



THE CONSEQUENCES OF OVERLOOKING METAL ADDITIVE MANUFACTURING

25 March 2026

Ehsan Foroozmehr, PhD

Director of E-Metal3D; Lecturer at EIT

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E-METAL3D
Additive Manufacturing Solutions



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Discover Why Students Choose EIT



#1

#1 Australian Provider for Student's Overall Satisfaction in Postgraduate Engineering Programs*



#1

#1 Australian Provider for Graduates in full time employment for Undergraduate Engineering Programs*



Top 3

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Top 3

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**2021/2022/2023 aggregated data from the Student Experience Survey and Graduate Outcomes Survey– qilt.edu.au*

Awards



2024 Australian Export Award for International Education and Training



2024 West Australian Export Award for International Education and Training



Introduction – Presenter

Ehsan Foroozmehr, PhD



PhD in Metal Additive Manufacturing

Southern Methodist University, Dallas, Texas, 2006-2009

Postdoc in Additive Manufacturing

University of Waterloo, Ontario, Canada, 2010-2011

Faculty Member of Mechanical Engineering

Isfahan University of Technology 2011-2022

Co-founder and Engineering Manager

Noura Co. (MAPNA Additive) 2012-2022

Technology Manager

Aroura Labs, Canning Vale, WA, 2022-2023

Co-founder and Director

E-Metal3D, Bibra Lake, WA, 2024

Lecturer

Engineering Institute of Technology, 2024

- Over 60 publications in peer reviewed journals
- Supervising and advising 8 PhD and over 70 MSc projects on AM
- Teaching Laser Material Processing and Additive Manufacturing
- Over 2100 citation and h-index of 23

- Design manager of 5 models of LPBF systems

- Eng manager of design team of first commercial LPBF system, AL250

Agenda

1	Introduction to Additive Manufacturing
2	AM Classification
3	Materials in Metal AM
4	Benefits of Metal AM
5	Some Case Studies of adopting Metal AM
6	Design for Additive Manufacturing



Industries



Oil & Gas

- Corrosion Resistant
- Subsea Parts
- Heat Exchangers
- High-Temp Equipment
- Supply Chain Optimisation
- Customised Spare Parts On-Demand
- New Product Design and Functionality



Mining

- Wear-Resistant Parts
- Customised Equipment
- Spare Parts in Remote Locations
- High-Performance Drill Bits
- Components Repair and Refurbishment



Medica

- Patient-Specific Implants and Prosthesis
- Surgical Tools and Guides
- Bone and Dental Implants
- Orthopedic Devices



Aerospace

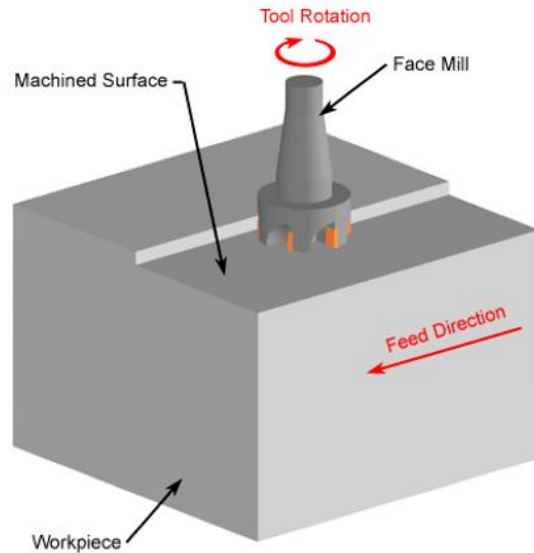
- Lightweight Structures
- Turbine Blades
- Fuel Nozzles
- Hydraulic Manifolds
- On-Demand Spare Parts
- High-Temp Engine Components



Manufacturing

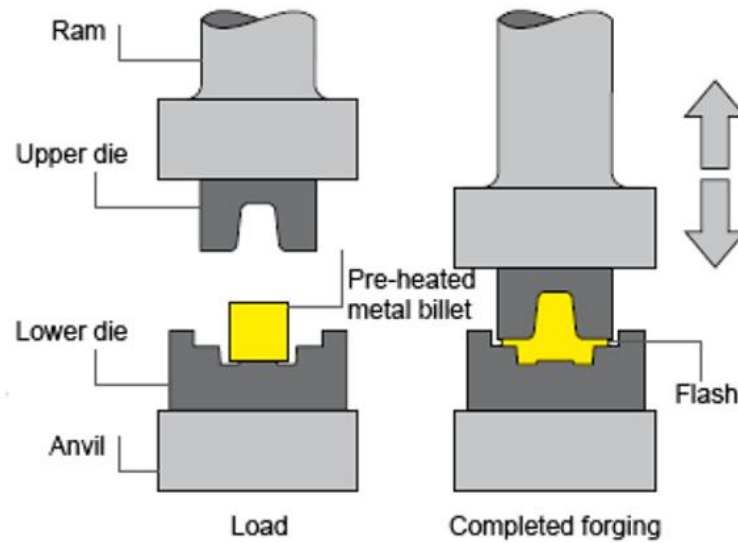
- Tooling and Jigs
- Rapid Manufacturing and Testing
- Customised Production Parts
- Low-Volume End-Use Parts
- High-Performance Molds and Dies

AM Technology

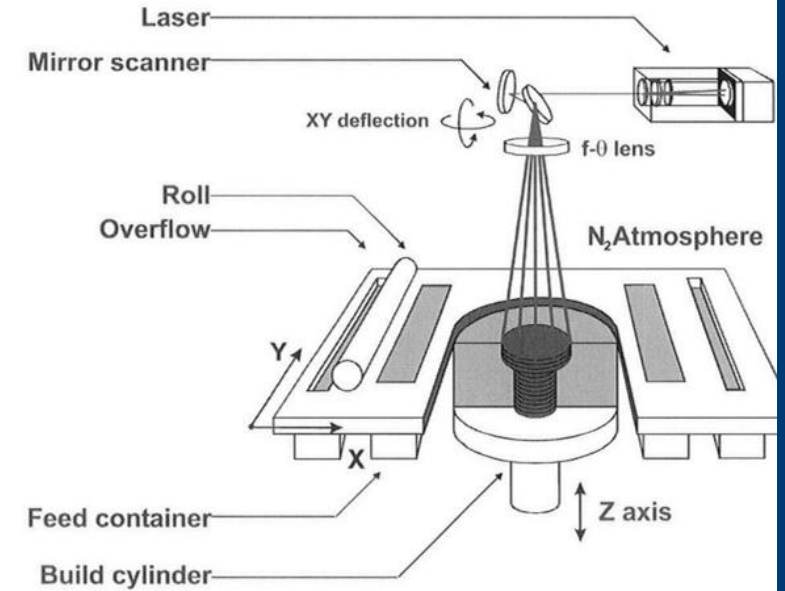


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Material Removal

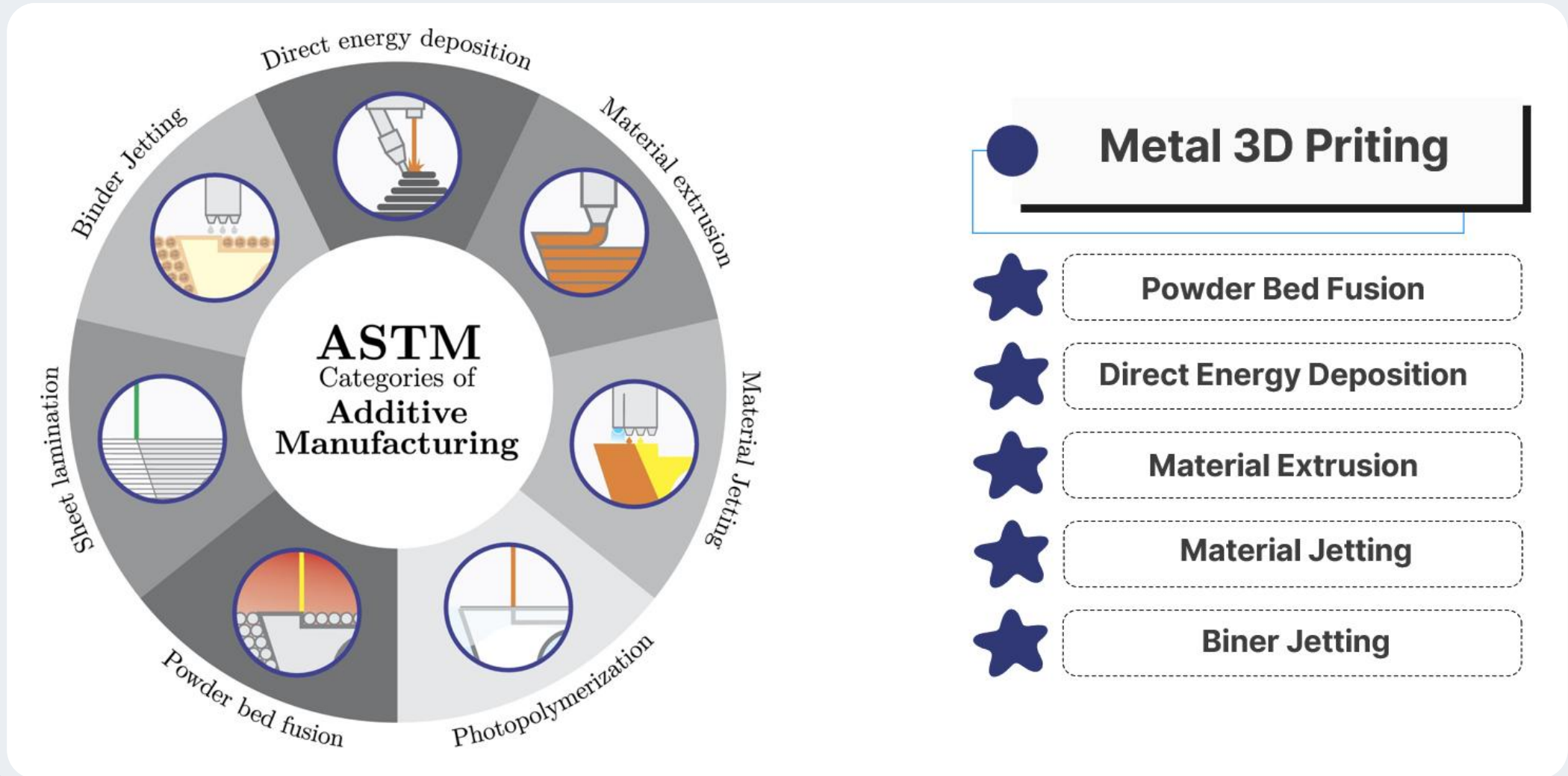


Forming

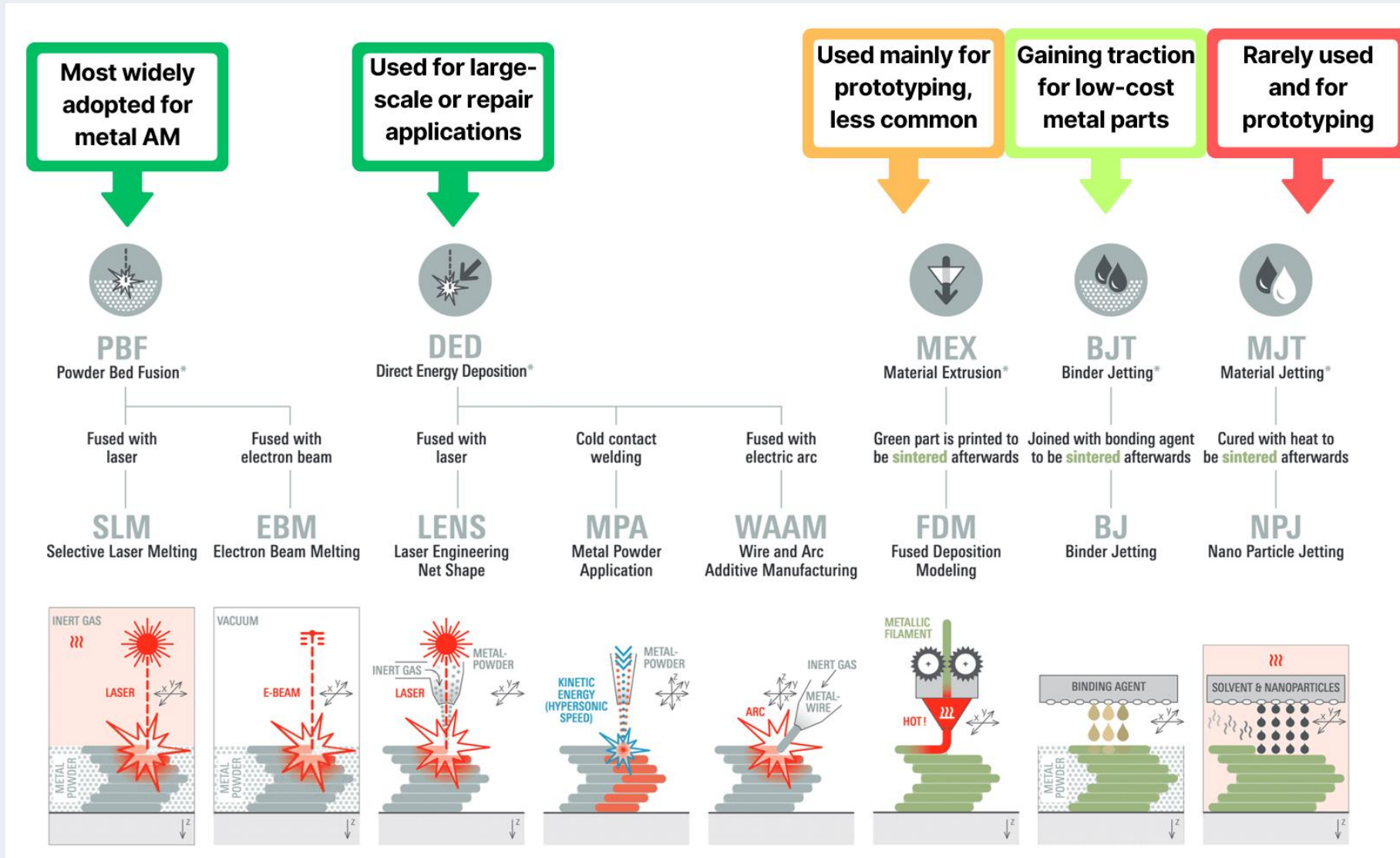


Additive Manufacturing

AM Classifications



Metal AM Methods





Metal 3D

The Metal 3D Printing Story



- **Steel**

- 18Ni300 (MS1)
- 13Ni400
- 316L
- 17-4PH
- 15-5PH
- H13
- Invar 36

- **Nickel Alloys**

- IN625
- IN718
- HX

- **Aluminium**

- AlSi10Mg
- AlSi7Mg
- CP1
- Scalmalloy

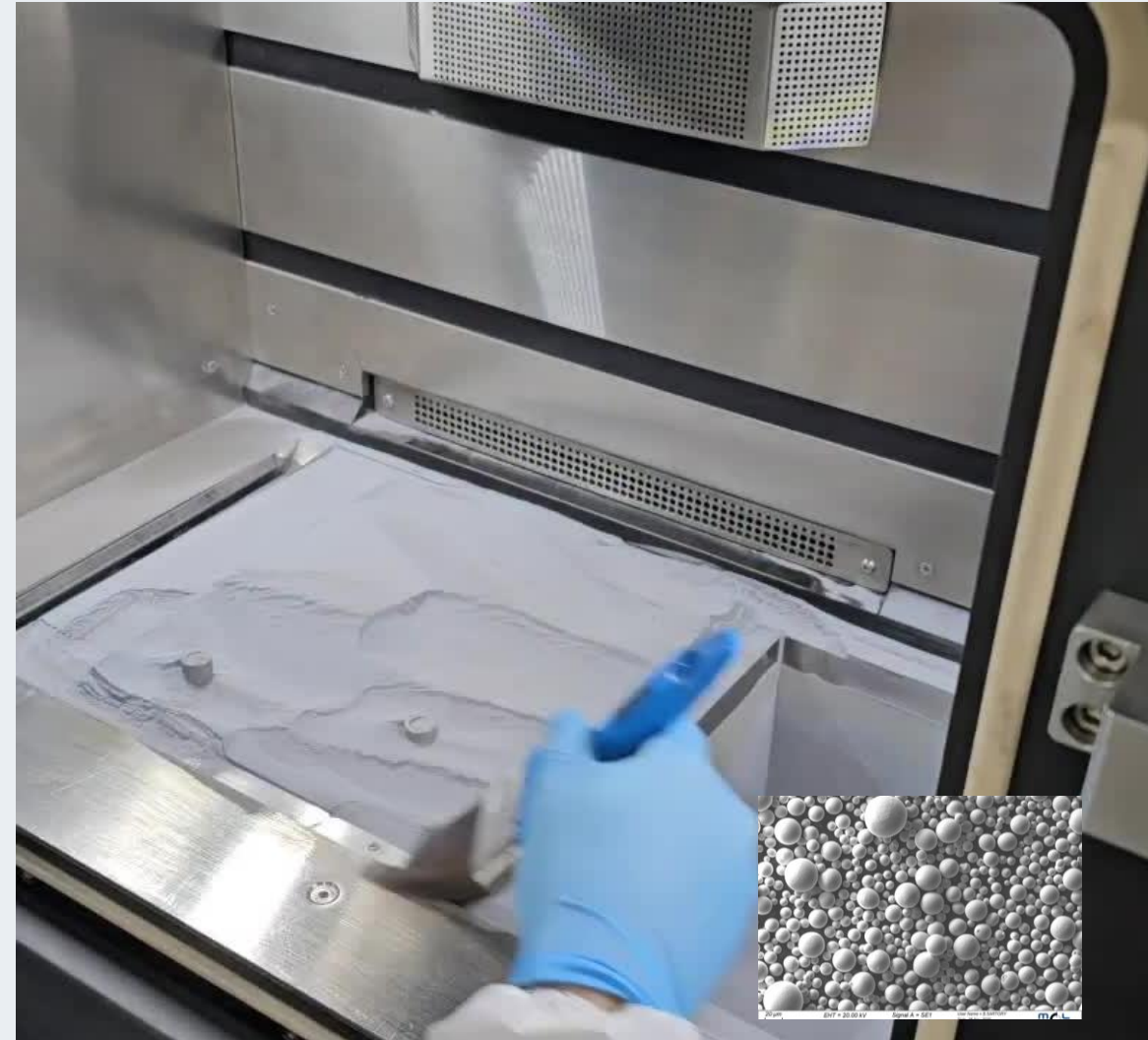
- **Titanium**

- Ti6Al4V
- CP-Ti

- **Copper**

- CuCr1Zr
- CuNi30
- CuNi2SiCr

And more...

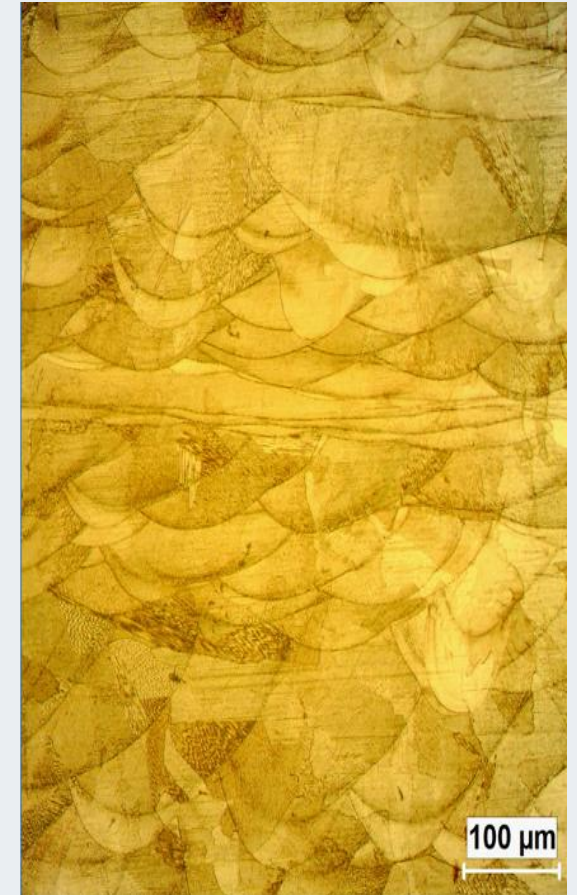


Properties

- **Fully dense structure with a density of over 99.5%**
- **Surface roughness of 5 μ m (Ra) or less, with the possibility of polishing to a mirror-like surface**
- **Exceptional mechanical properties**
- **High-dimensional accuracy**








Polished cross-section of SS316L
about 25 layers



Etched cross-section of SS316L
about 25 layers

Mechanical Properties

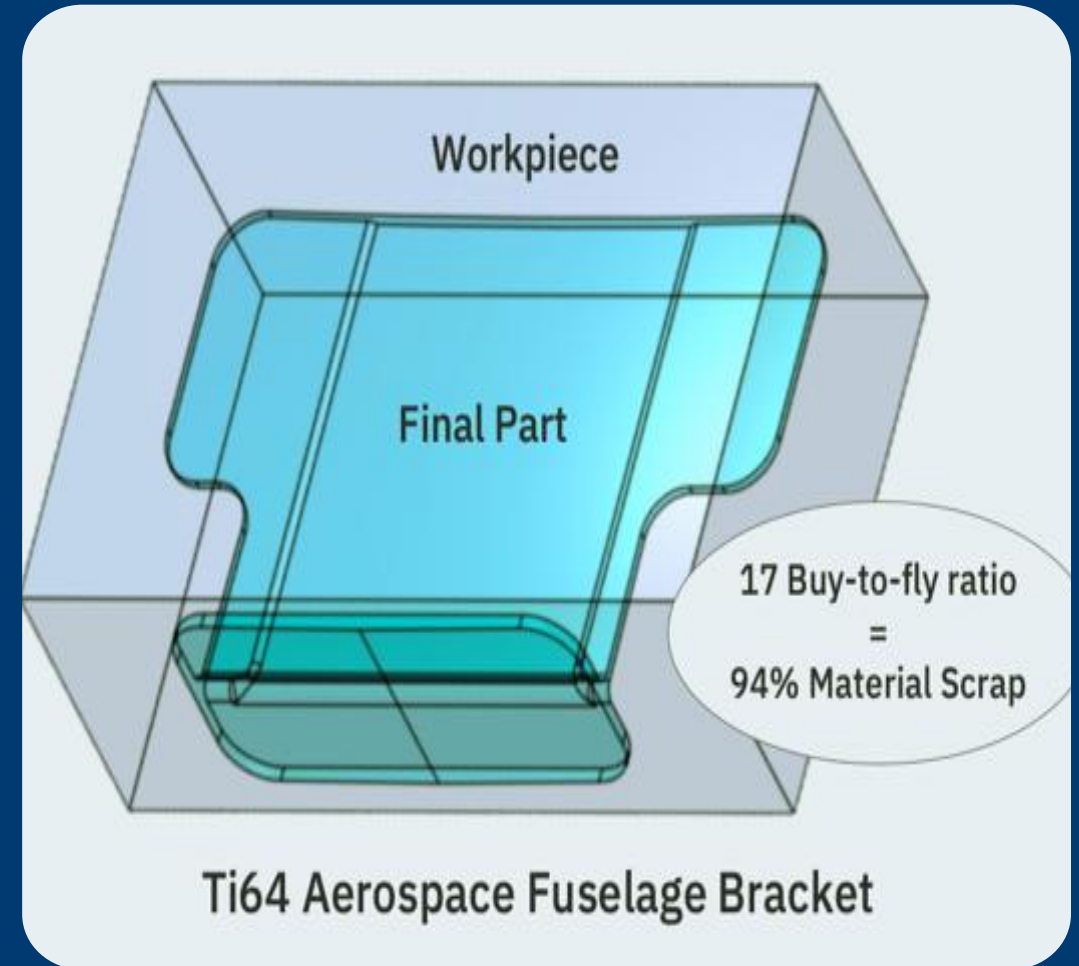
Data extracted from EPlus3D, EOS, Nikon SLM Solutions	As-Built Properties				Heat Treated Properties			
	Yield Strength	Ultimate Strength	Elongation	Hardness	Fatigue Strength	Yield Strength	Ultimate Strength	Elongation
 316L	XY: 550±50 MPa Z: 510±50 MPa	XY: 670±30 MPa Z: 600±20 MPa	XY: 40% ±8 Z: 45% ±10	220 HV ±3				
 AlSi10Mg	XY: 270±30 MPa Z: 230±30 MPa	XY: 460 ±30 MPa Z: 445±30 MPa	XY: 9% ±2 Z: 6% ±2	125 HV ±5	110 MPa	XY: 250±30 MPa Z: 260±30 MPa	XY: 310±30 MPa Z: 320±30 MPa	XY: 11% ±2 Z: 11% ±2
 Ti6Al4V	XY: 1100±50 MPa Z: 1080±50MPa ASTM: 860 MPa	XY: 1200 ±50 MPa Z: 1180 ±50 MPa ASTM: 930 MPa	XY: 10% ±2 Z: 11% ±2 ASTM: 10%	360 HV ±10	595 MPa			
 IN718	XY: 770 ±30MPa Z: 640 ±15MPa	XY: 1070 ±20MPa Z: 970 ±10MPa	XY: 27% ±5 Z: 31% ±5	300 HV±5		XY: 1240±50MPa Z: 1145 ±30MPa ASTM: 1034 MPa	XY: 1505 ±50MPa Z: 1375 ±10MPa ASTM: XY: 1241 MPa ASTM: Z: 1276 MPa	XY: 17% ±3 Z: 12% ±1 ASTM: XY: 6% ASTM: Z: 12%
 IN625	XY: 740±30 MPa Z: 630±20 MPa	XY: 980±20 MPa Z: 870±10 MPa	XY: 30% ±2 Z: 40% ±5	300 HV ±7		XY: 680±10MPa Z: 640±10MPa	XY: 1000±10MPa Z: 890±10MPa	XY: 34% ±2 Z: 49% ±2

Metal AM Benefits

Less Material Waste

Buy-to-fly determines the amount of material waste generated during the rough-cut step and the machine time required to complete the rough cuts. In aerospace, the average is 11:1 and can reach to 30.

By adopting AM, this value can be less than 2.



Metal AM Benefits

Less Carbon Footprint

Minimal waste during the manufacturing process results in less carbon generation, comparing with traditional machining processes.



Metal AM Benefits

Design Freedom

Unmatched design freedom exists when using LPBF technology in manufacturing metal parts.



Metal AM Benefits

Rapid Production

From design to the final part takes a few clicks! No special programming is needed for each part.



Metal AM Benefits

Superior Mechanical Properties

As-built 3D printed parts demonstrate high strength and almost no porosity. The high strength is accompanied by high elongation due to fine-grained structures. Heat treatment can be used to further modify the microstructure.

Tensile strength of SS316L made via EPLUS M260 in 30um layer thickness

Table 1: Test area / items identification (provided by the client) and results

Item identification	Specimen ID	Dimension (mm)	GL (mm)	Max force (kN)	Fracture position	UTS (MPa)	0.2% Proof (MPa)	%E or A ₅
01) T	LP25-0626-01	6.25 Ø	25.0	21.80	Central third	711	538	37.2
02) R	LP25-0626-02	6.24 Ø	25.0	22.20	Central third	726	572	33.6
Requirements :						Minimum	NA	NA
						Maximum	NA	NA

Legend: Ag - % Elongation @ stated gauge length, Ar - Proportional % elongation @ VS.65 So, C - Comply, DNC - Did not comply, E - Elongation, E(µm) - Elongation within stated tolerance, F - Failed, GL - Gauge Length, Ls - Shank length, NA - Not applicable, N - Elongation at Break, RP - Report findings, UTS - Ultimate Tensile Strength, Y - Elongation <= within specified tolerance

Comments

Nil

Metal AM Benefits

Weight Reduction

Not only can the design be optimised to reduce the part's weight, but by using lattice structures, internal components can be manufactured with less weight while still capable of withstanding high loads.

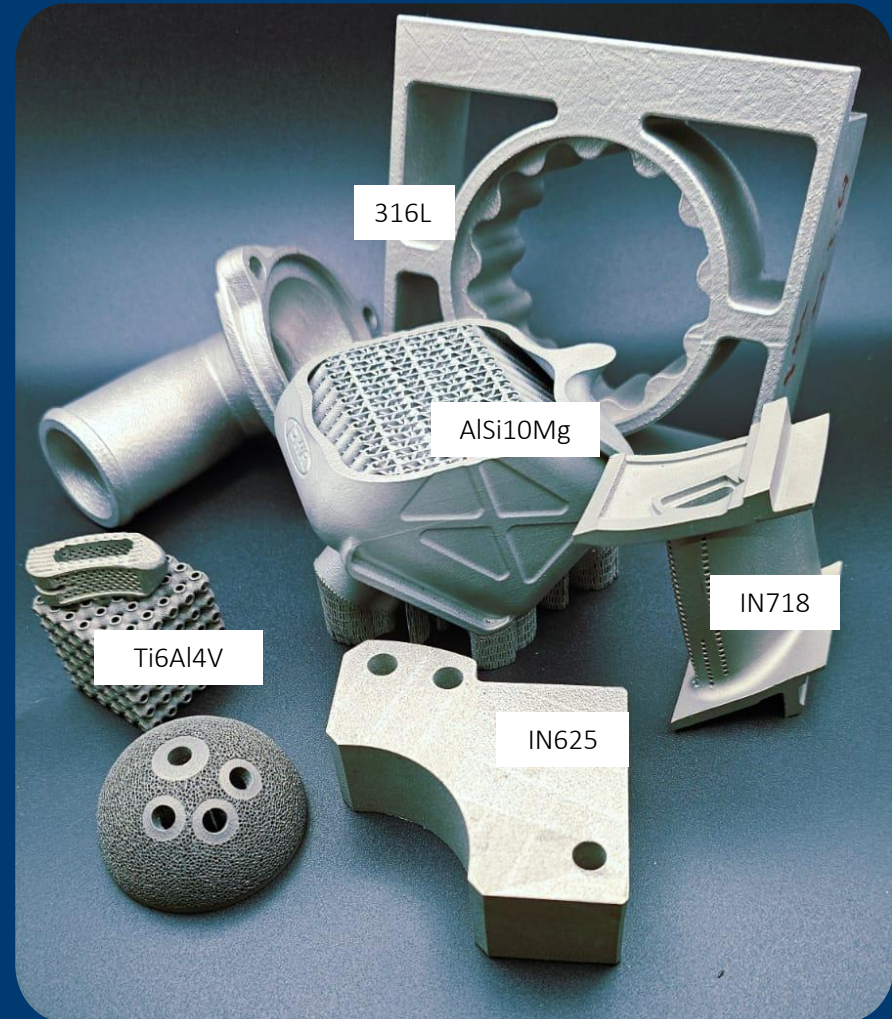


Metal AM Benefits

Wide Range of Materials

From high-temperature alloys to corrosion-resistant materials, from high-strength stainless steel to creep-resistant materials, can be found in printable materials.

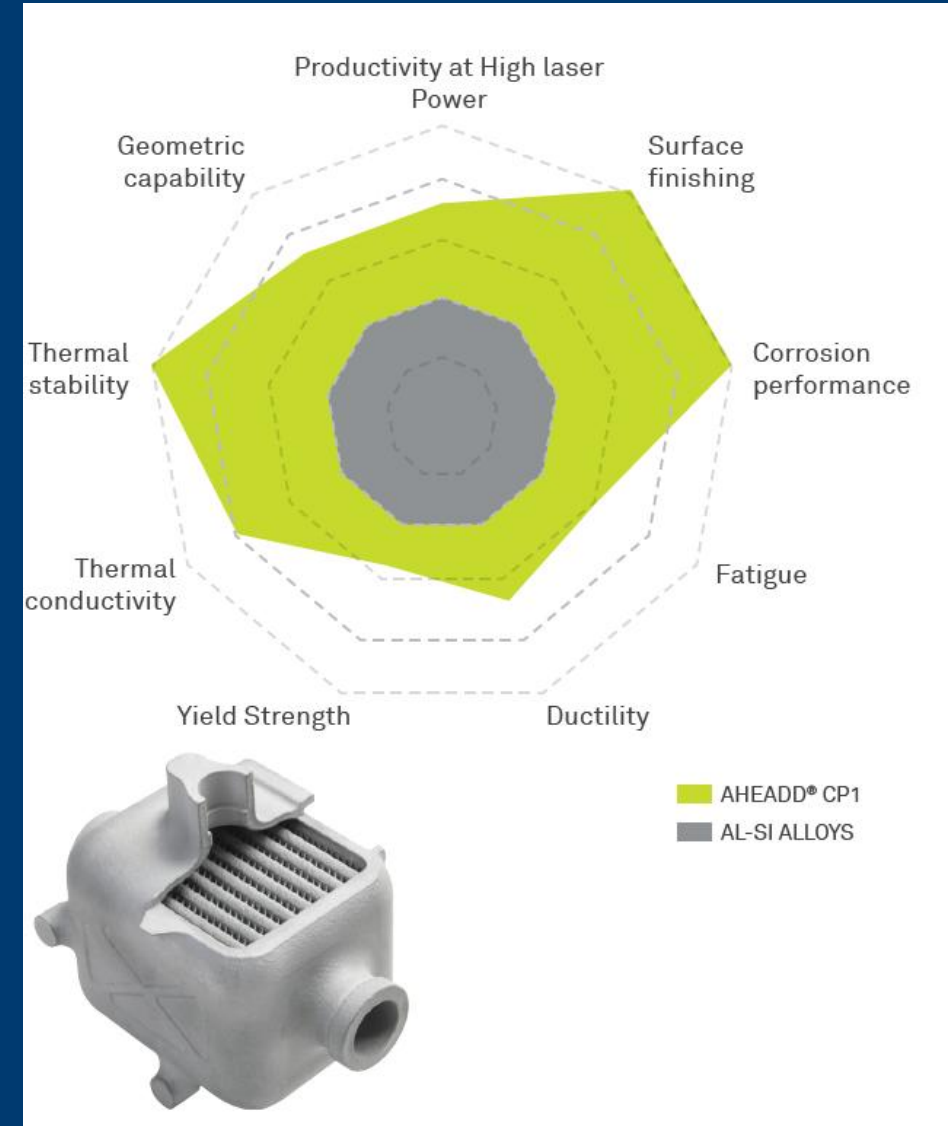
Newly designed alloys for AM can provide better properties than conventional ones.



Example

Aheadd® CP1:

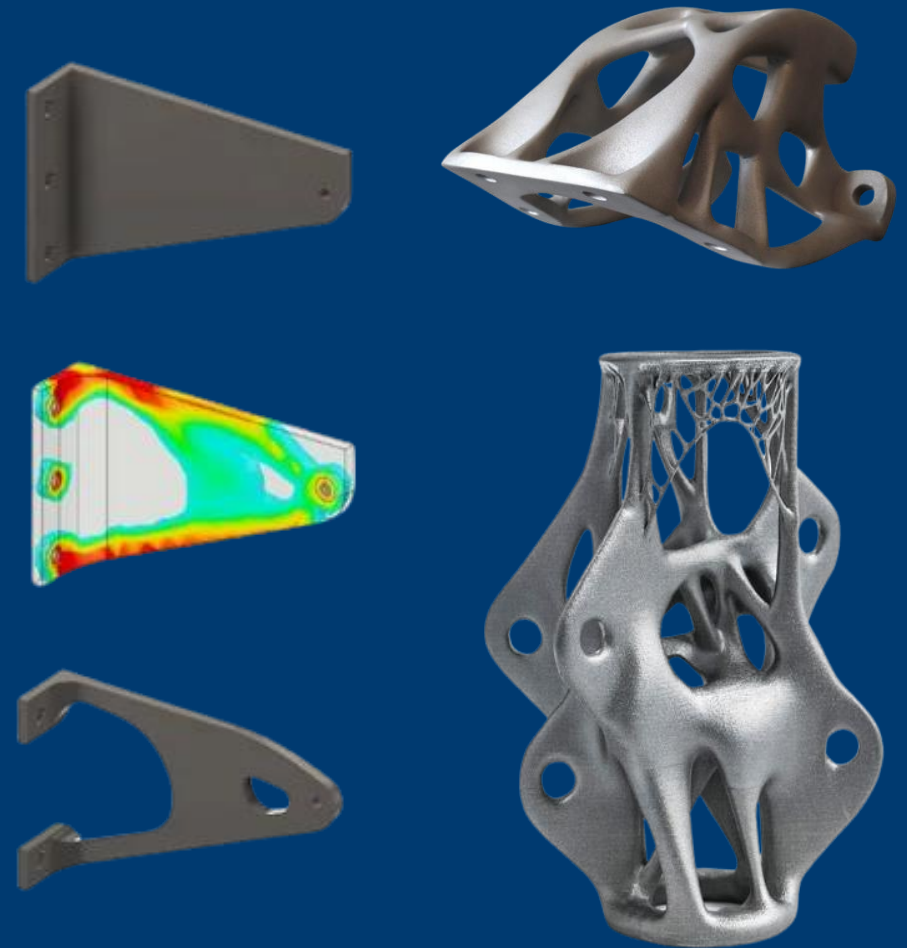
An Aluminium-Iron-Zirconium powder solution designed specifically for the additive manufacturing by Constellium



Metal AM Benefits

Topology Optimisation

Considering the load distribution, the material is used where it is needed. With topology optimisation methods, lightweight structures can be designed and turned into the most efficient industrial components via additive manufacturing.



Metal AM Benefits

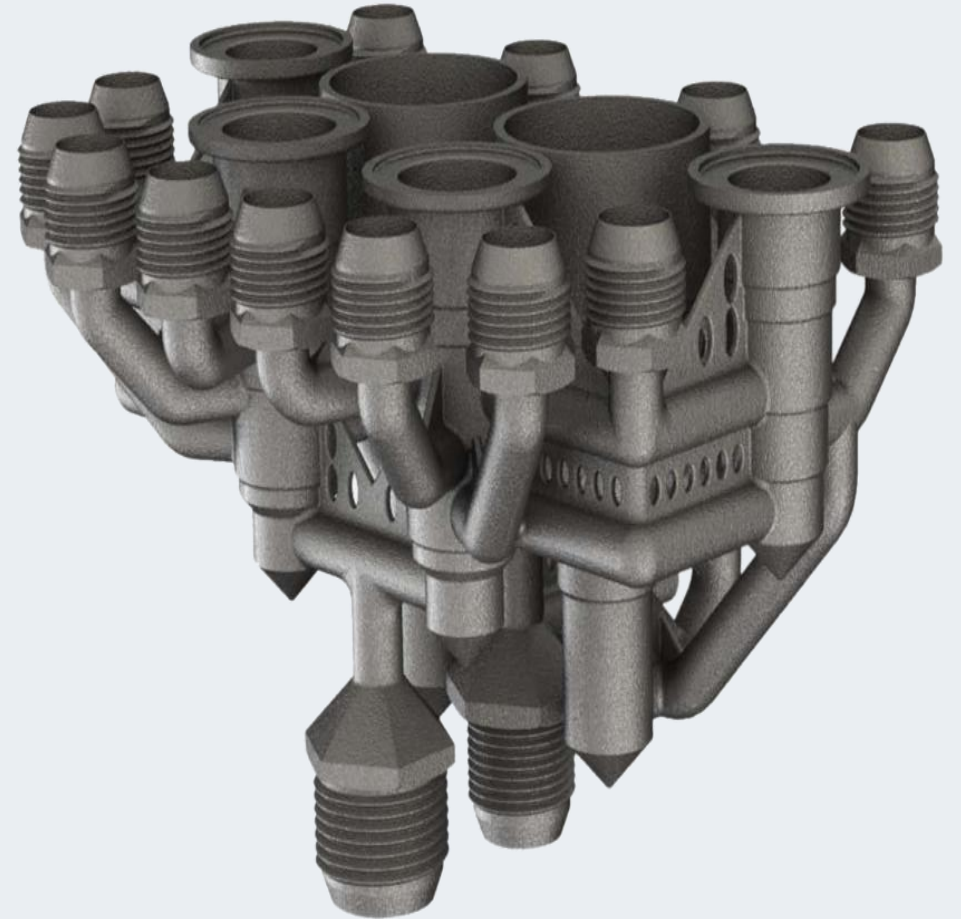
Part Consolidation

Consolidated assemblies remove the time, labour, and potential human error of assembly. They eliminate bolting, screwing, welding, or other joining methods that may introduce weaknesses to the overall structure and remove the potential for alignment issues or inconsistent tolerances among parts.



Hydraulic Manifold

A Caser Study



Objectives

To optimise a Hydraulic manifold of Atlas Copco for:

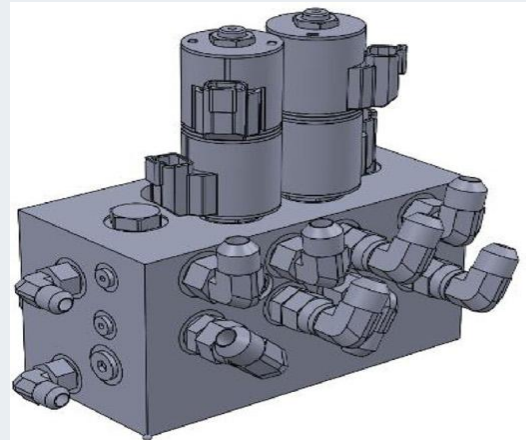
- Weight reduction
- Better efficiency
- Cost reduction

Original manifold:

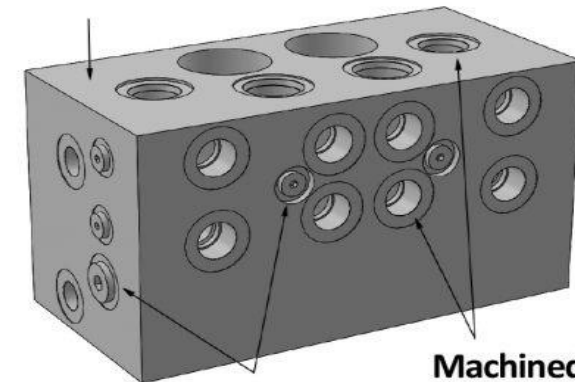
- Material 316L
- Weight 16.2 kg

The project was defined initially in 2017 at Lund University in Sweden and then in 2020 at Auckland University in New Zealand.

The second project was defined to improve the proposed 3D manifold in round one.



Stainless steel block

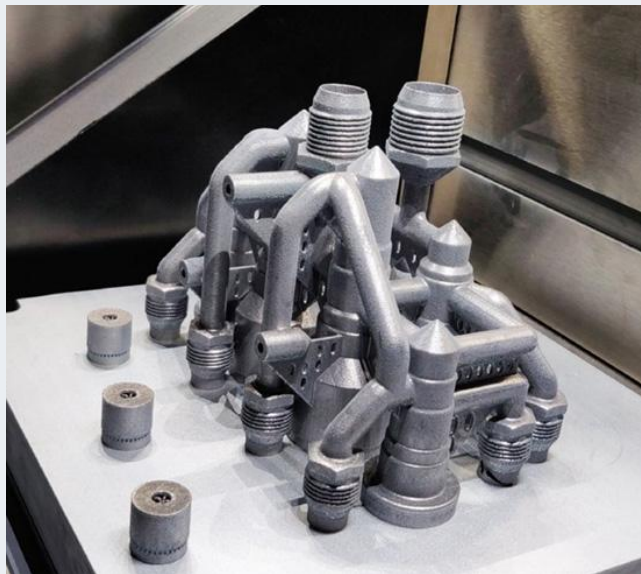


Plugged holes

Machined and drilled input and output ports and channels

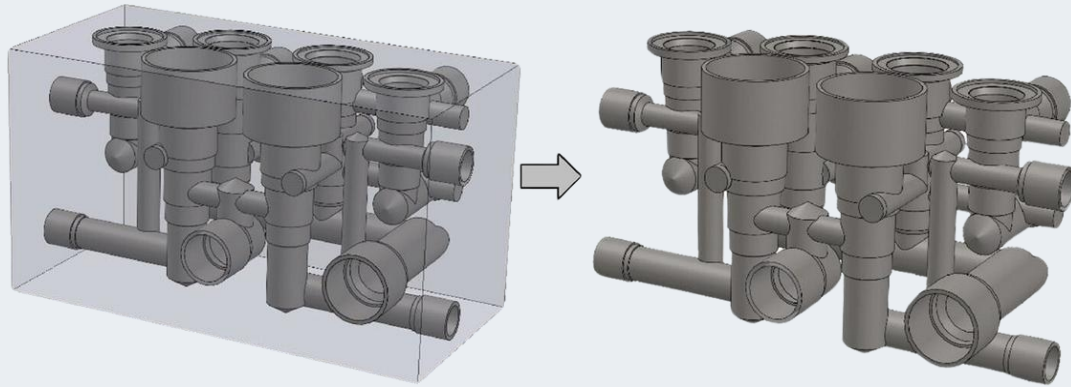
Results

The design in the first step improved efficiency and weight. However, the post-processing required to remove all support structures needed much time and cost.



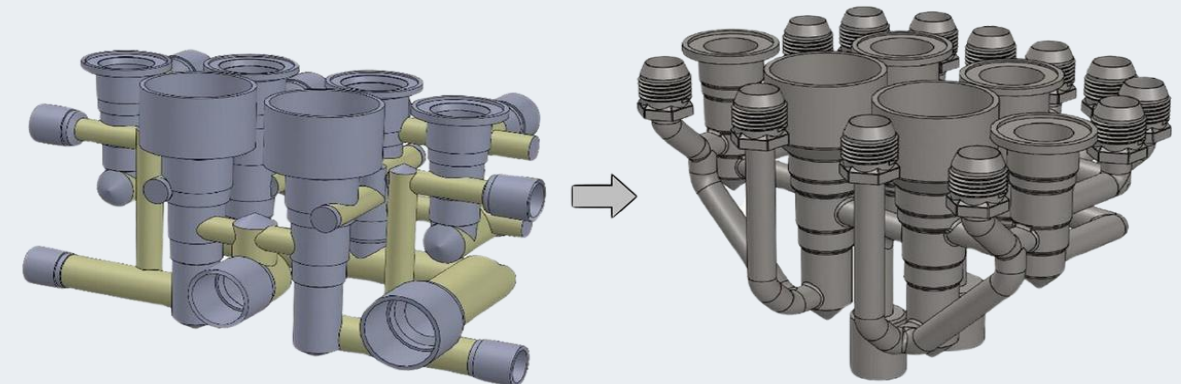
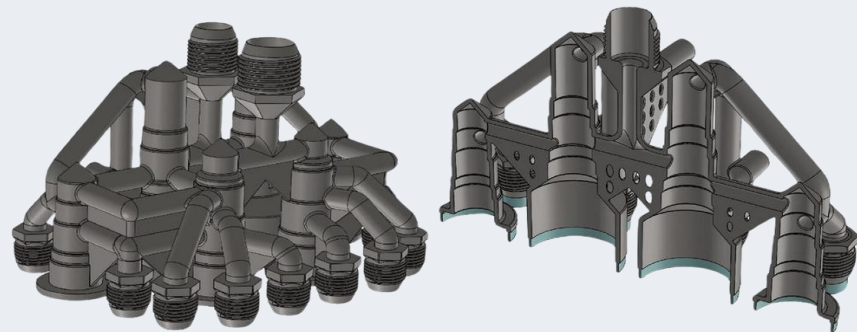
The second design showed less than 2% support structure with minimal post-processing time.

Design Process



Step 1: Removing all material that does not add functionality.

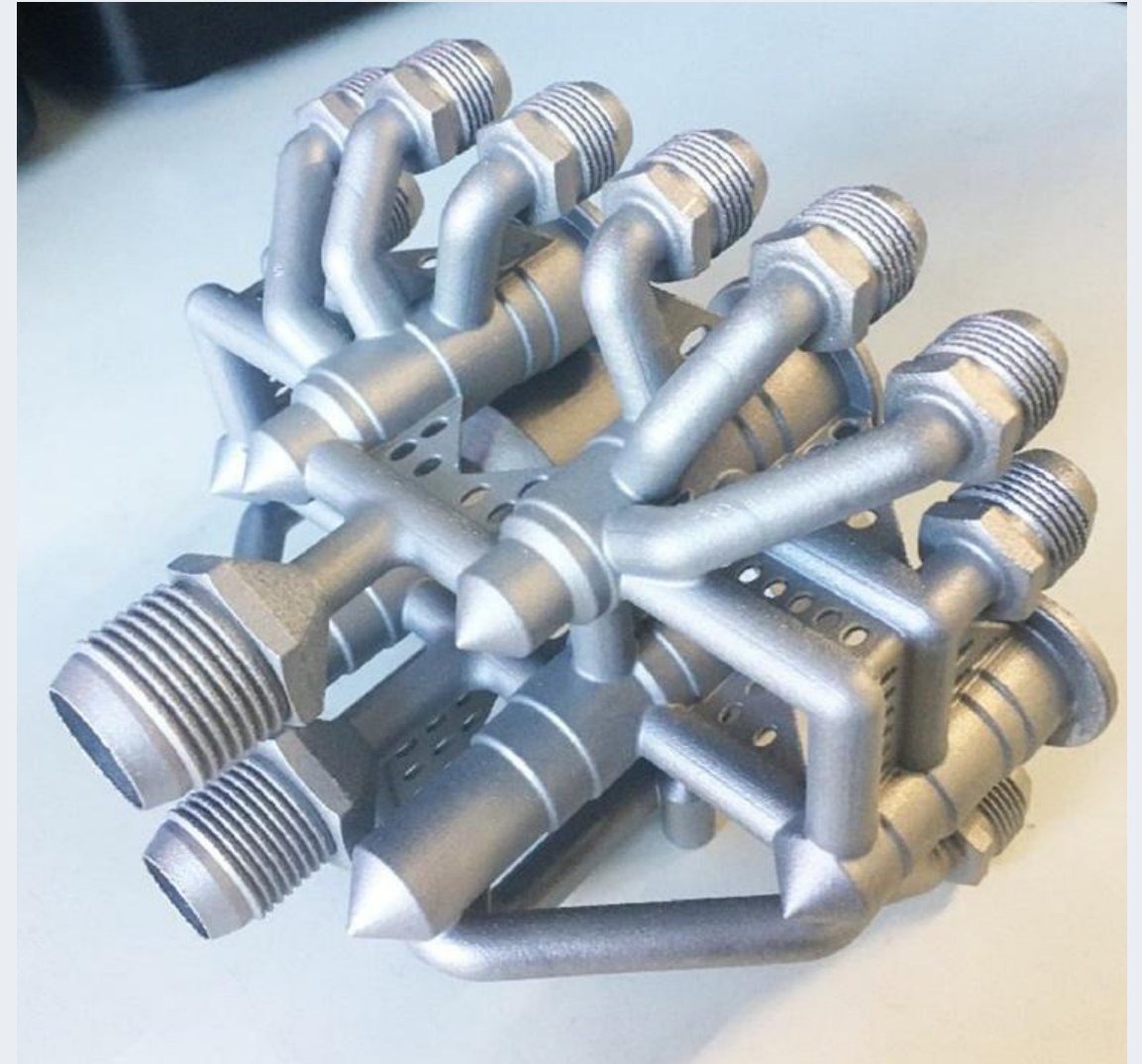
Step 2: Redesigning the manifold to improve its functionality



Step 3: Design modification by adding permanent walls to eliminate the need for support material

Outcome

- Uniform 2mm pipe thickness with 1.5mm support walls and gussets.
- **1.4kg 316L stainless steel**
- 91.2% weight reduction
- Allowable pressure of 68MPa
- Print time: 24h



A Microphone Story

New Version

Old Version



Challenges

1. Discontinued production of the frame parts
2. Multiple items to manufacture and purchase
3. Long assembling time
4. High shipping weight

Objectives

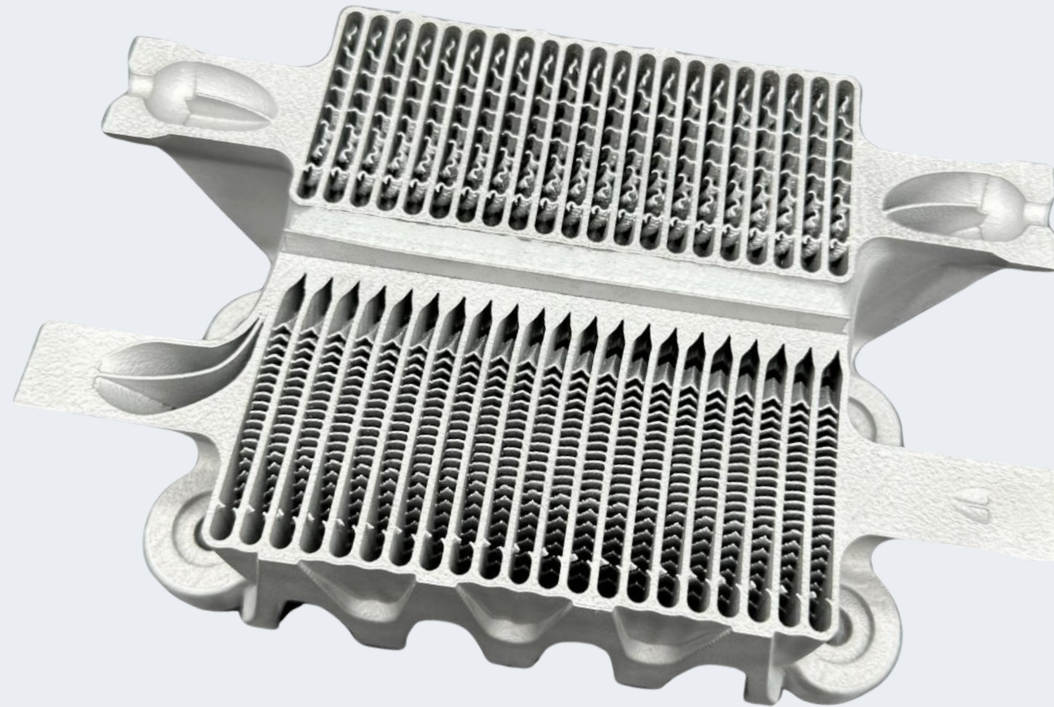
1. Integration of multiple parts
2. Weight reduction
3. Ease of assembly
4. Cost-effective



Project Progress

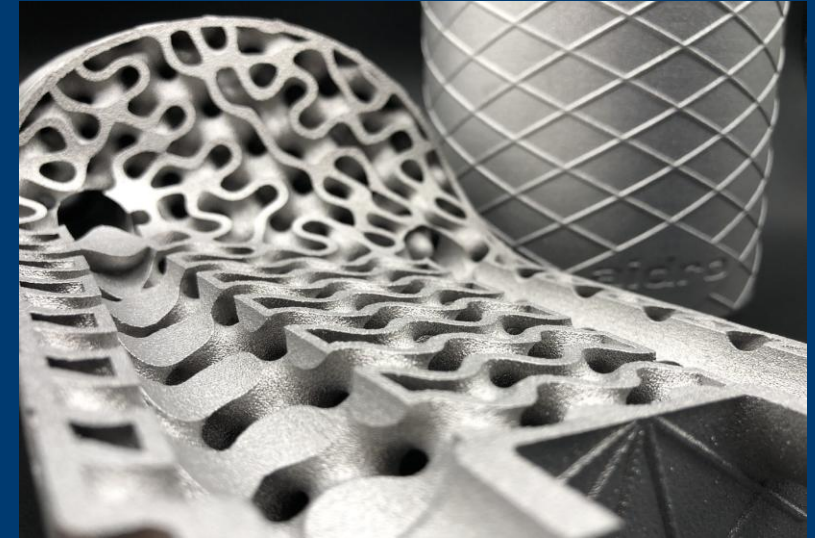


High Efficiency Heat Exchangers



Compact Heat Exchangers

- Large surface area per unit volume improves the heat exchangers' efficiency
- Compact and lightweight design makes them suitable for mobile and aerospace applications
- Eliminates brazing and, by consolidation, reduces leakage risk
- Fluid flow can be easily optimised
- Heat exchangers from corrosion-resistant and high-strength materials can stand a harsh environment
- Customisation is accessible for specific applications
- Rapid development and iteration are possible

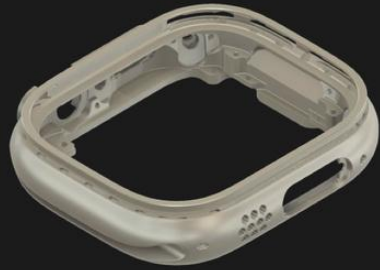


New Generation Apple Watch



Apple Watch

3D Printing Saves Raw Materials



400+
metric tons

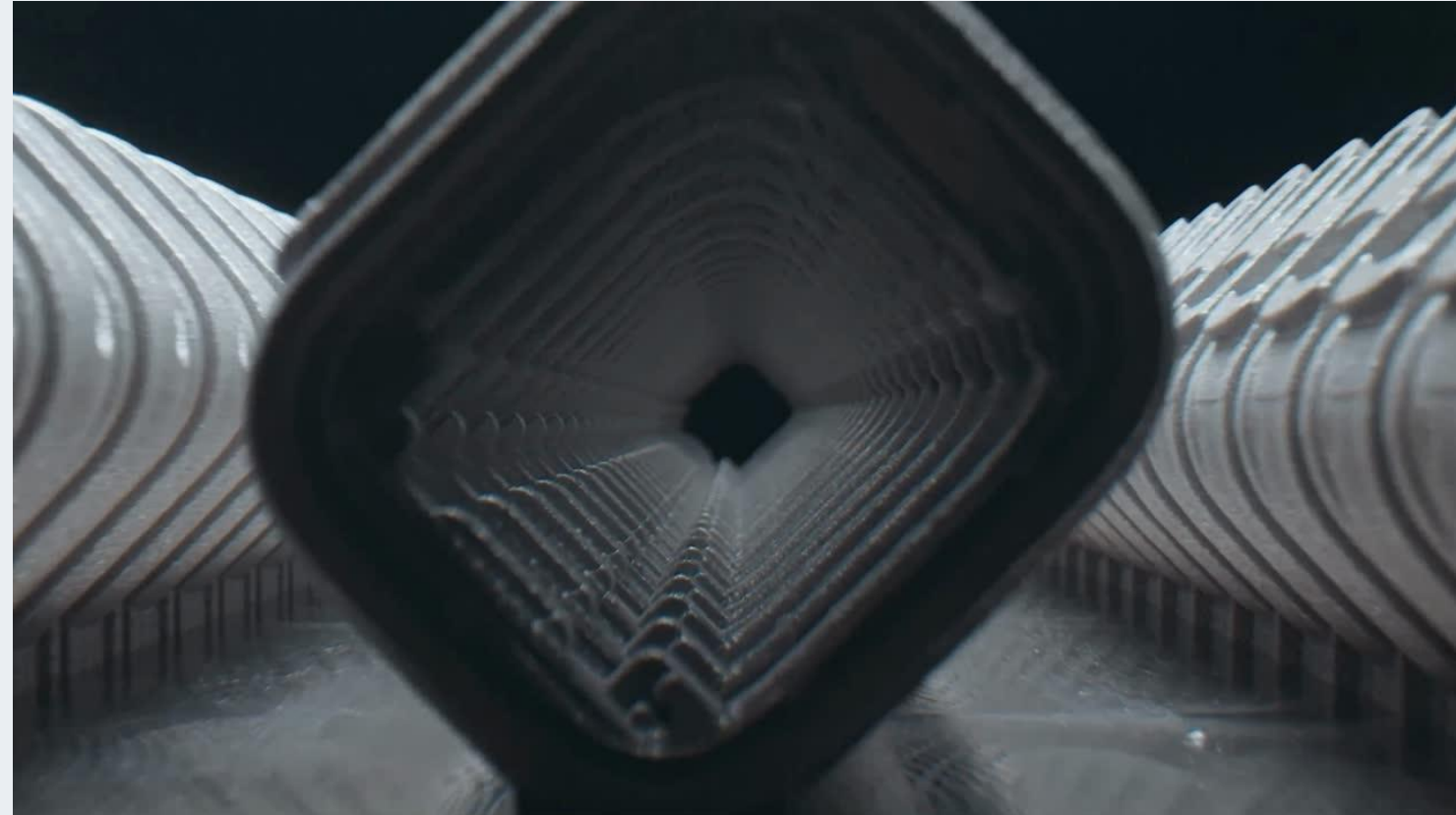
in raw titanium
savings in 2025

100%

aerospace-grade
recycled titanium
powder

50%
less

raw material used
than previous
generations

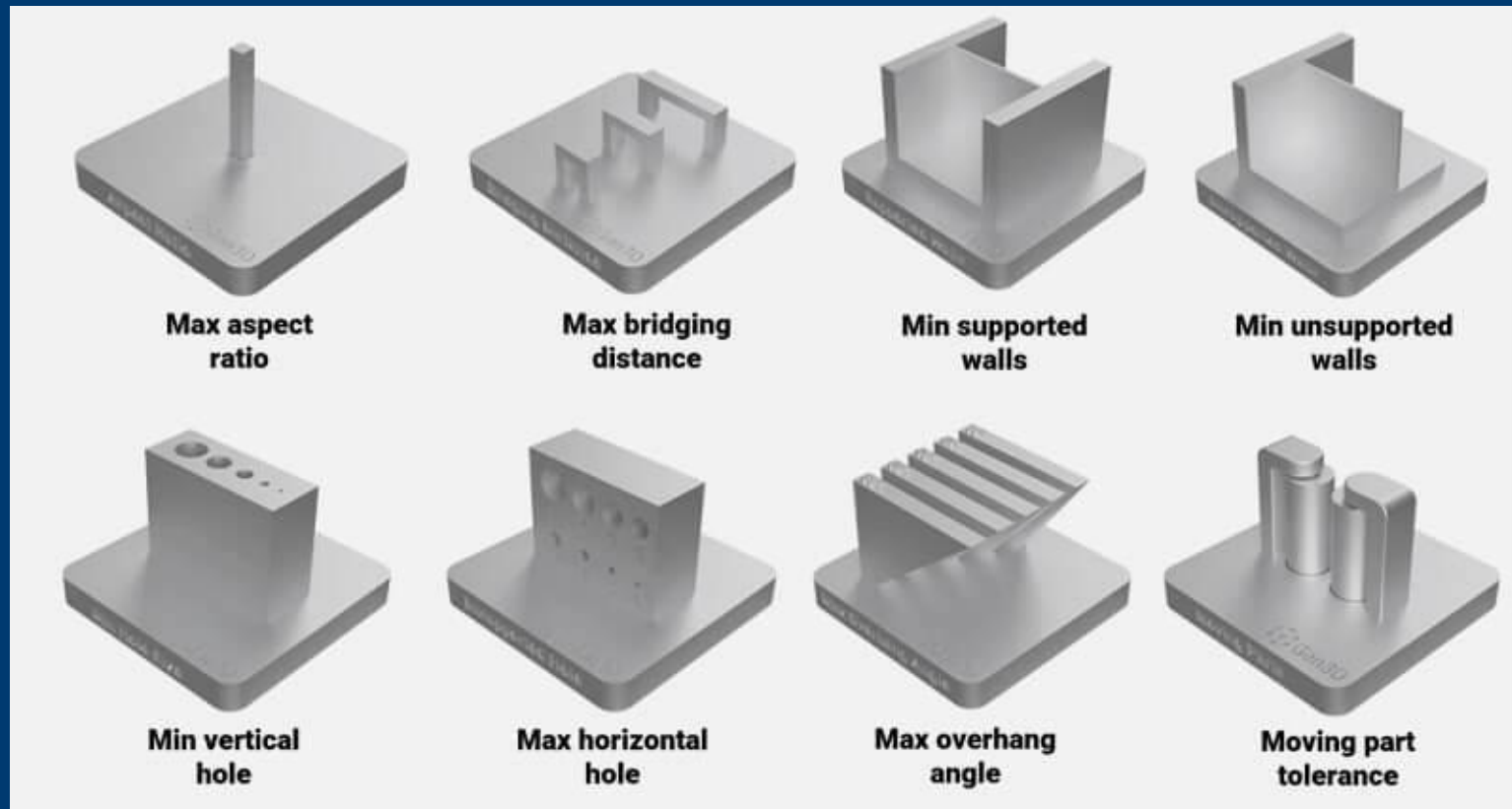


Design for Additive Manufacturing



Key Factors of DfAM

1. Design for the correct AM Process

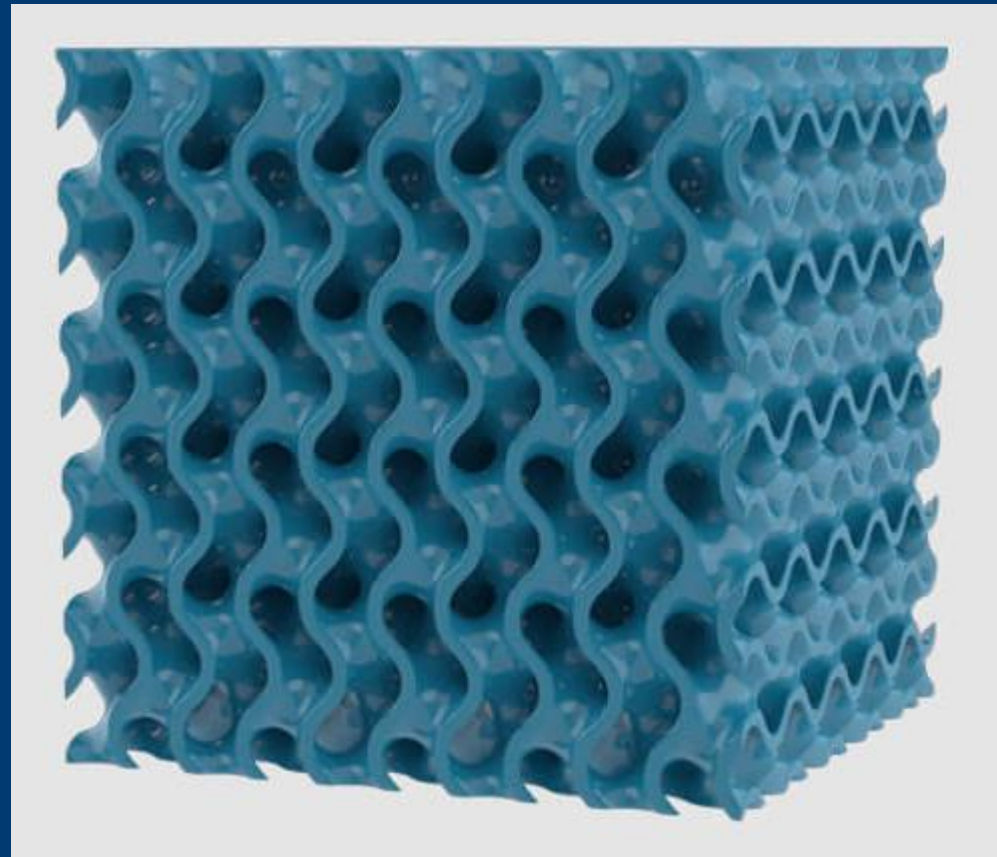


<https://altair.com/>

Key Factors of DfAM

2. Design for minimal usage

Less material means less time in printing and less cost

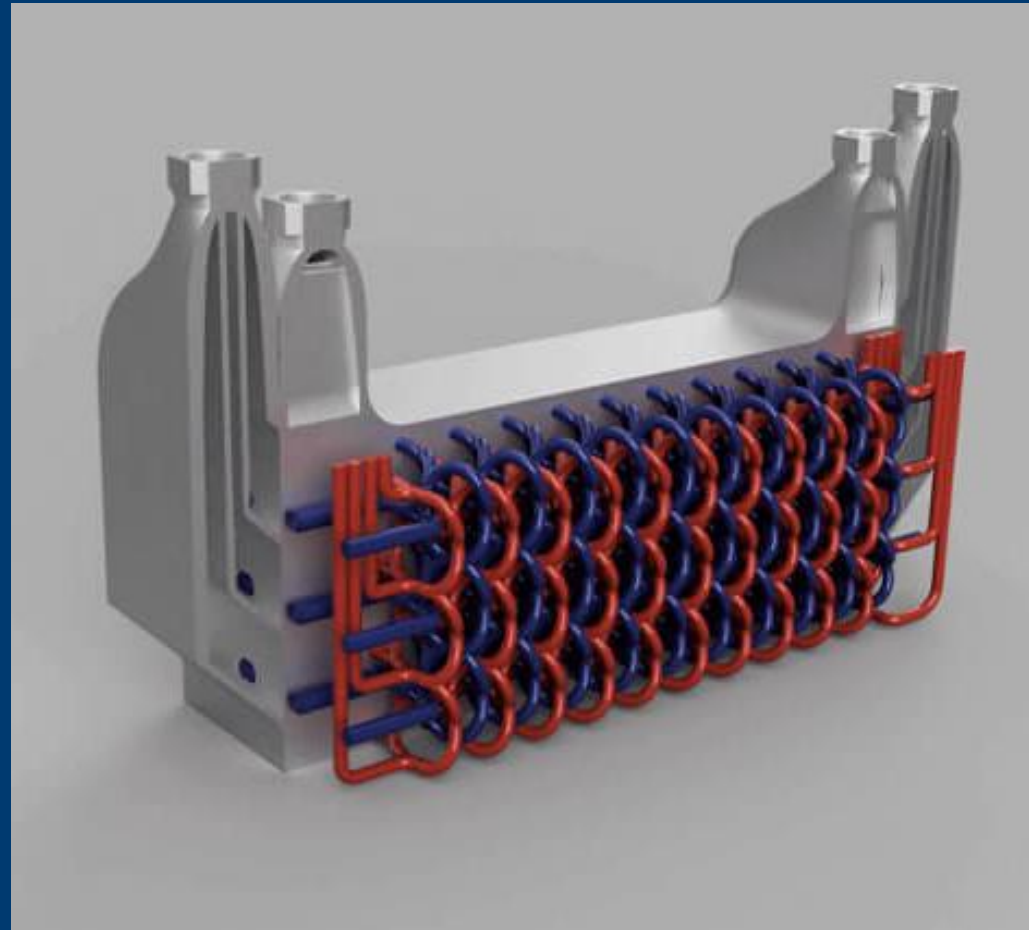


<https://altair.com/>

Key Factors of DfAM

3. Design for improved functionality

Maximise the benefits of using AM, like internal channels, optimized fluid flow, weight reduction, material optimisation



<https://altair.com/>

Key Factors of DfAM

4. Design for part consolidation

Reducing the number of parts, assembly time, inventory, and better controlling the supply chain



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Thank You!

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Q&A



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