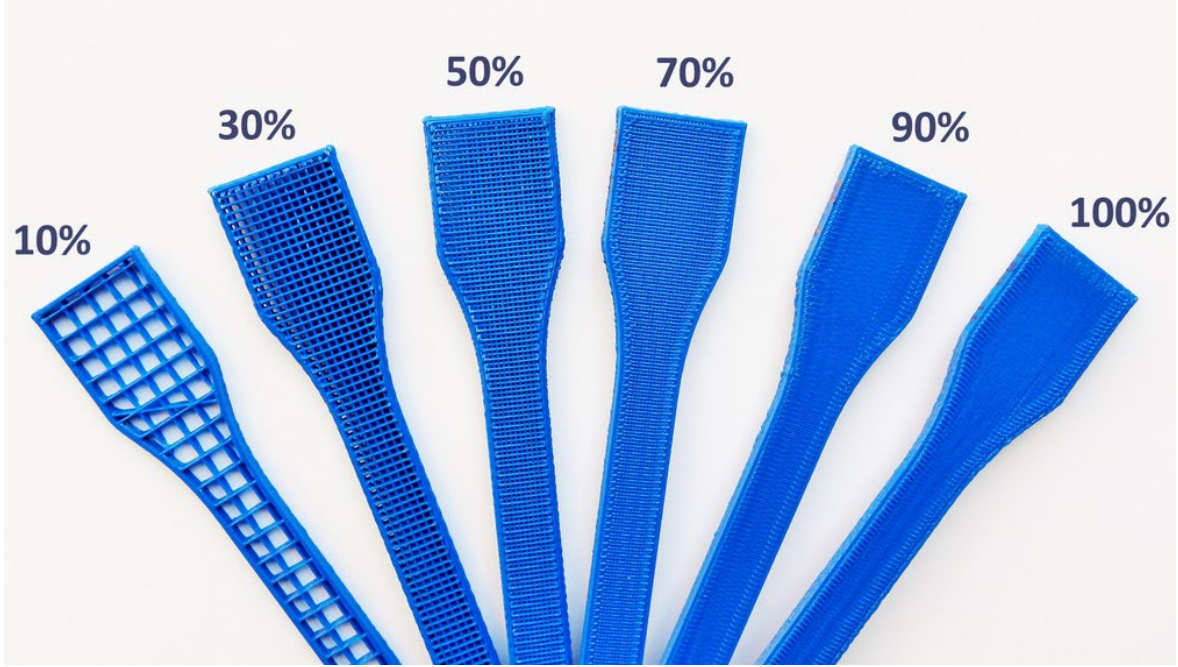
Fused Filament Fabrication 3D Printing

Build Control Using True Thermoplastics



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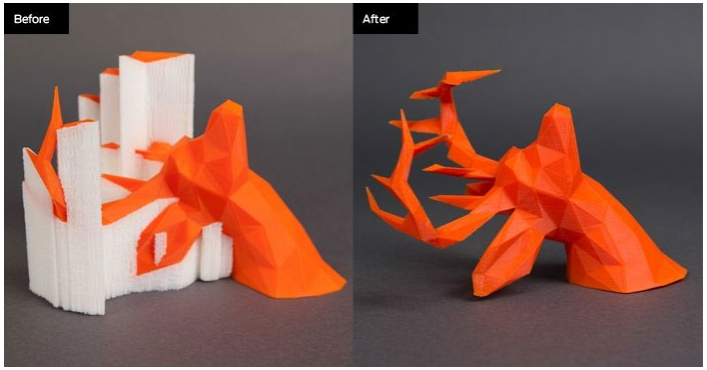
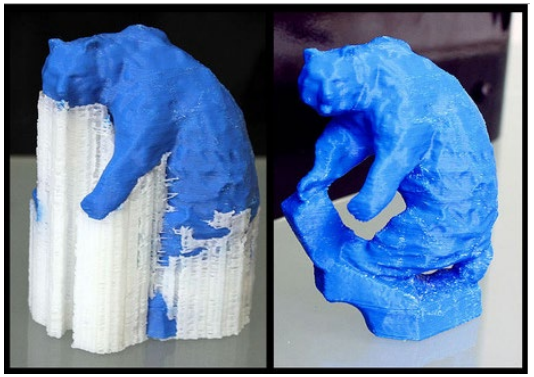
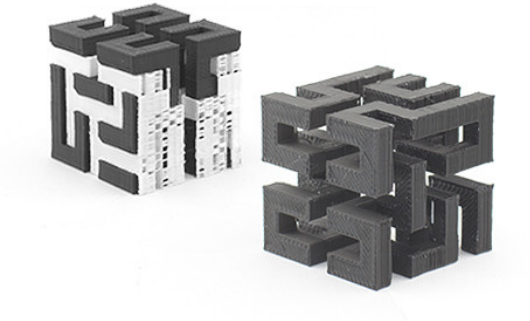
Support Material Option







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Where Does FDM Fit in Manufacturing

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Have you and the team ever said

- “Can we test multiple prototypes at a time to determine what is the best design to go with?”
- “We need to get those fixtures from our job shop by Monday or were in big trouble”
- “The CNC is backlogged but we cant stop taking on work because we don’t want to potentially loose our customers”
- “If we tool a mold for these parts the cost per part doesn’t financially make sense”

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Solutions for Manufacturing

Assembly Aids

End of Arm Tooling

Alignment Fixtures

Digital Inventory

Check Gauges

Organization Tools

Nesting Fixtures

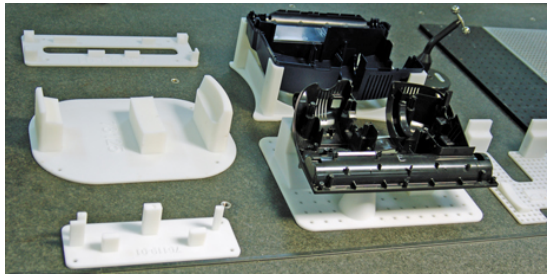
Inspection aids

Tooling Guides

Assembly Line Tools

Safety Guards and Tools

CMM Part Fixtures



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Prototyping & Concept Modeling

- Fine detail and layer resolution
- Low material cost to build
- Sparse fill options
- Same day design validation
- Cross department communication tools

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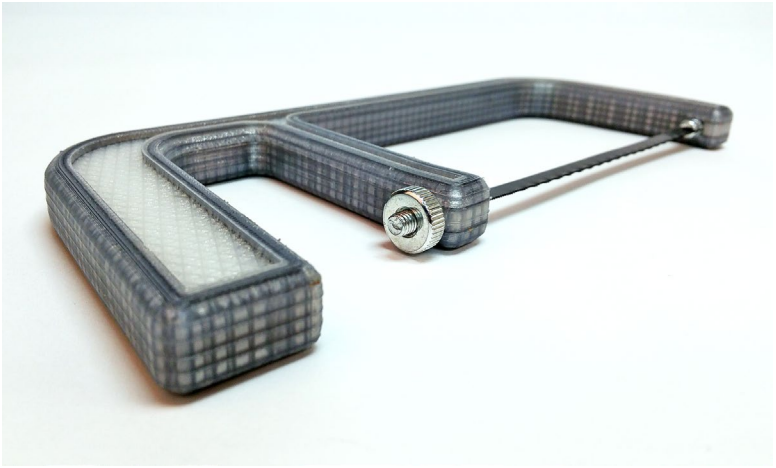
FDM 3D Printing for Prototypes

Detail and Precision

Material Strength



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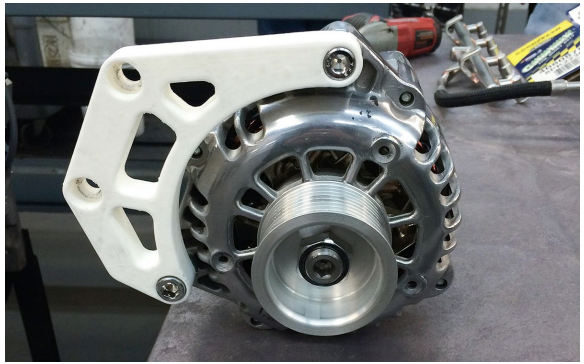
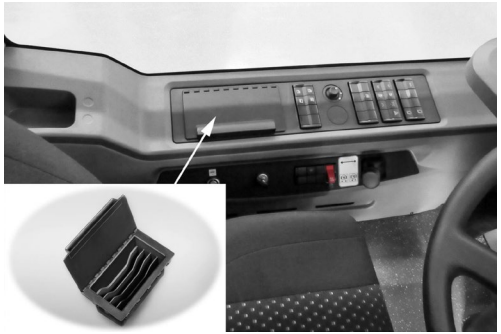
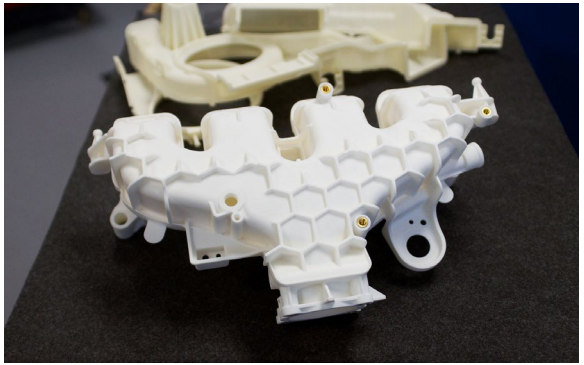
Testing



Alternator Bracket



Air Vent Design



Ducting Design

Axle Case

Intake Manifold

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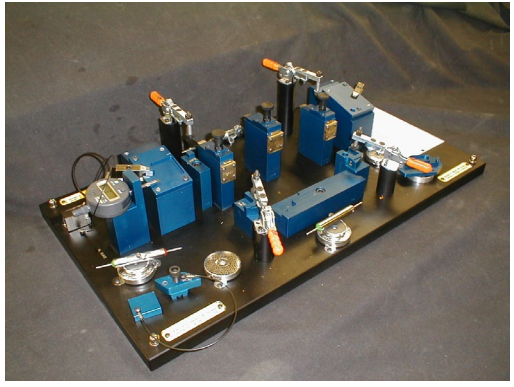
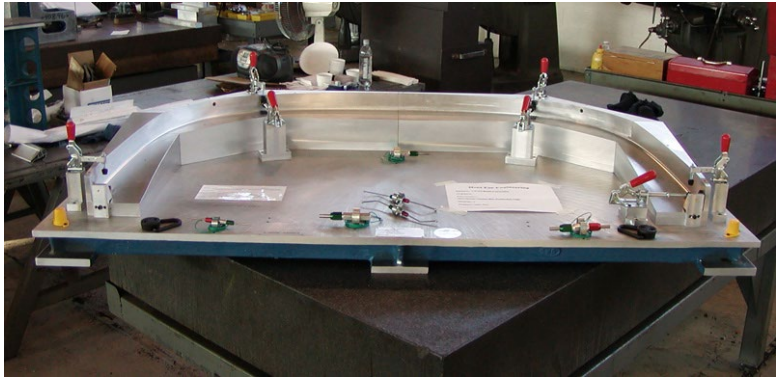
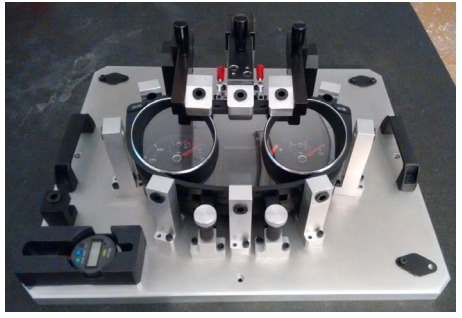
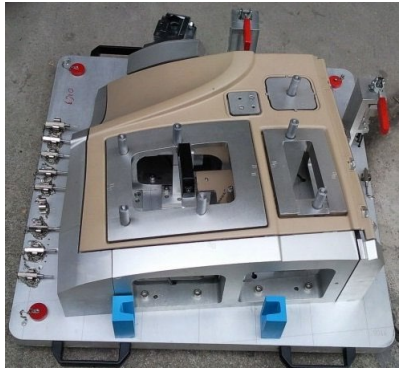
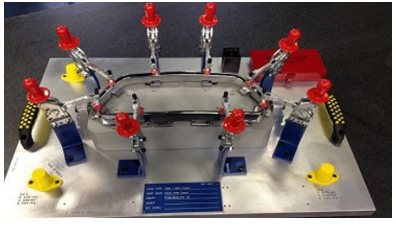
Fixtures, Gauges, Clamps, & Jigs

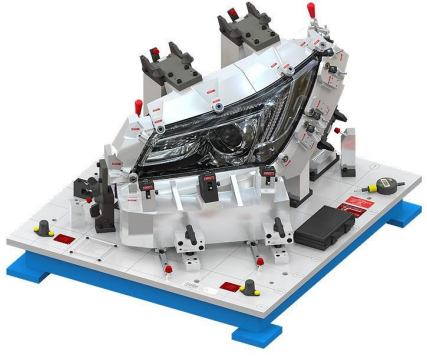












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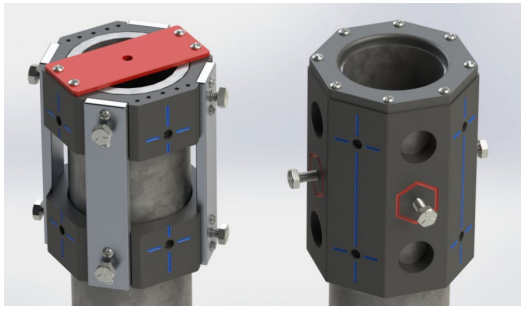
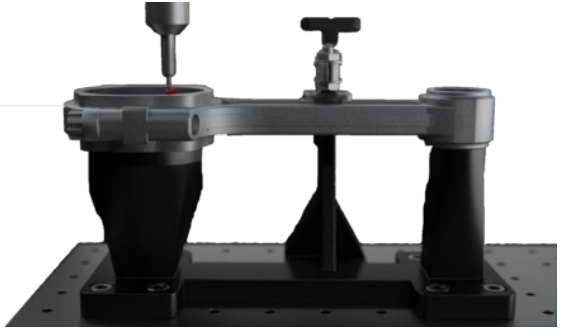
Most Commonly Used Manufacturing Applications for Manufacturing

End of Arm Tooling

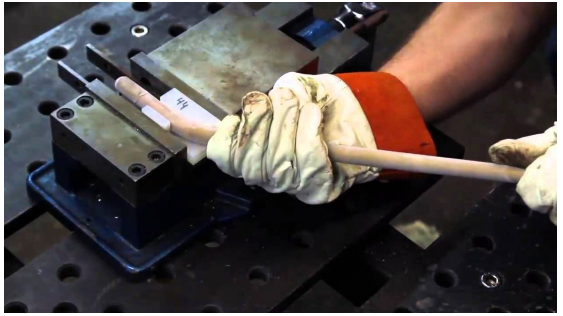


Tool Guides

Soft Jaw Tooling



Fixturing



Tooling Aids

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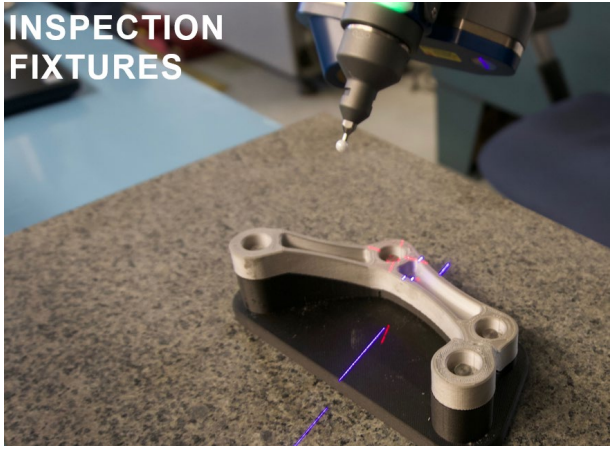
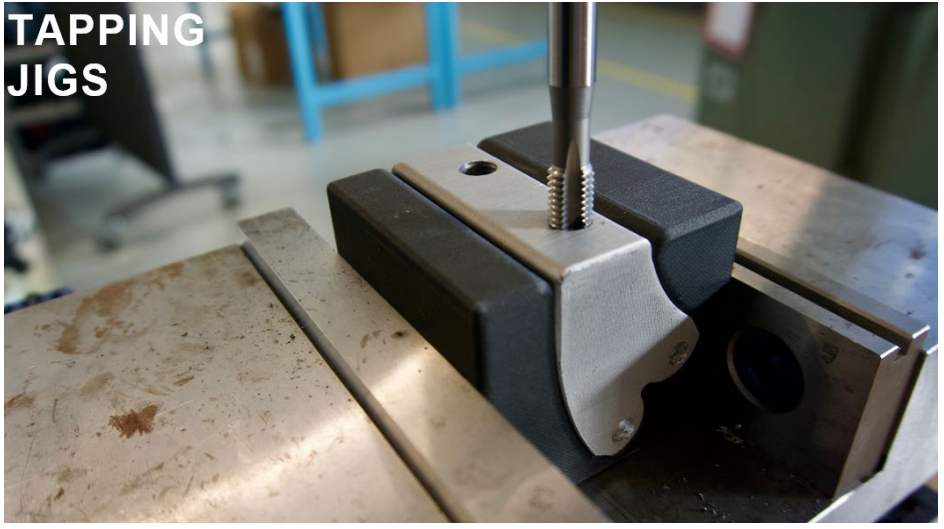
Common Manufacturing Applications





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CAM Logic In Process Fixture Project

Challenges

- Fixtures aren’t cheep
- Weight impacts mobility
- Storage of fixtures
- Turn around time from supplier roughly 10-12 weeks
- Making changes and adjustment is costly

Car Bumper In Process Check Fixture

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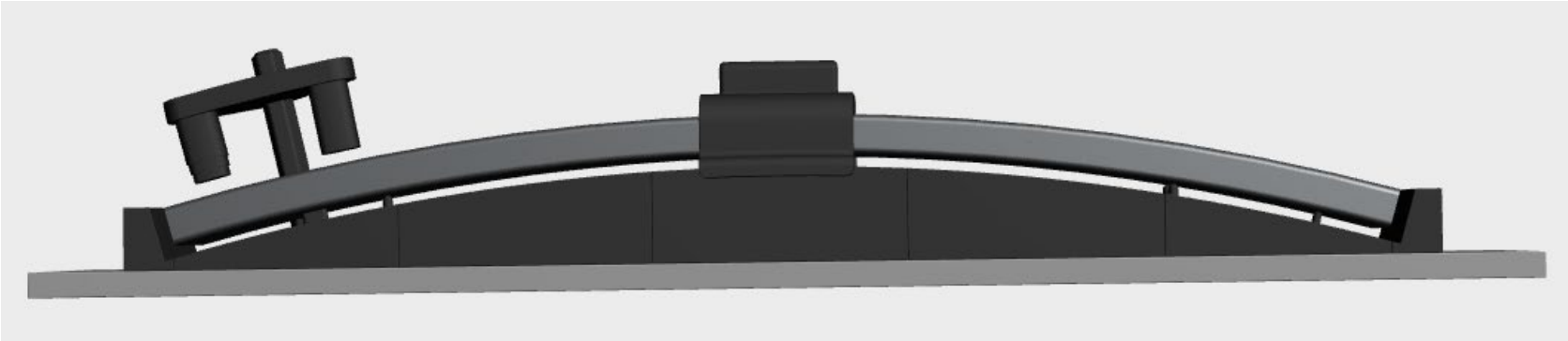
Why does FDM work for in process fixture



- Print fixture for requirements you need… Design for additive
- Markforged tight tolerances
- Auto companies don’t pay for in process check fixtures, costs come out of suppliers pocket

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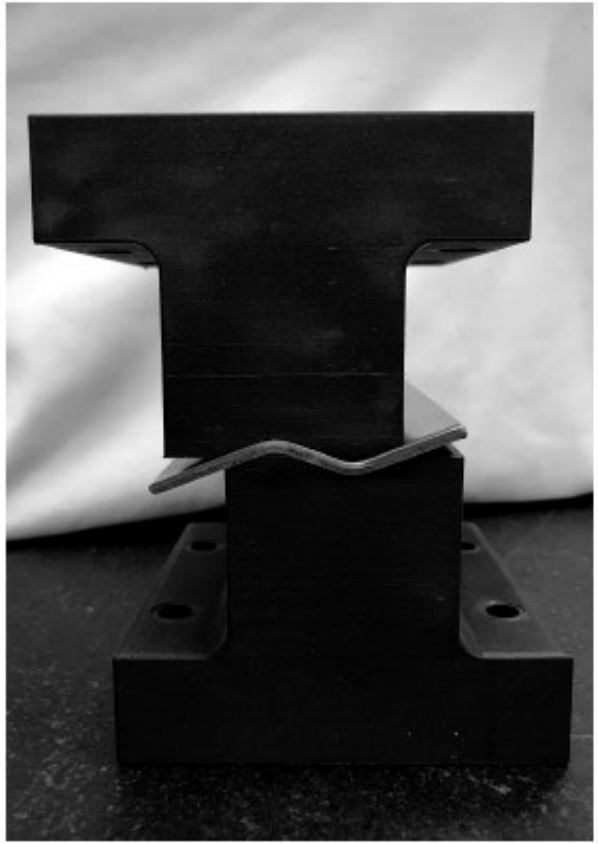
CAM Logic Forming Tools

Using Composites to Form Steel

- CAM Logic engineering expertise (DFAM)
- Formed 3mm cold rolled Low carbon steel
- Leveraged Markforged technology
- Full quality report generated to prove concept



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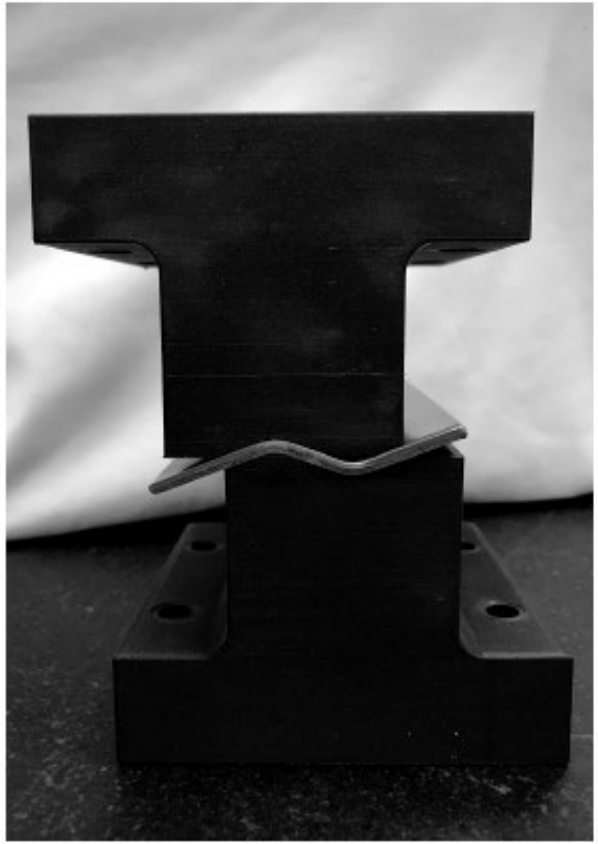
CAM Logic Forming Tools

Using Composites to Form Steel - Example

- Formed over 5000 parts
- Leveraged design for additive
- Did project in the shop next door
- No material waste
- Digital inventory
- Print directly from CAD no CNC
- No premium for part complexity
- Tools done in days not weeks



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Ford Motor Company

Summary of Additive at Ford

- 1986 Ford bought first Stereolithography machine
- In last 20 years Ford has printed over 500,000 parts
- Large use of additive for prototypes without tooling
- Looking more for using additive for replacement parts
- Interest not in using additive to put a million 3D printed parts in each F150 but using additive to reduce cost and enable innovation on each truck

Markforged Machines

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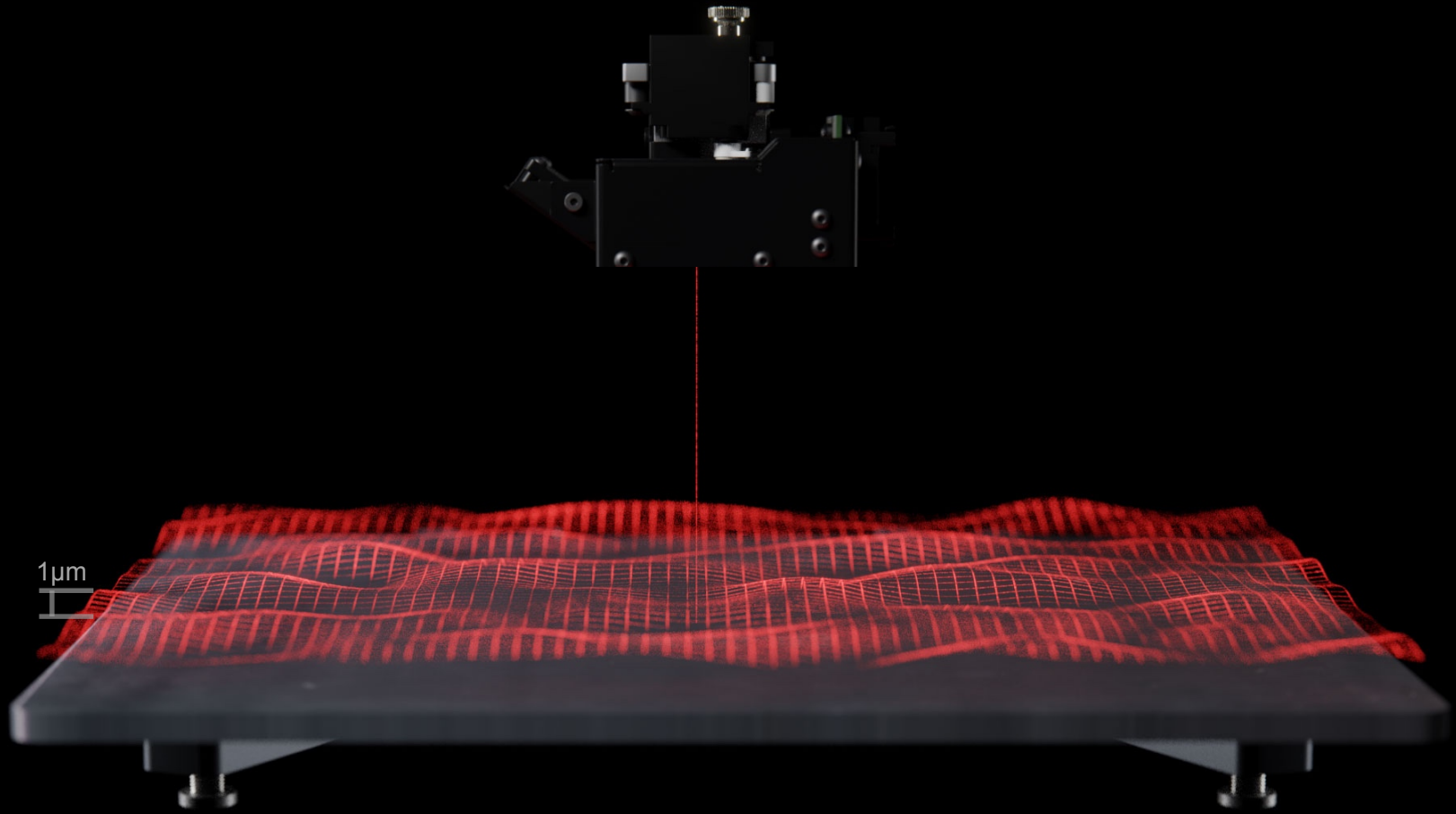
THE X7 SETS THE BAR

CONTINUOUS CARBON FIBER AND KEVLAR

	X7
PART STRENGTH	22.6x ABS UTS (Carbon Fiber & Kevlar)
FLEXURAL STIFFNESS	24.8x ABS
RESOLUTION	50 micron minimum
ACCURACY	+/- 125 micron
LASER CAPABILITIES	Calibration, In process inspection
COST	$ 69,000

ONLY MARKFORGED HAS QUALITY CONTROL FOR UNDER $1M



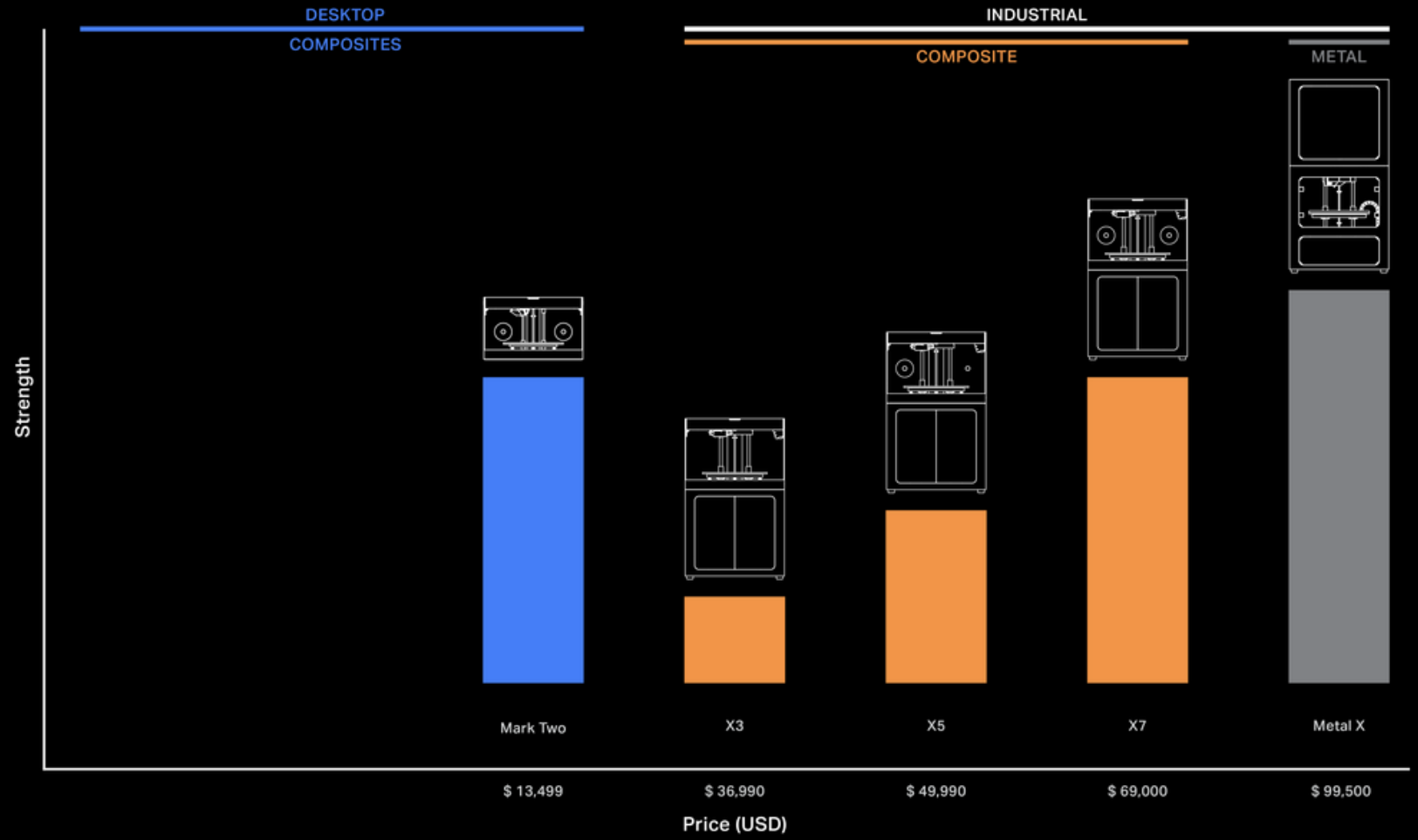
MARKFORGED PRODUCT INNOVATION

3D PRINTING INDUSTRY AWARDS 2017 WINNER

ACE Awards for Composites Excellence
2015 Materials and Process Innovation Award Winner

THE AMAZING 10TH ANNUAL CRUNCHIES HARDWARE OF THE YEAR

MARKFORGED MARK TWO

EY Entrepreneur Of The Year®
2017 Finalist

FULL RANGE OF PRINTERS