

The Digital Forge

Industrial Production at the Point of Need



Presenter:
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Manufacturing and consulting background
7 years in additive manufacturing



Manufacturing is Changing. Press Print.



Inflection point is driving onshoring for more **resilient and flexible** supply chains.

Business Challenges

Profitability and cost pressure

- Aging equipment, high carrying costs, rising costs

Industrial agility and market trends

- Evolving global markets, conservative investment, inflexible supply chains

Labor gaps and upskilling

- Limited capacity, long training cycles, and retiring tradespeople

Our Customers are Leading the Charge

Automotive Business Drivers



Empower the Team

- _ Foster creative problem solving and innovation
- _ Develop talent and upskill workforce
- _ Recruit and retain great employees

Improve Manufacturing & Supply Chain Efficiency

- _ Higher OEE and throughput
- _ Reduced lead times
- _ Faster line changeover
- _ Reduced inventory (MRO)

Secure a Competitive Advantage

- _ Improve profitability
- _ Accelerate time to market
- _ Accelerate time to revenue
- _ Less reliance on outside suppliers
- _ Sustained culture of innovation

Our Customers are Leading the Charge

Application Areas



Manufacturing Line Support



Machinery & Automation



High Value Part Production

Automotive Production

Top 10
Auto OEM

Tier 1
Supplier

System
Integrator



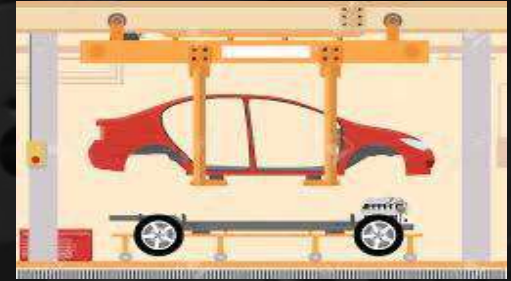
Plant Level (Bottom-Up)
Collaborative + bottom-up
Create Best Practice & Scale

High Value Application
Workstream
Production Line MRO for
Operational Efficiency



Executive Level (Top-Down)
Prescriptive + Strategic
Enterprise Engagement

Global AM Program
Develop culture enabling
Design & Process Standard's



CoE Driven
Reactive
Opportunistic

\$MM Value at Stake
Time Critical Re-tooling
Production Assembly Line
Meet Product Launch Date

Business Transformation

Automotive Production

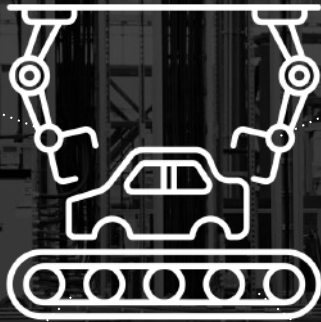
Top 10
Auto OEM



Plant Level (Bottom-Up)
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Create Best Practice & Scale

High Value Application
Workstream
Production Line MRO for
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Goals and Objectives



GOAL: Improve profitability

- *Reduce Price Pressures (and Material Costs)*
- *Reduce supply chain dependency, reliance on expensive labor and 3rd party suppliers, and reduce lead times.*
- *Improve vehicle profitability*

GOAL: Accelerate transformation

- *Drive improved total company adjusted EBIT margin (10%)*
- *Drive strong margins and cash flow*
- *Reduce physical inventory of parts in stores*
- *Reduce carry cost/tax on physical inventory*

GOAL: Company culture of empowering our people

- *Talent Development Plan to empower, upskill, re-skill employees throughout the transformation*
- *Build + train teams of champions in plants that "own it"*

GOAL: Enable deep insight

- *Increase agility & competitiveness. Integrated biz systems, software, sensors, and plant data*
- *Build skills & capabilities for the next century of innovation*

Value at Stake



500+ CELLS

- 1M transmissions per year
- JIT production of critical components
- No gears = no cars



TRANSFER ARMS

- Steel from OEM, 50lbs load
- Failures = downtime and scrap
- \$3500/pair. 6-12 weeks lead time



GRIPPER PAIRS

- Temporary 'red neck engineering' fix
- Downtime, slow running, scrap
- \$25k/set (!!). 4-12 weeks lead time



NESTS

- Critical for QC
- Wear item impacts throughput, tolerances
- \$3500/set. 4-8 weeks lead time

Business Transformation

Automotive Production

Tier 1
Supplier

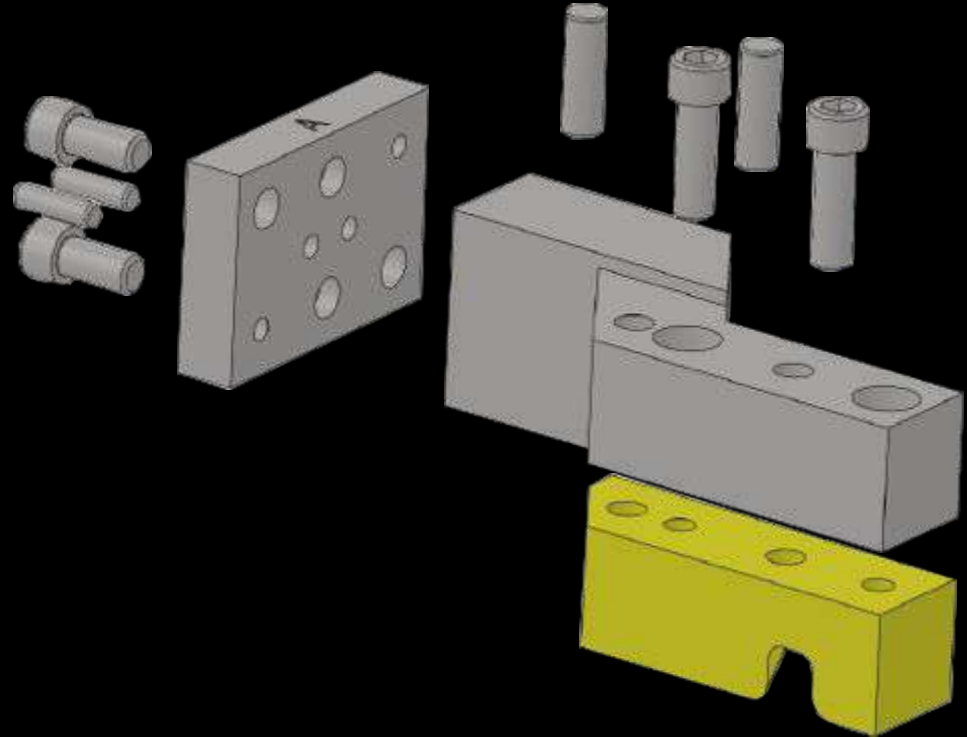
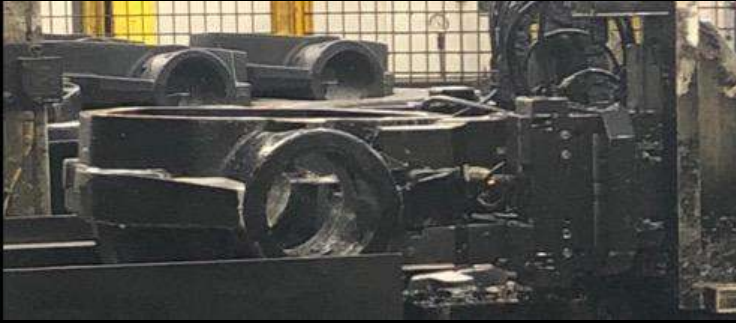


Executive Level (Top-Down)
Prescriptive + Strategic
Enterprise Engagement

Global AM Program
Develop culture enabling
Design & Process Standard's

Axle machining cell

Current State



- Original effector requires 11 parts in inventory
- Tool steel design requires dedicated machinist time and equipment

Axle machining cell

Value at Stake

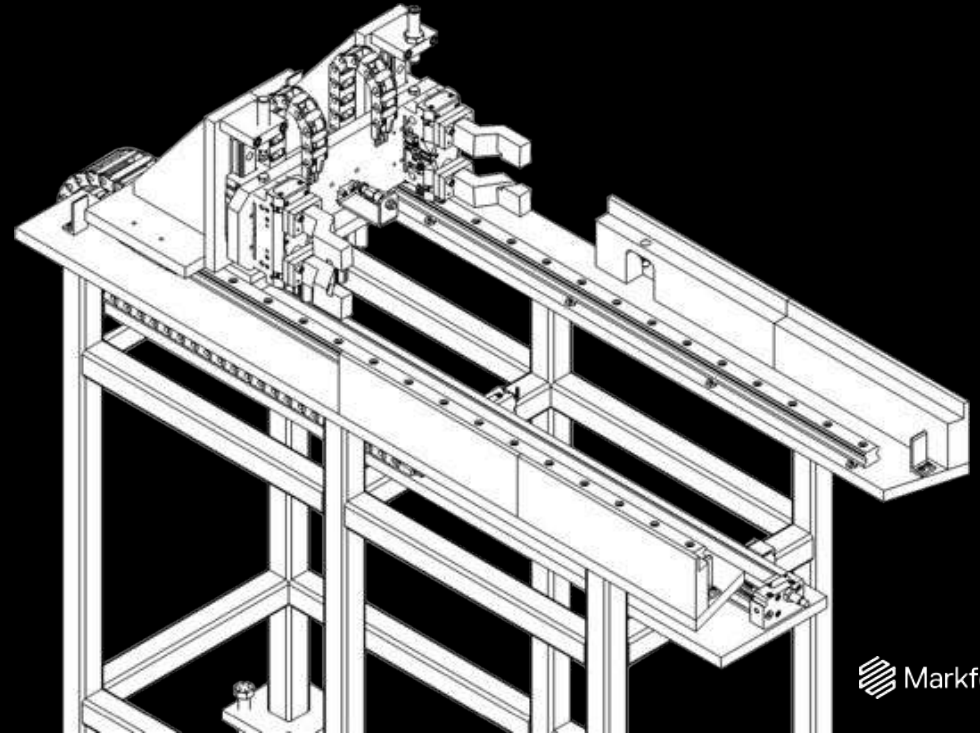
Price per set \$4,060

Replacement per year 2

Yearly spend per assy \$8,120

Number of cells 40

Gripper spend (year) \$324,80



Tier 1 Supplier

Positive Business Outcomes



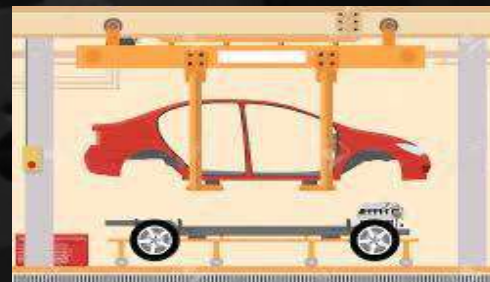
85% Cost Reduction
92% Lead Time Reduction

- ✓ Part consolidation: 11 to 3 components
- ✓ Inventory reduction
- ✓ Lightweight (ergonomics, safety, & automation speed)
- ✓ 100% produced in-house

Business Transformation

Automotive Production

System
Integrator

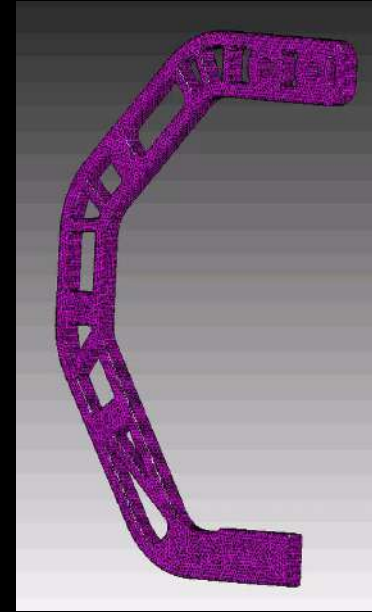
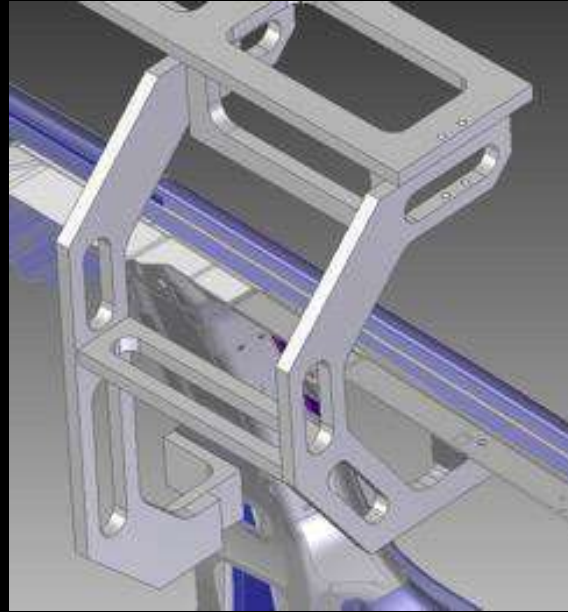


CoE Driven
Reactive
Opportunistic

\$MM Value at Stake
Time Critical Re-tooling
Production Assembly Line
Meet Product Launch Date

Required Capabilities

- **Light-weight and strength**
- AM pallet tooling must survive long-term production environment
- Maintain side aperture position for robotic access
- **Qualified Partner** with CAD and DfAM skills to support SI
- Production-ready technology to support timeline and volume



Engagement Overview



Positive Business Outcomes

- Program **launch timing preserved**
- Pallet tooling **budget maintained**
- Repairs via digital and **on-demand inventory**
- **Expanded load carrying capacity** of accumulating conveyor via use of printed composite tooling
- **Improved yield** with less inertia and non-marring material



In all cases:

Teams empowered to innovate

Education and enablement through partnership

Industrial technology deployed with a plan



The Digital Forge

Solving Supply Chain Problems for the World's Leading Companies



Industrial Automation

Replacing traditional infrastructure.



Aerospace Industry

Flying on military aircraft and orbiting the International Space Station.



Military & Defense

Supporting troops in combat zones.



Automotive Industry

Enabling vehicle production.



Healthcare & Medical

Protecting lives with critical medical equipment.



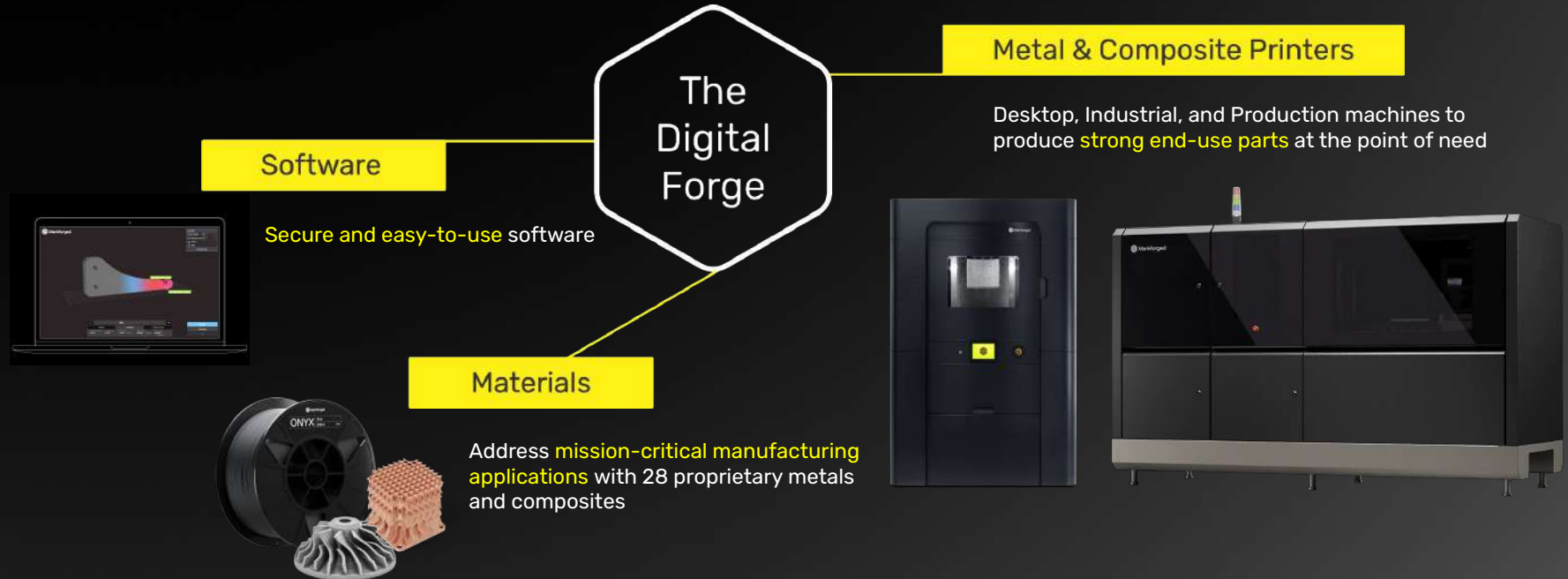
Research Institutions

Building brand loyalty with the next generation of engineers.

Note: Select customers included. Not inclusive of entire customer base. Use of logos does not imply endorsement

The Digital Forge brings resiliency to thousands of manufacturing floors today

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



Diverse hardware capabilities address the most demanding applications and scale across the business.



Mark Two

ADVANCED COMPOSITES

The easiest and efficient way to replace metal parts advanced composites



X7

ADVANCED COMPOSITES

Industrial and smart continuous fiber reinforcement 3D printer for real manufacturing applications



Metal X

METALS

End to end metal printing system for functional metal parts



FX 10

ADVANCED COMPOSITES +

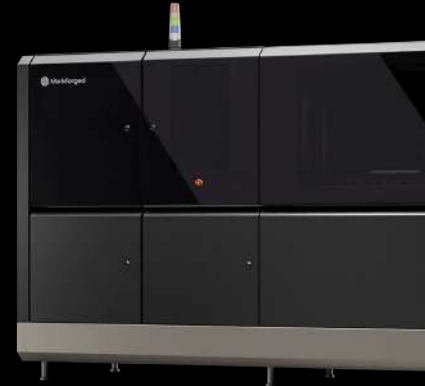
Intelligent 5th generation printer for distributed production and autonomous QC



FX20

ADVANCED COMPOSITES

Our Production Beast. Large scale, precise continuous fiber 3D Printer for high-temp materials



PX100

PRODUCTION METALS

A step change in metal binder jetting enabling high volume production of precise metal parts for reliable industrial quantities

Materials portfolio to unlock the widest range of applications



Carbon Fiber

Aramid Fiber
Kevlar®

HSH Fiberglass,
and Fiberglass



VEGA | ULTEM™
9085 Filament



Onyx™



*Onyx FR™
(Aerospace)



Onyx ESD™
(Electronics)



Precise PLA
(Prototyping)



Smooth TPU
(Shore 95A)



17-4PH Stainless Steel



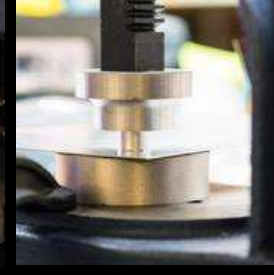
Inconel 625



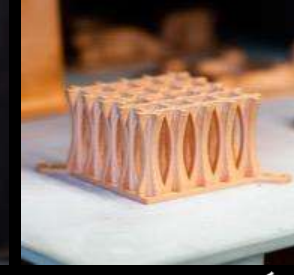
H13 Tool Steel



D2 Tool Steel



A2 Tool Steel

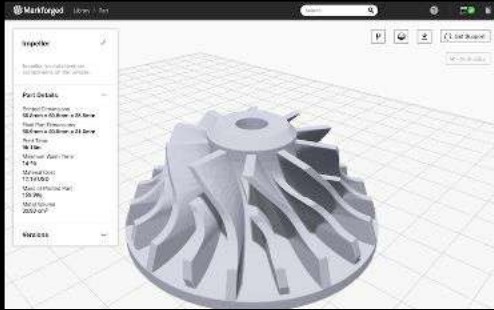


Copper

Powered by software

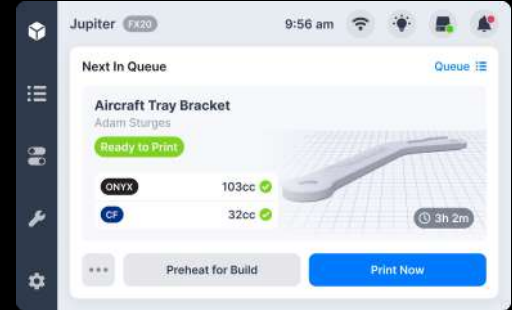
Eiger

Cloud-based Eiger is fully integrated with all Markforged 3D printers, enabling you to create builds, print parts, and monitor prints in a seamless workflow



Device UI

Software that enables a seamless and intuitive user experience when operating Markforged printers, from printing to maintenance and everything in between



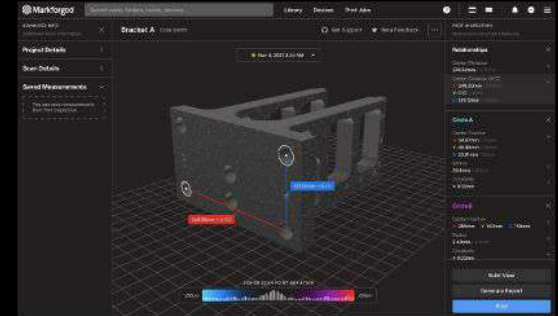
Simulation

Digitally validate part strength and stiffness and virtually optimize slicing parameters to minimize print time and material use while ensuring performance



Inspection

Validate parts at the point of production with in-situ inspection so you can print parts with confidence across a globally distributed fleet



Flywheel Driving Improvement and Reliability

The Digital Forge continuously improves through over-the-air updates



Grow Expertise at the Speed of Global Production

New printers are added to network to scale manufacturing capacity



Consistent Improvement

Federated fleet learning combined with real-time part corrections create a reliable and repeatable production process

Better parts

New users

More part data



Part Prep and Fleet Management

Simulation enables pre print strength testing. Devices are constantly streaming back data on parts and performance.

Smarter printers



Part Scanning and Industrial IOT

Drives AI-powered part quality improvements across entire fleet





What's Next?

FX10

The most versatile tool
for your factory floor.



Vision Module

- High fidelity imaging system
- Deep resource for process monitoring
- ML trained to assess device health through tailored calibration print
- Future intent: generalized to any printed part



Sensors & Telemetry

- Hundreds of sensor streams synthesized with print data
- Secure cloud infrastructure to process gigabytes of raw data per printer per day
- Advanced internal tools for human interaction, for faster development/diagnosis
- Modular software for future automation





An on demand platform for
3D printing certified parts,
when and where they're needed.

Evolving the Supply Chain

Improved customer satisfaction.

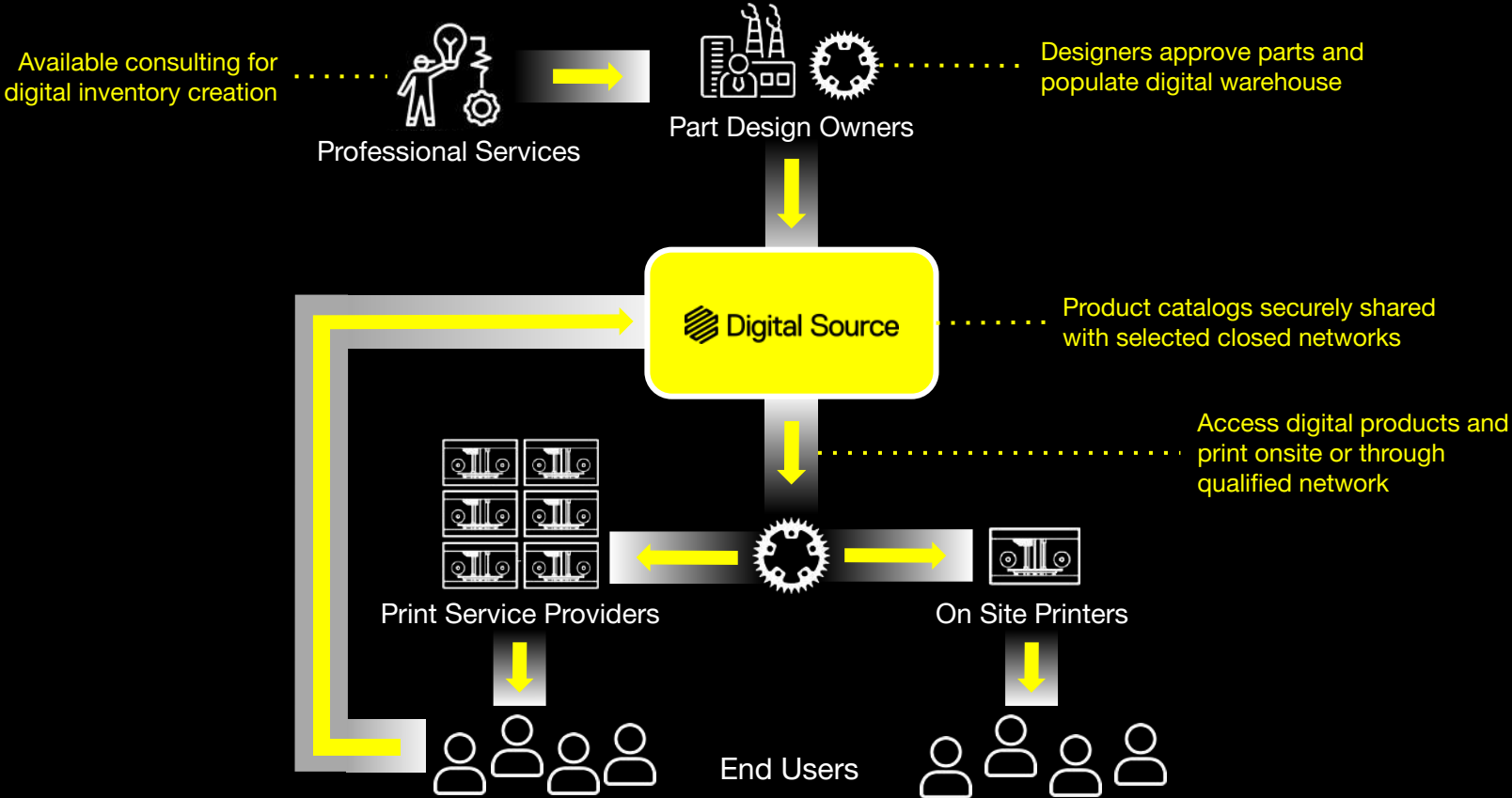
Better quality.

Higher margins.

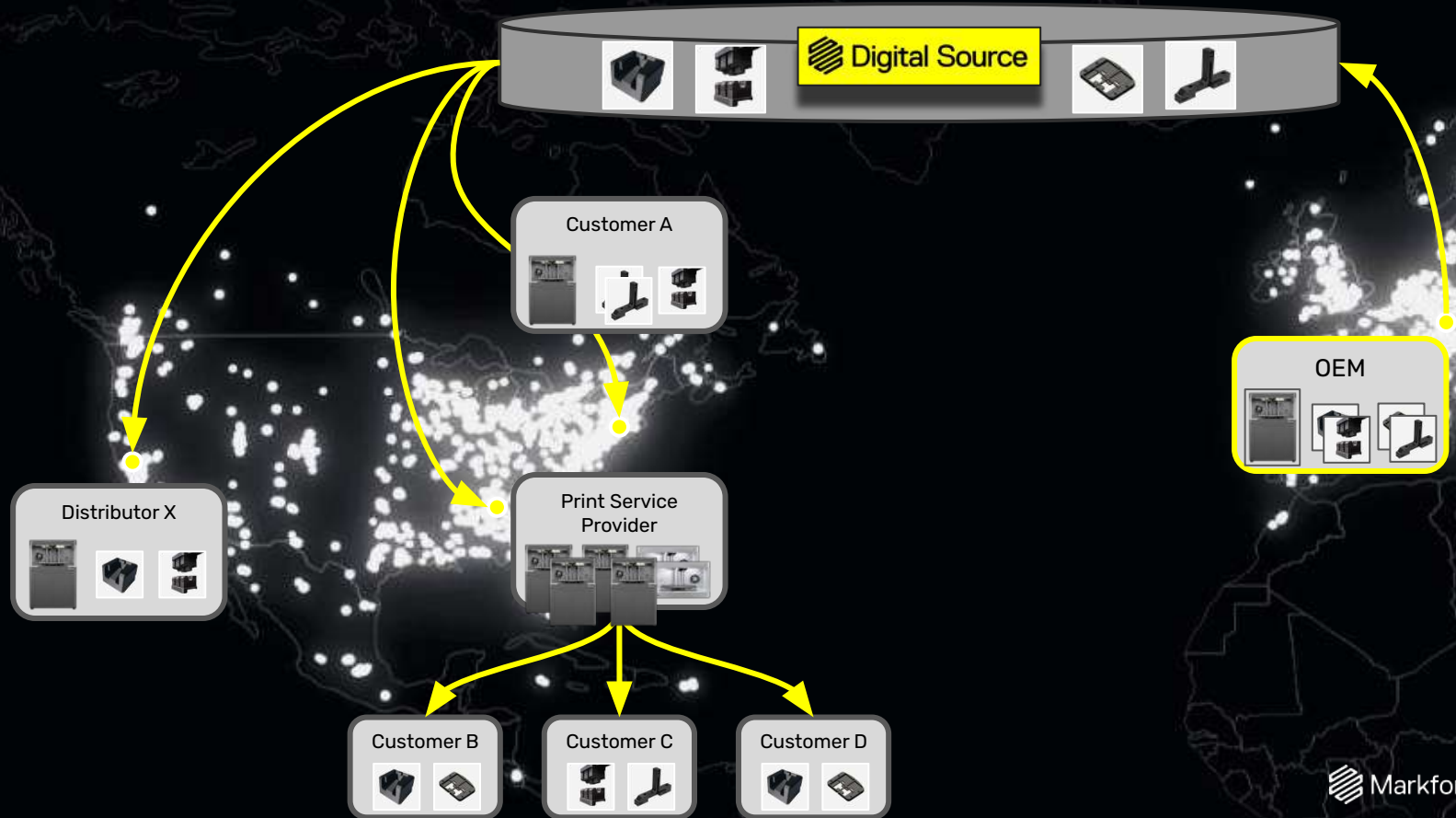
- _ Guaranteed part availability
- _ Lower carrying costs
- _ Instant version control
- _ Reduced carbon footprint

Digital Inventory.
IP Management.
Enterprise Security.

How It Works



Secure Deployment



Set goals.

Empower your team.

Choose a partner.

Validate and deploy technology.

Transform a business.

DISCUSSION & QUESTIONS?

Contact: tripp@markforged.com