3D PRINTING AS A VIABLE & COST-EFFECTIVE AUTOMOTIVE MANUFACTURING PROCESS

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SVP Commercial Development

HP 3D Printing

AGENDA

1. Megatrends Supporting Digital Manufacturing
2. HP Learning Journey
3. Partners and Ecosystem

OUR PORTFOLIO – TODAY

HP JET FUSION 4200[1]
Production

HP JET FUSION 4210[1]
Mass production

HP JET FUSION 500/300 SERIES[2]
Full color prototyping and short runs

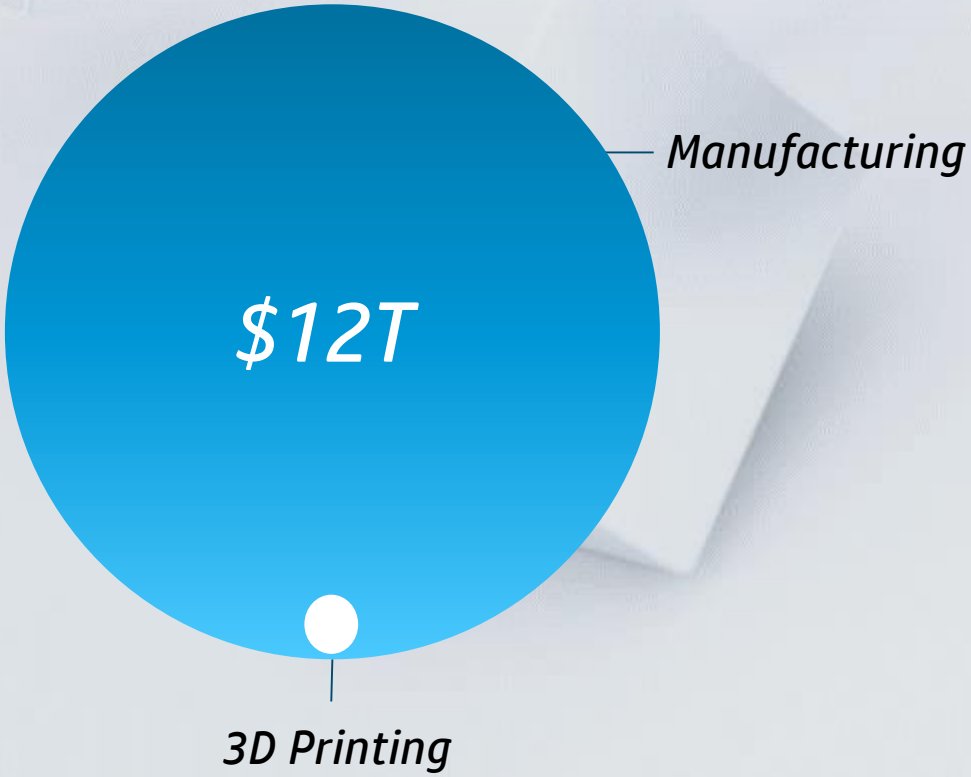
HP METAL JET[3]
Mass production

OPEN MATERIALS PLATFORM • *INTEGRATED SOFTWARE SUITE* • *BIG DATA AND ANALYTICS BACKBONE*

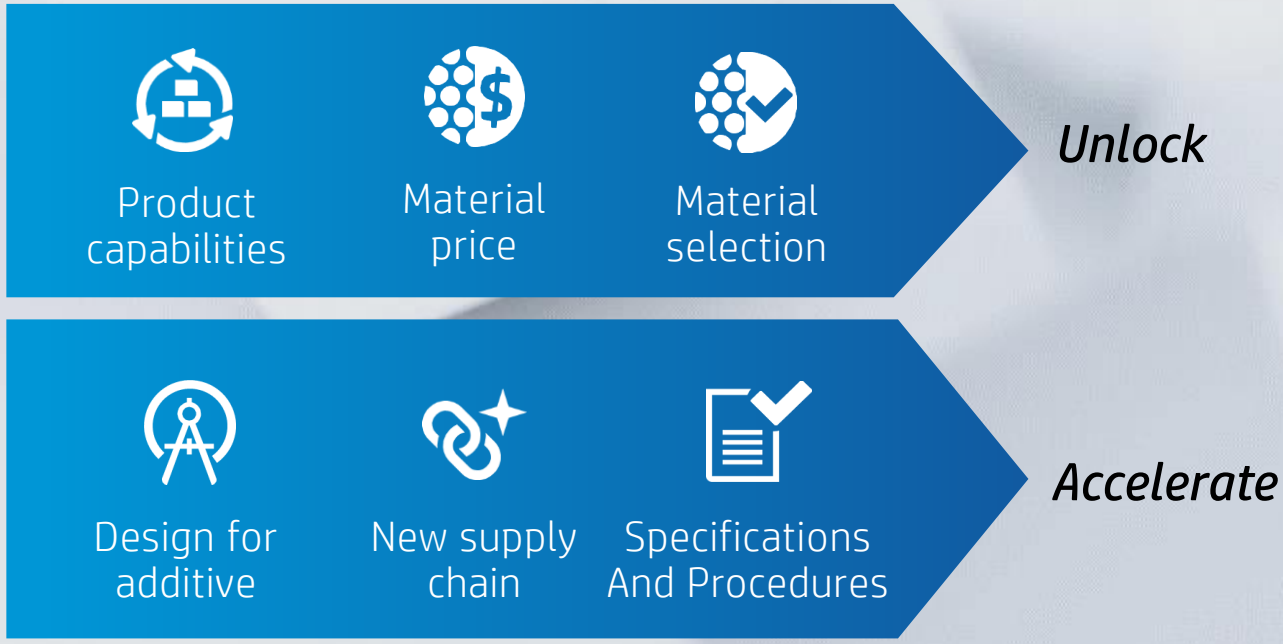
1. Available now.
2. Available to select customers in 2018. General availability in 2019.
3. Production Service available in 2019. Select Metal Jet availability in 2020. Broad availability in 2021.

SIX LEVERS FOR DISRUPTING THE $12T MANUFACTURING SECTOR

MANUFACTURING SECTOR OFFERS GREAT POTENTIAL FOR 3D PRINTING



SIX KEYS TO TRANSFORM THE $12T MARKET



ACCELERATING THE INDUSTRY

- Leaders in key verticals
- Repeat customers, multiple unit orders
- 3.5M total parts / 50% for end use

- 50+ materials leaders engaging today
- World's first open 3D materials lab
- Industry's first 3D materials development kit

- Scaled out to all regions
- 65+ resellers
- 25+ reference and experience centers
- Transformational sales engagement

FORECAST 3D
Johnson & Johnson
Danfoss
materialise
innovators you can count on
Medtronic
mtc
proto labs
stratasys
DIRECT MANUFACTURING
ETH zürich
shapeways
GoProto
JABIL
JAGUAR
LAND ROVER
SHINING 3D
Henkel
KTM
SIGMADESIGN

EVONIK INDUSTRIES
dressler group
Henkel
ARKEMA
INNOVATIVE CHEMISTRY
Sinopec
Lubrizol
Lehmann & Voss & Co.
LUV
BASF
We create chemistry

APPLICATIONS FOCUS

TRANSPORTATION

EV BATTERY COOLING

MOTORBIKE MANIFOLD

TRAIN DOOR SUPPORT

INDUSTRIAL

ROBOTIC ARM

TUBE BENDING TOOL

ROBOT ARM GRIP

MEDICAL

DENTAL ALIGNERS

ORTHOTICS

PROSTHETICS

CONSUMER

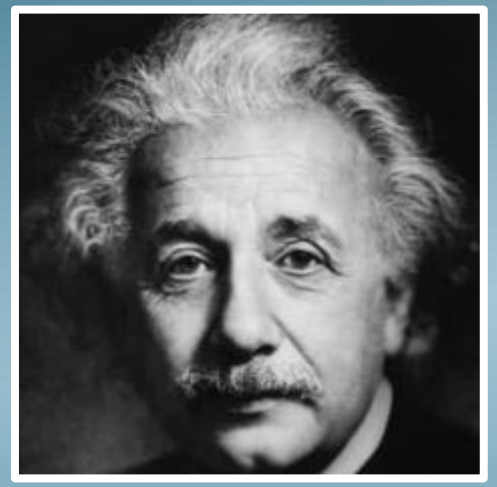
VR HEADSET AND CHARGER

BIKE HELMET

PERSONALIZED / CUSTOM FOOTWEAR

DISRUPTIVE TECHNOLOGIES ARE NOT ALWAYS OBVIOUS

History is littered with wrong predictions, often made by very smart, tech savvy people



1932

"...not the slightest indication that nuclear energy will ever be obtainable..."

- Albert Einstein

1889: 'No one will use AC electricity, ever.' **THOMAS EDISON**

1903: 'Horses will outlast cars': Horace Rackham, bank advisor warning Henry Ford

1959: 'World potential for copy machines is 5,000 at most' **IBM CEO** to founders of Xerox

1966: ''Remote shipping...will flop' **TIME MAGAZINE**

1981: 'Cell phones won't replace wire phones: **MARTY COOPER,** inventor of mobile phone

1992: 'Smart phones are a pipe dream': **ANDY GROVE,** former Intel CEO

1995: 'Internet will ...catastrophically collapse' **ROBERT METCALF,** Founder of 3COM

RISE OF THE AUTONOMOUS WORKFORCE

From human workers → To no workers

1 of 3 White Collar Jobs will be converted to software, robots and smart machines by 2025

47% of U.S. jobs at risk in the next 2 decades

$5.2T to $6.7T est. positive economic impact from automation by 2025

IMPLICATIONS:

Lower cost of operations

Impact on the workforce

Office of the future

Digital manufacturing

KEY THEMES: Robotic AI workers | Global job impact | Man + machine | Jobless society

CYBER TRUST AND SECURITY

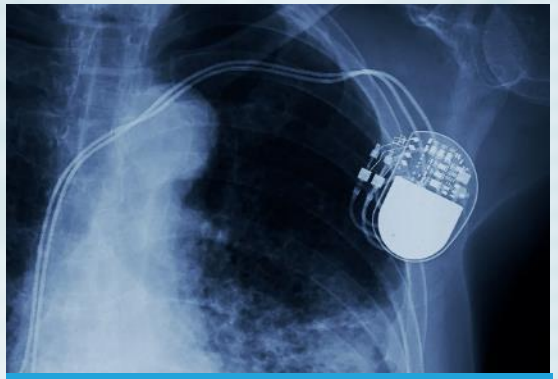
From hacking for Data and Profit → To hacking for Destruction

$445B annual cost of cyber attacks on global economy in 2016

Over 1700 significant data breaches worldwide in 2016

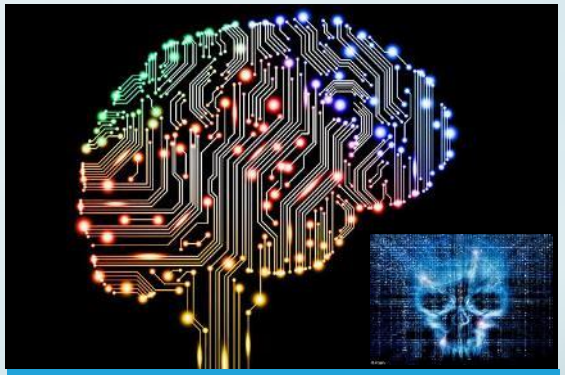
IMPLICATIONS:

End-point security



Personal Vulnerability

IoAT for security



AI versus AI

KEY THEMES: Cyber espionage | Cyber warfare | IoT Devices | Intelligent AI Hacking

THE BUTTERFLY EFFECT OF SELF-DRIVING CARS

From driverless cars → To refined industries

$2T annual revenue from U.S. automotive ecosystem

4M U.S. jobs lost in next 2 decades from self-driving

$507B Annual (est.) productivity gains in U.S.

1.1M lives saved annually in U.S. from eliminated accidents

IMPLICATIONS:

Roving offices

Secondary Effects on Businesses, Roads & Towns

Job Impacts

Real Benefits

KEY THEMES: Butterfly effect | Driver unemployment | New Businesses | Lives and Money Saved

DIGITAL MANUFACTURING

From specialized design, mass production, inventory & global supply chains

To seamless digitization from design to localized production

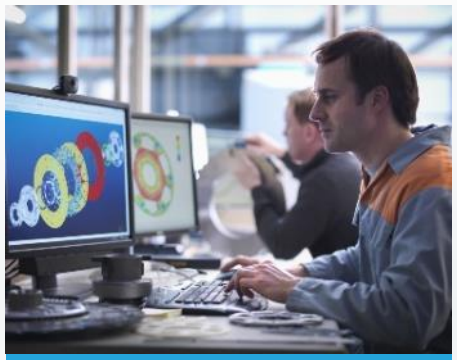
$12T global manufacturing market

Pre-Industrial
Handmade & time intensive

1780s to 1860s

Industrial Revolution
Blueprint design & mass production

1870s to 1960s



Internet
Computer-aided design and JIT machine production

1970s to 2010s

3D transformation
Immersive design and digital production

2010s – Future

Next Industrial Rev
Democratization of design and ubiquitous production

KEY THEMES: AI | Big Data Analytics | Industrial IoT | 3D Printing | Robotics


You can either be an *agent of change*,
or be the victim of change.

OUR LEARNING JOURNEY

TO START: A LITTLE CONTEXT

#1 in WW PCs (22.5% market share)

#1 in WW Printing (40.3% market share)

$50 Billion
business

1
printer shipped per second

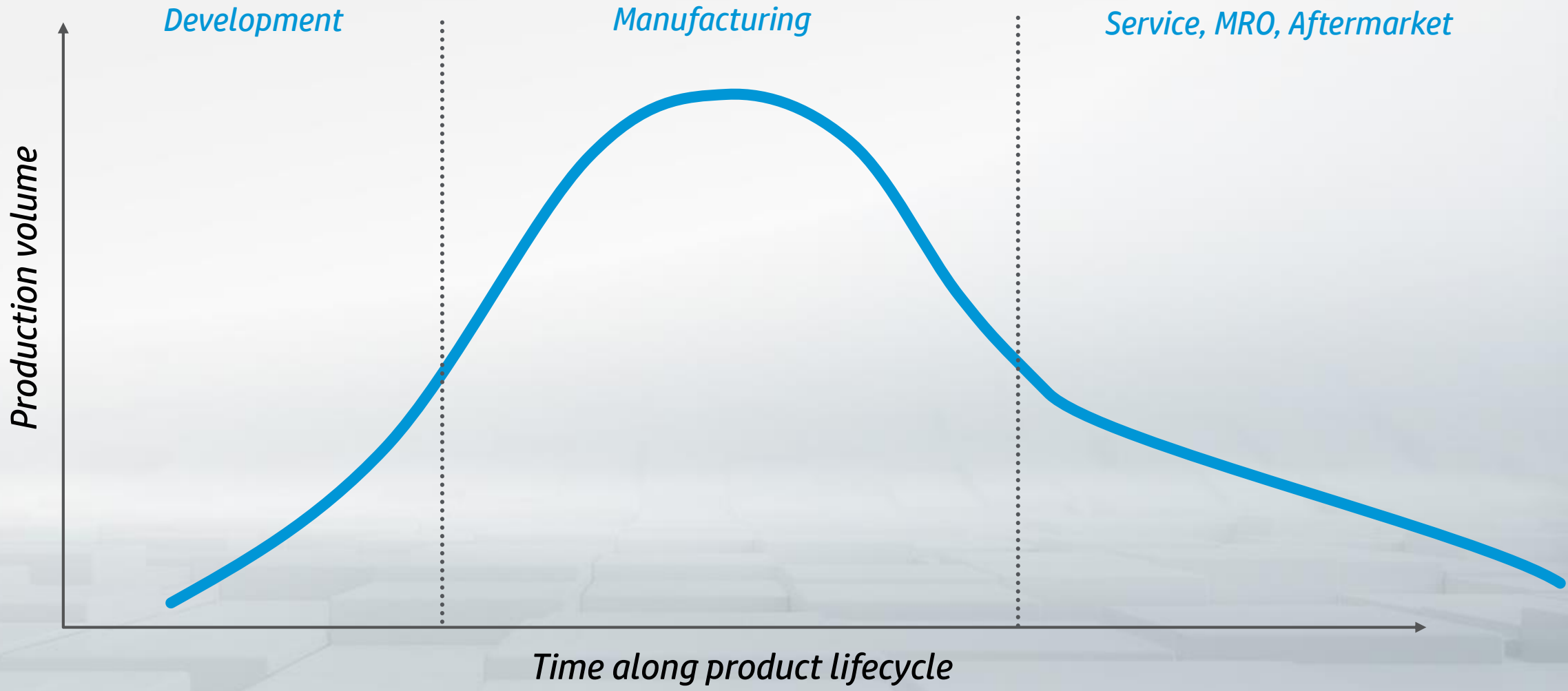
100 Million
products delivered each year

+170
countries worldwide

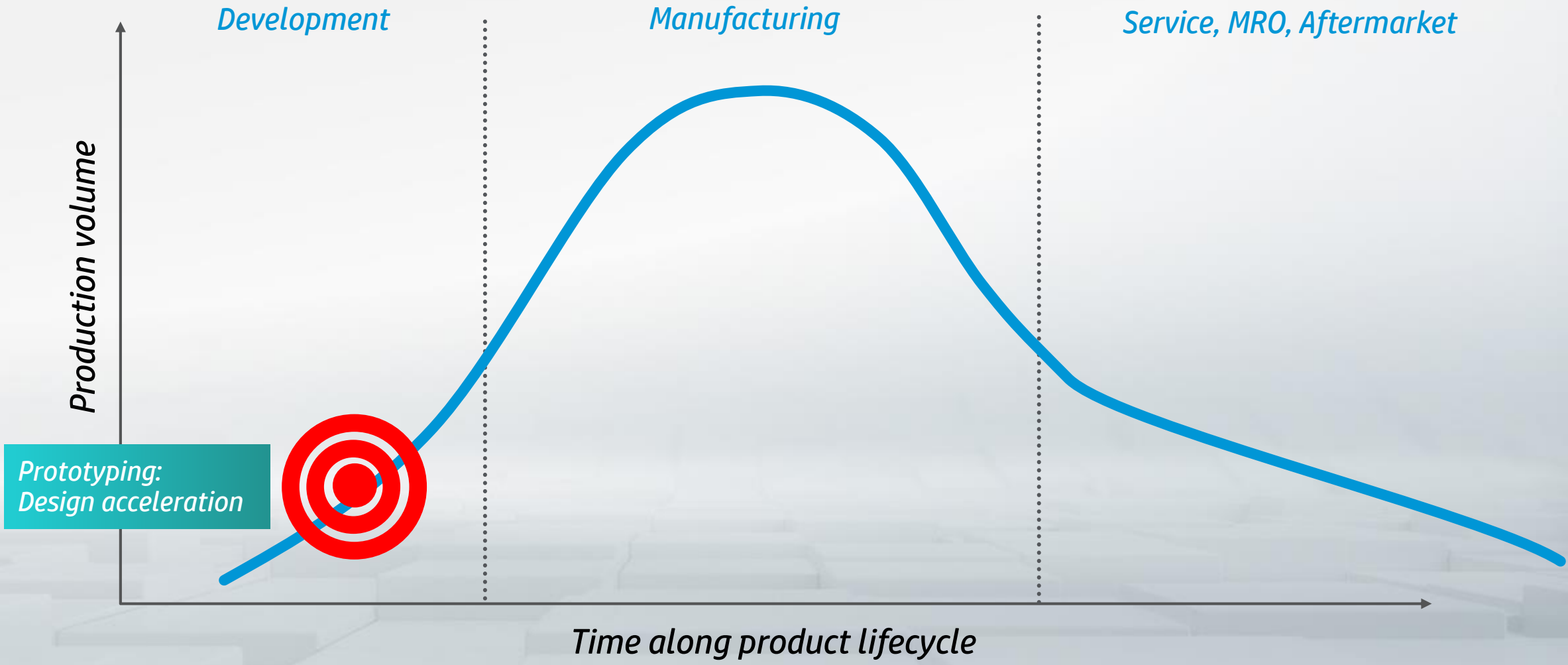
1.7
PCs shipped per second

Market Share: IDC PCD Tracker CQ3'17 (DT+NB+WS excludes Detachables), IDC HCPT WW Tracker CQ3'17 (excludes GSB)

TO FRAME: THE PRODUCT LIFECYCLE



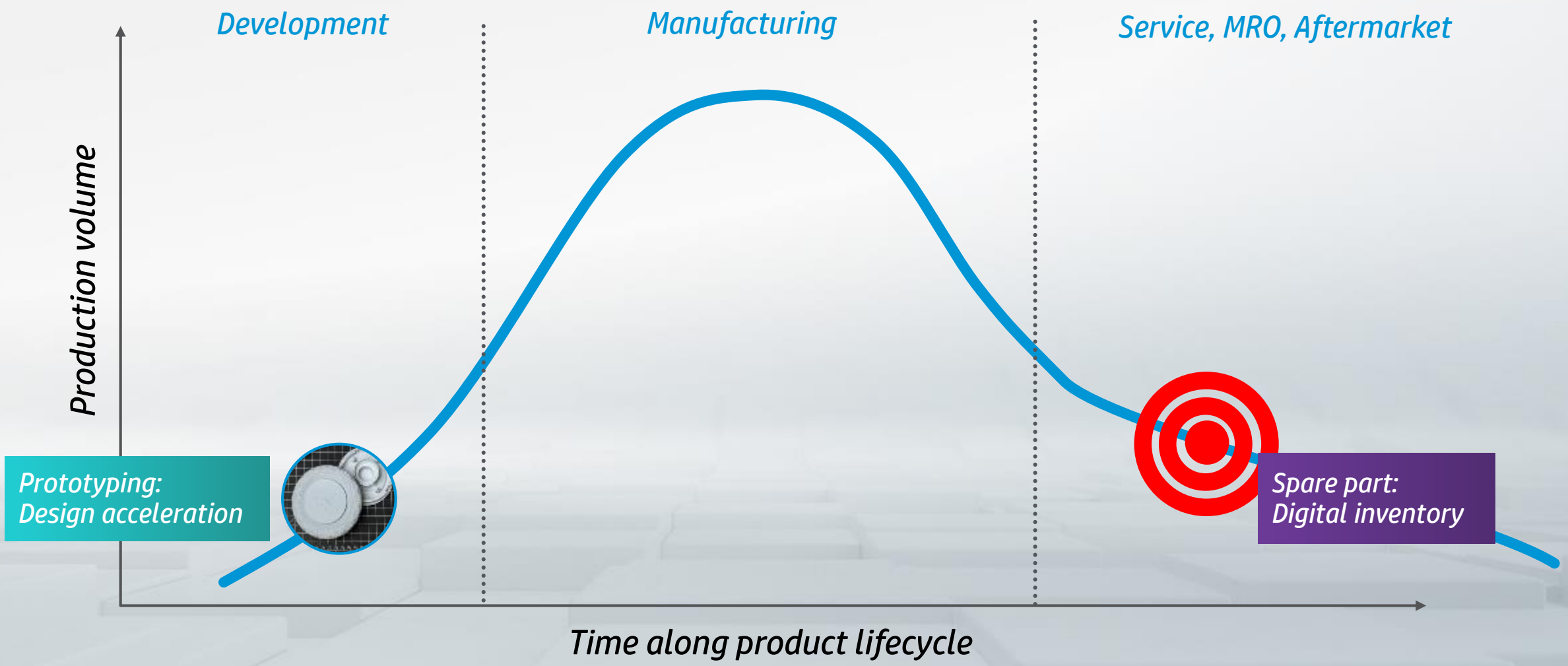
PRODUCT LIFECYCLE APPROACH



PROTOTYPING

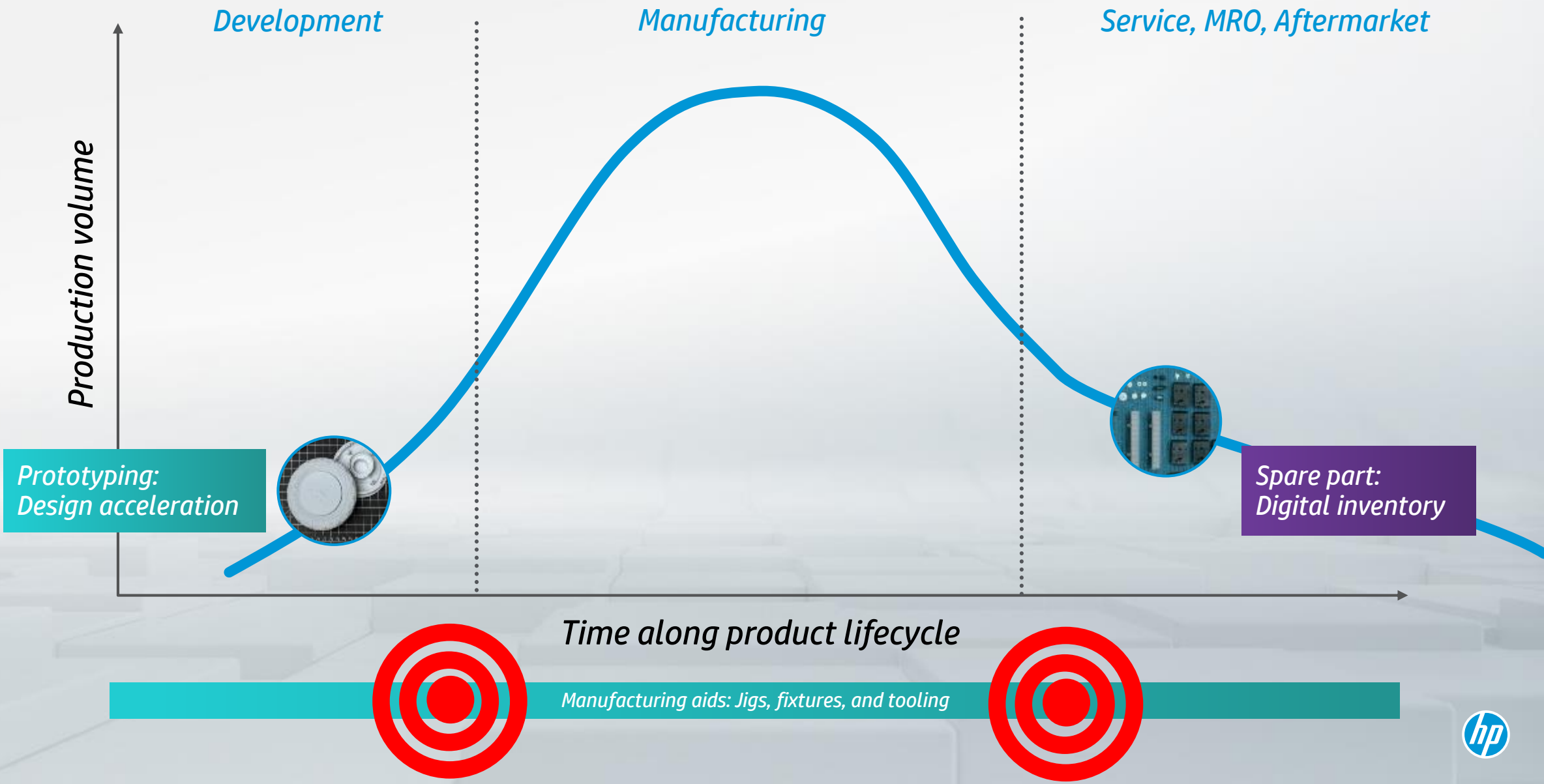
Incorporating MJF it into your prototyping process, enables getting ***more-representative*** parts, faster and cheaper

PRODUCT LIFECYCLE APPROACH



SPARE / AFTERMARKET PARTS

PRODUCT LIFECYCLE APPROACH



EQUIPMENT FIXTURES AND NESTS

- 2K parts for tooling
- Lead time reduction:
  13 weeks to 2 weeks
- 90% cost reduction
- Reduce changeover time

BETTER PERFORMING, EASIER-TO-BUILD TOOLS

HP printheads manufacturing line: Drill extraction shoe

95%
Cost reduction

90%
Weight reduction

Consolidated from 7 parts to 1

Manufacturing technology:	Machining
Material:	Aluminum
Weight:	575g
Cost:	450$
MOQ:	13
TAT:	3-5 days

Manufacturing technology:	HP Multi Jet Fusion
Material:	HP 3D HR PA12
Weight:	52g
Cost:	18$
MOQ:	1
TAT:	1-2 days

Insight: Saving in Ongoing Production Cost / Lightweight

PRODUCT LIFECYCLE APPROACH

Development

Manufacturing

Service, MRO, Aftermarket

Production volume

Bridge production

Prototyping:
Design acceleration

Spare part:
Digital inventory

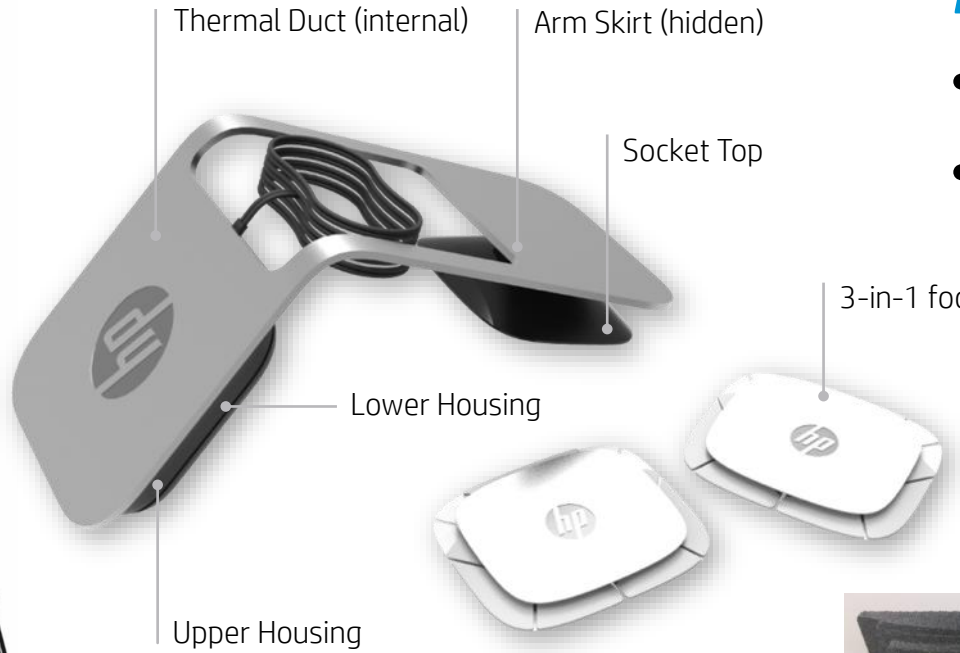
Time along product lifecycle

Manufacturing aids: Jigs, fixtures, and tooling

HP Z 3D CAMERA

Brand new market space

Priority on speed and learning

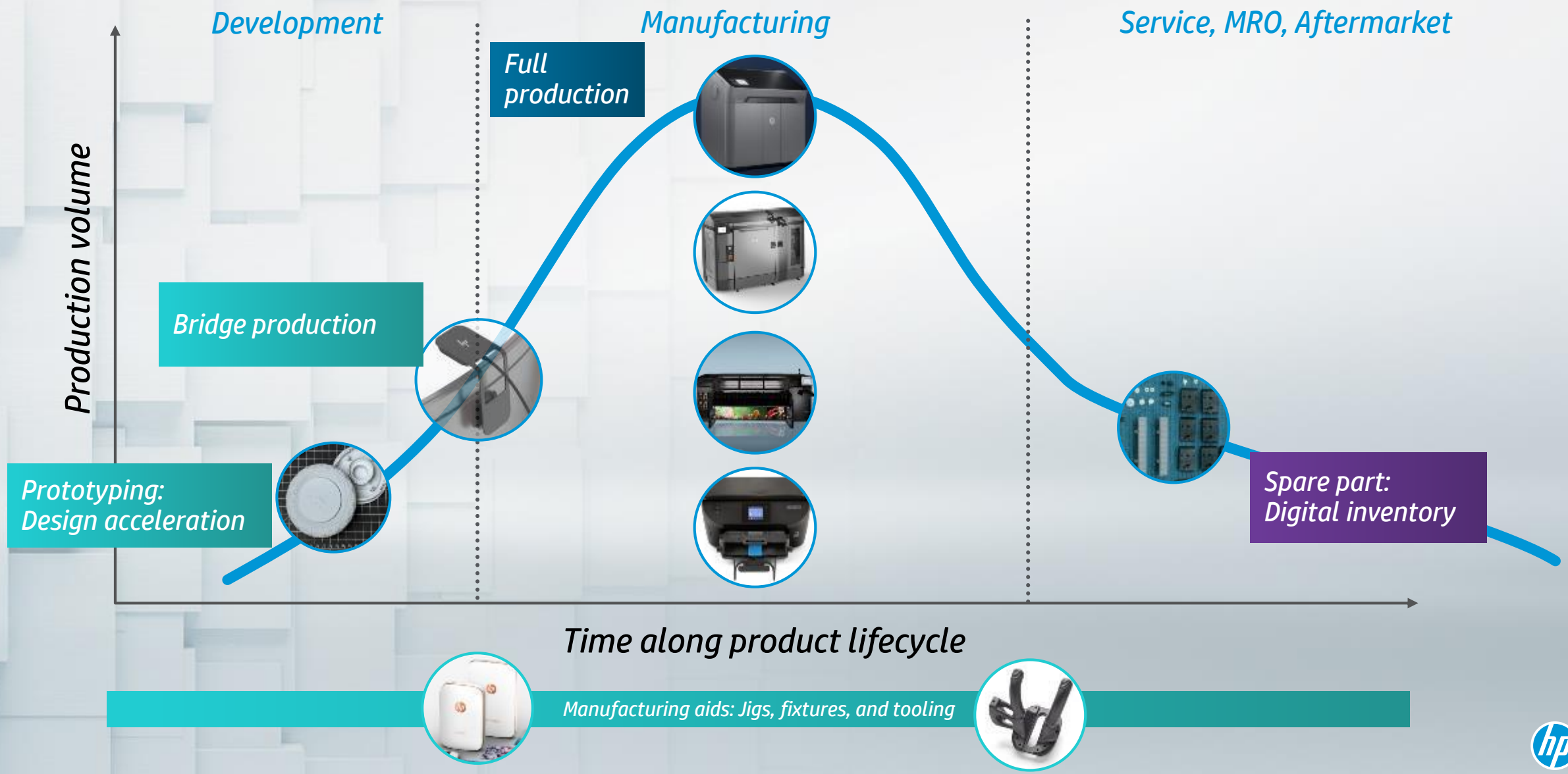


Intro MJF parts

- Cost avoidance
- Reduce design cycle by 6 weeks

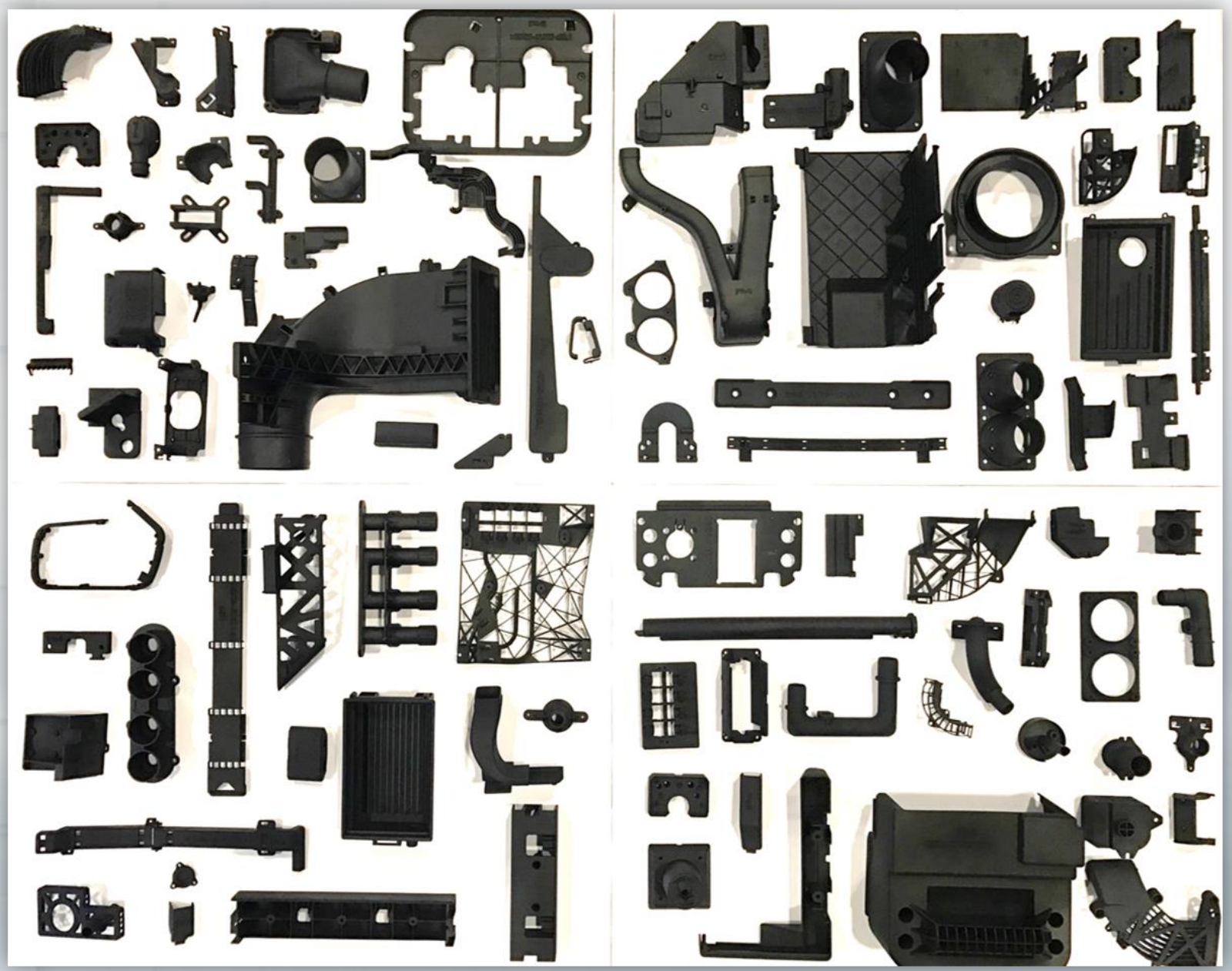
Thermal Duct

HOW TO CREATE NEW VALUE



HP JET FUSION 500/300 SERIES 3D PRINTERS

Representative sample: Multi Jet Fusion end-use parts



DESIGNING TO REDUCE MASS

Design evolution

77%
Mass reduction

84%
Mass reduction

93%
Mass Reduction

Aluminum machined
Traditional design

355g

Plastic 3D Printing
Replicated design

80g

Plastic 3D Printing
Adapted design

55g

Plastic 3D MJF Printing
Optimized design

23g

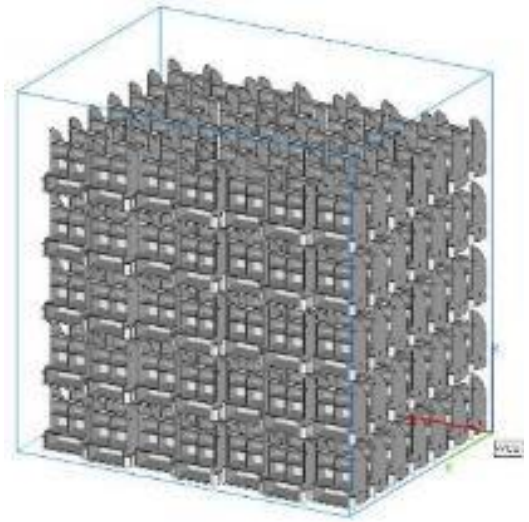
Note: this example is from HP Latex Printer

DESIGNING FOR FLEXIBLE MANUFACTURING

We started with the vision for additive manufacturing

- Balanced capacity
- Flexible manufacturing platform
- Limited fixed cost investment
- Schedule flexibility
- Scalable
- Minimal waste
- Parts delivered JIT

Single part, nested 245 times

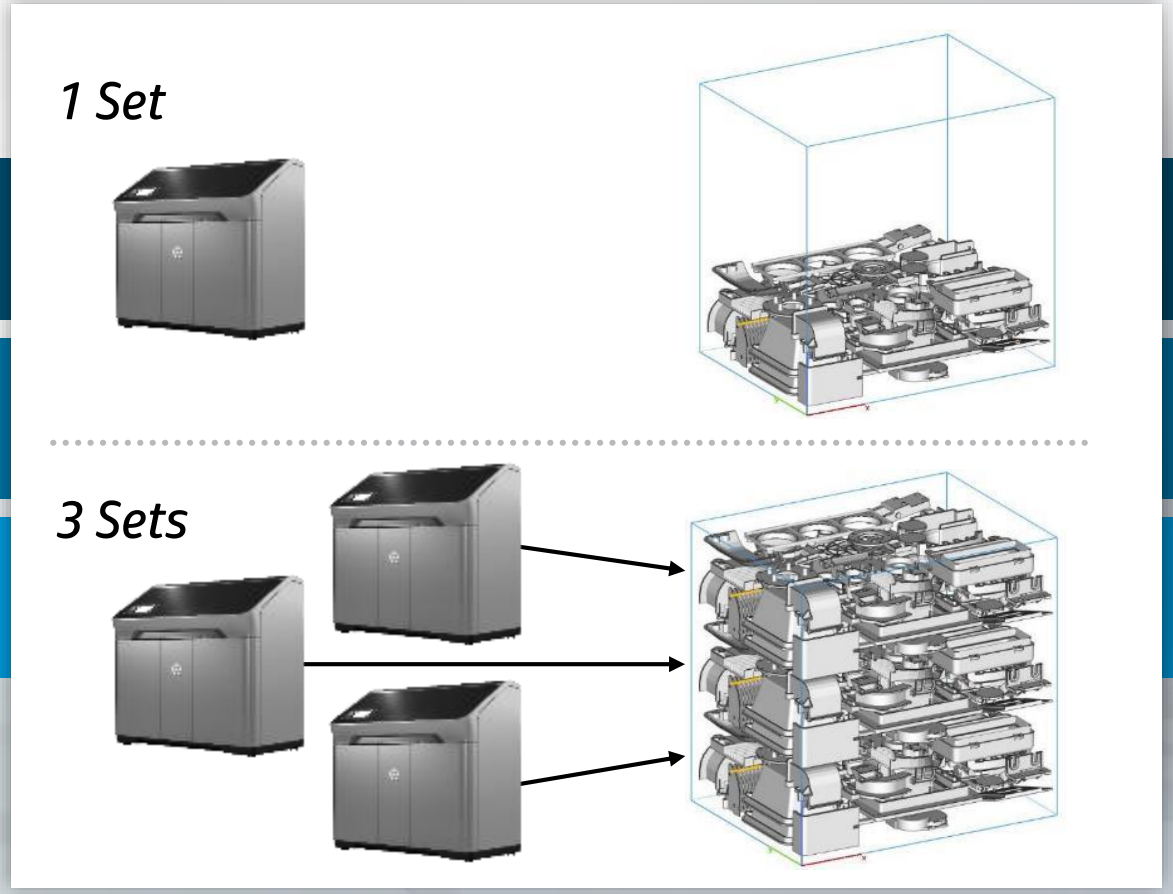


And we quickly realized that massive orders of individual parts, how we've always operated, ***was not fulfilling that vision.***

DESIGNING FOR FLEXIBLE MANUFACTURING

By ordering in complete sets we were able to

- Control inventory
- Lower our costs
- Better match supply and demand

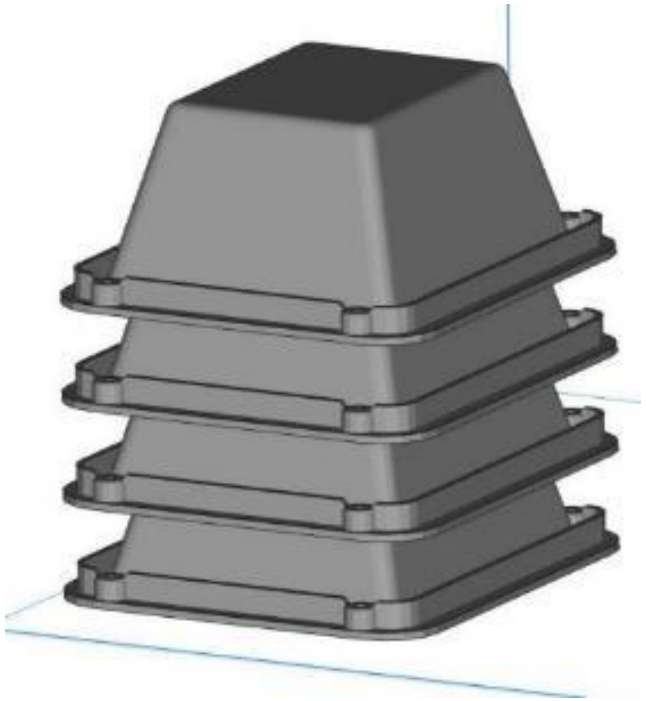


Kanban [kahn-bahn]

Noun 1. a just-in-time method of inventory control, originally developed in Japanese automobile factories.

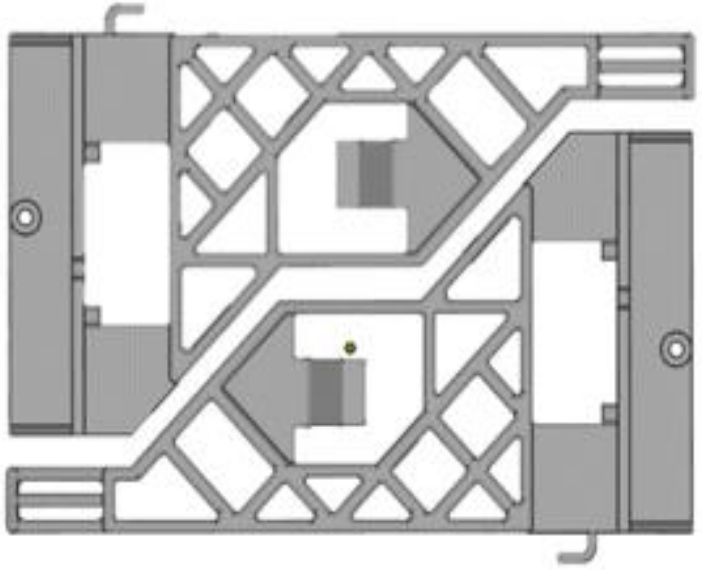
DESIGN FOR PACKING

Vertical stacking



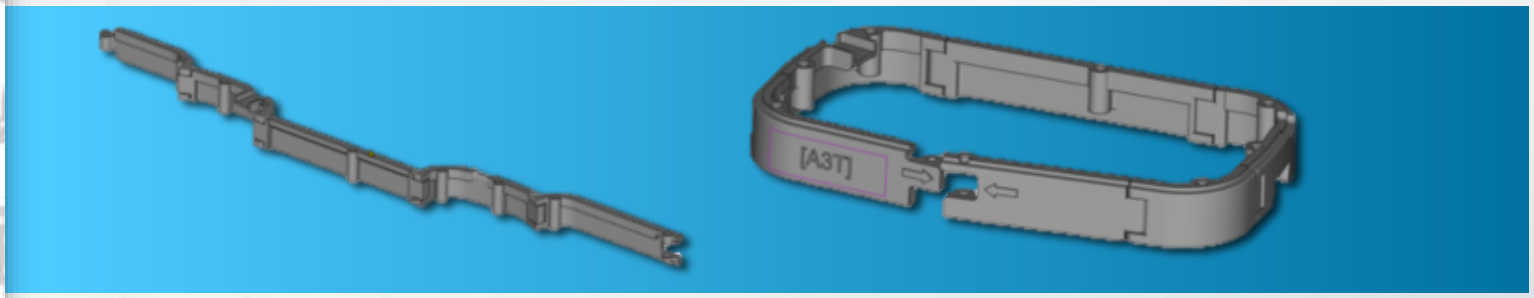
Nested structure

Planar symmetry



Tessellating patterns

FOLDABLE DESIGNS ENABLE NEW ASSEMBLY OPTIONS



Ductility Enables Living Hinges

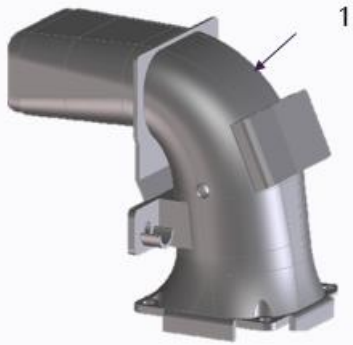
Design Freedom Enables *Hinges*

Replacing clamps and Attachments

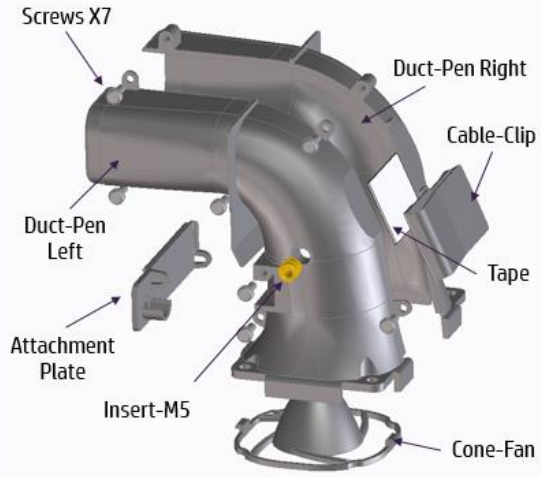
FLUID MANAGEMENT SYSTEMS

Polyamide-12 has low moisture absorption and high chemical resistance

Multi Jet Fusion



Injection Molded Version



>30%
total cost reduction

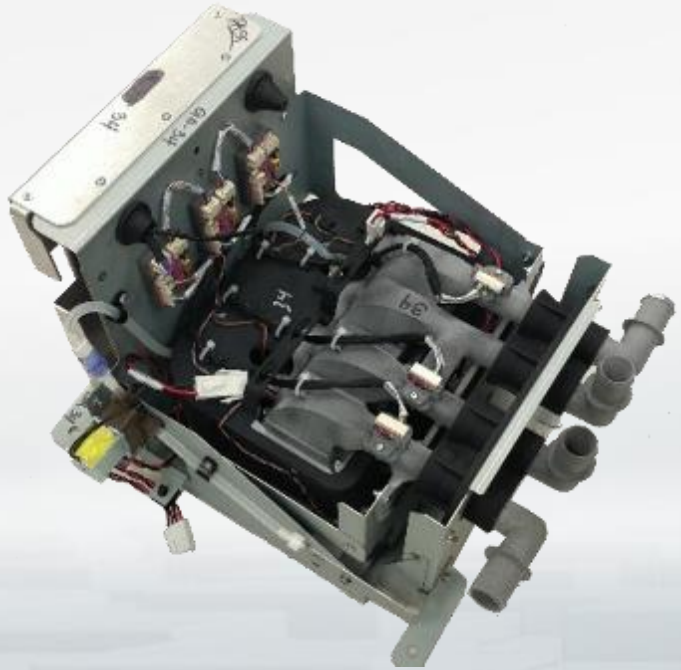
>$190k
in capital expense avoided

Invented by: Samuel Jeong

- No tooling spend or assets to manage
- No assembly / testing required
- Simplified supply chain and qualification
- Time savings for designer

ACCELERATED DEVELOPMENT

New subsystems required



Design for 3D guiding principles

Design strategy

- Commodity and custom parts
- Simple sheet metal
- Minimize custom tool parts
  freeze and commit early
- Complexity and design changes in
  Multi Jet Fusion parts

Design for functionality in Multi Jet Fusion only

- Don't design to be tooled later
- Complexity through integration
- Change in Multi Jet Fusion

Enables focus on "how it works" not "how to make"

Results

Schedule enablers

No design for plastic tooling	*4-6 weeks*
Internal MJF vs outsourced 1 day vs. 5 day turn for testing	*2-3 weeks*
Avoid tooling and tooling changes	*5-7 weeks*
Ramp with tested design	*0-6 weeks*
Mfg lead time 2 weeks vs 5 weeks	*2-4 weeks*

Total savings ***13–26 weeks***

Enables focus on integration testing

WHAT DOES IT TAKE IN THE ORG.

Changing the way we innovate and do business for increased competitiveness

MJF Challenge

Change management across ALL levels and functions in the organization

MJF Learning

Rally teams across functions to think differently

Design for additive

New supply chain

Specifications and Procedures

AUTOMOTIVE ECOSYSTEM

Deloitte.

JABIL

SIEMENS

Henkel

FR

LINEAR AMS

NovaStar SOLUTIONS

THANK YOU!

Join us at our lunch & learn today at 1:15pm near the HP 3D Printing booth (#23) in the exhibit hall!