Design for Additive Manufacturing

Understanding value

Olaf Diegel

THE UNIVERSITY OF AUCKLAND
NEW ZEALAND

CENTRE FOR ADVANCED MATERIALS MANUFACTURING & DESIGN

Creative Design and Additive Manufacturing Lab

A playground to explore and experience AM

THE UNIVERSITY OF AUCKLAND NEW ZEALAND

CENTRE FOR ADVANCED MATERIALS MANUFACTURING & DESIGN

Creative Design and Additive Manufacturing Lab

A slightly controversial statement

Additive Manufacturing (AM, 3D Printing) is one of the most expensive manufacturing methods in the known universe.

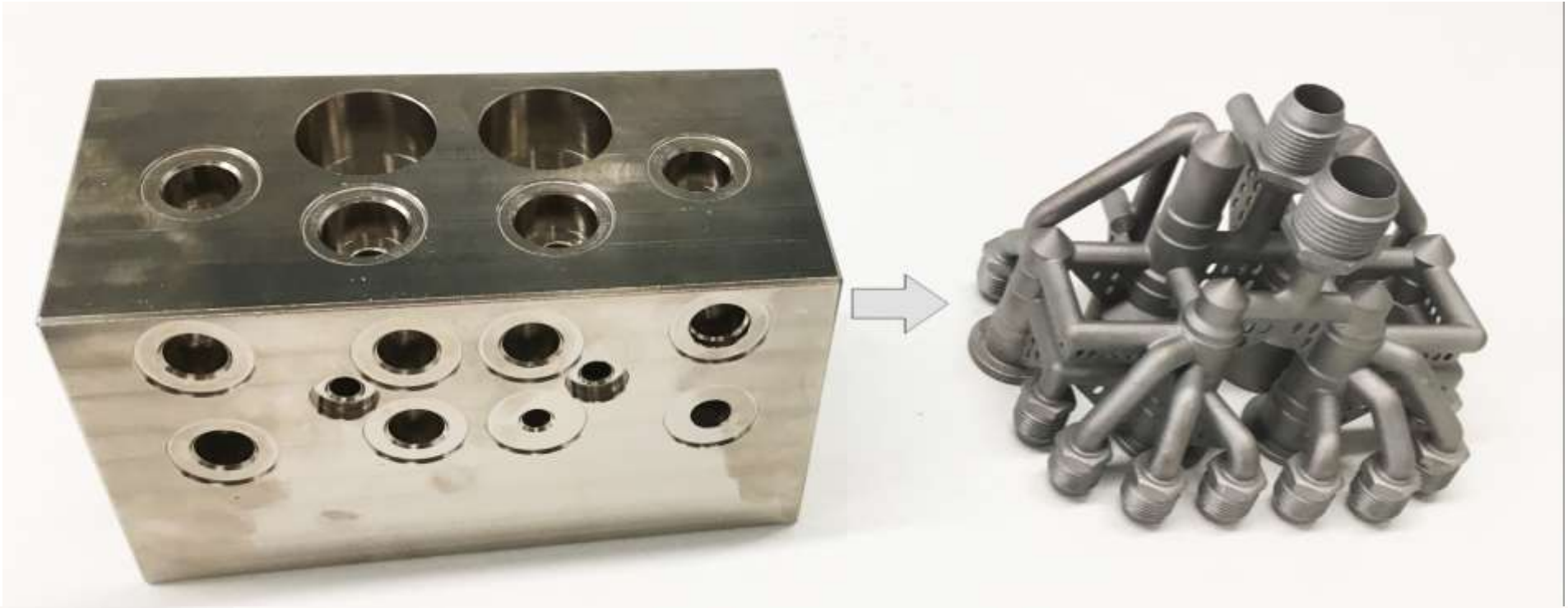
Therefore, for it to be usable, it must add enough **value** to overcome those high costs.

The main way to do this is through design for AM.

Weight saving application
Atlas Copco hydraulic manifold

Courtesy of Atlas Copco

Atlas Copco hydraulic manifold



Hydraulic manifold with weight reduced from 16.2Kg to 1.42Kg so over 90% weight reduction

DfAM: topology optimisation

Topology optimisation: using maths to remove whatever material is not contributing to improve the mechanical characteristics of a part

Work for Radic Performance for printed mountain bike brake calipers with 45% weight saving over machined caliper

Courtesy of Taylor Grey and Jake Powell

Getting products to market at no risk

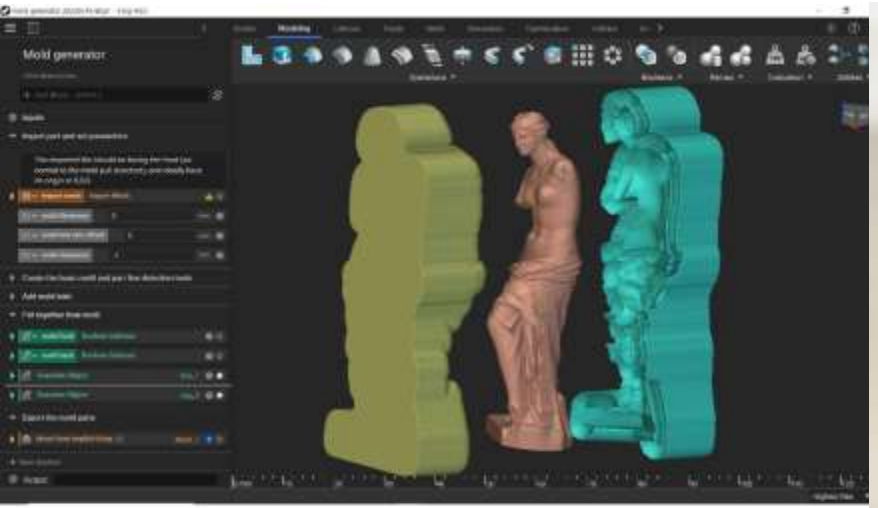
Courtesy of Jenna Makgill, AUT University

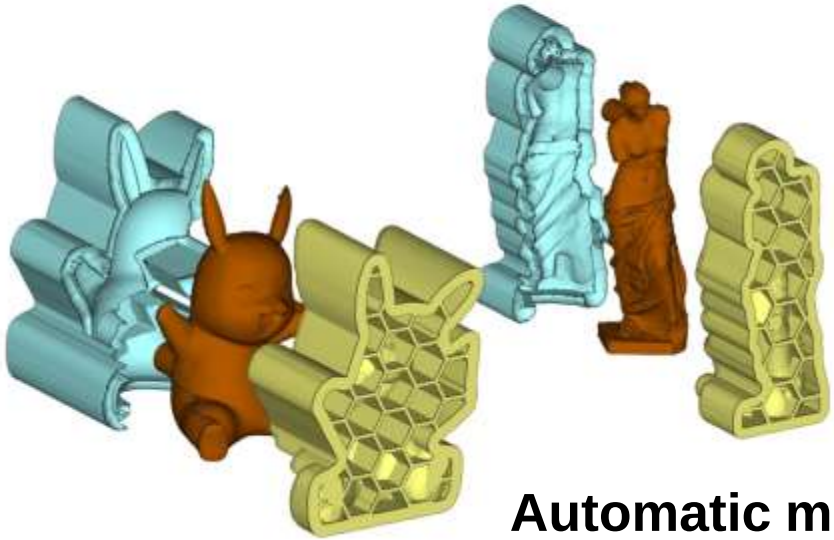

iPad
19:42
02:45
-40:54
iSound
iSound

A new breed of design automation software

- Over the past few years, we have seen a number of new **design automation software packages**.
- These packages use a relatively novel form of CAD modelling – ‘implicit modelling’ – a light-weight method of **representing complex 3D objects using mathematical functions** to describe solid bodies, making it highly adaptable to **computational design, which is also formulae driven**.
- These packages allow the construction of ‘workflows’ that can be repeatedly used to easily create new instances of a design.
- Examples of these software systems include **nTopology, Gen3D, Hyperganic, Leap 71 (PicoGK),** etc.

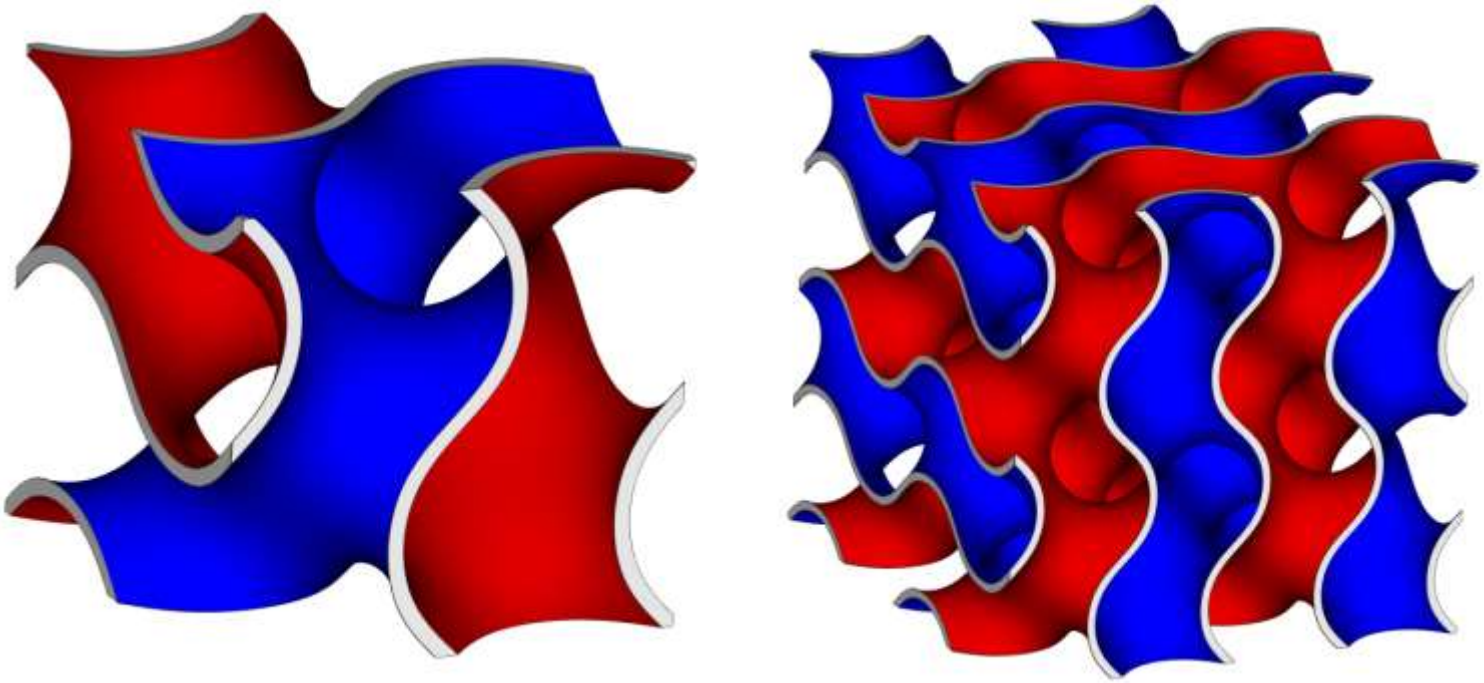

Handle generator.ntop - nTop 4.0.5
Create
Modeling
Lattices
Fields
Math
Simulation
Optimization
Utilities
Handle generator
Add description...
Add Block... (Ctrl+L)
Analysis
Model
Material Attributes
Mesh
Boundary Conditions
Utilities
Exchange
Inputs
Section 1
Handle parameters
Handle diameter 200 mm
Handle ring width 20 mm
Handle total depth 40 mm
Number of spokes 3
Spoke width 20 mm
Texture the handle
Texture handle: True
Centre mounting hardware
Select bolt size
Square key option
Square size 15 mm
Side handle parameters (set to zero if no side handle)
side bolt boss diam... 20 mm
Workflow will automatically add 0.5mm clearance
side bolt boss hole ... 8 mm
Output:
The wonderful world of design automation
0 mm
100
200
300
400
500
Highest Res



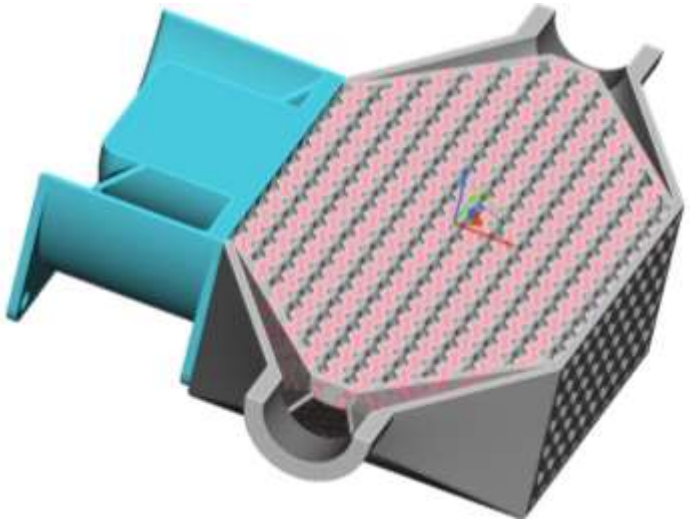


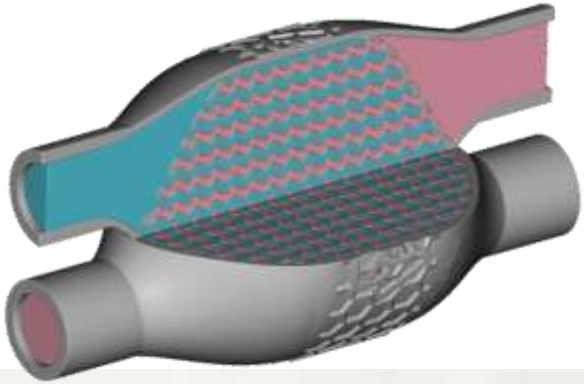
Automatic mold generation

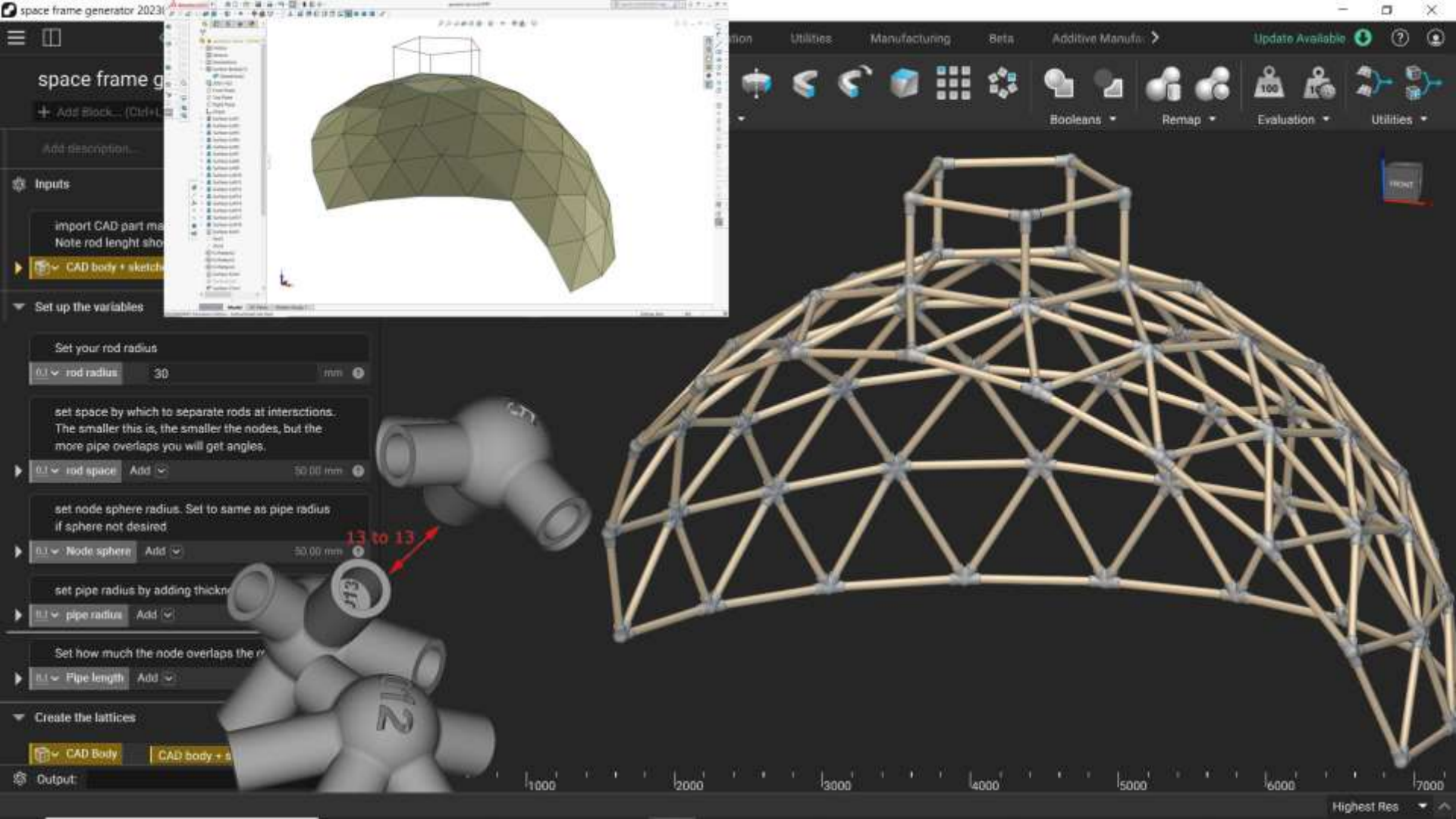
Gyroids have had a major impact on AM

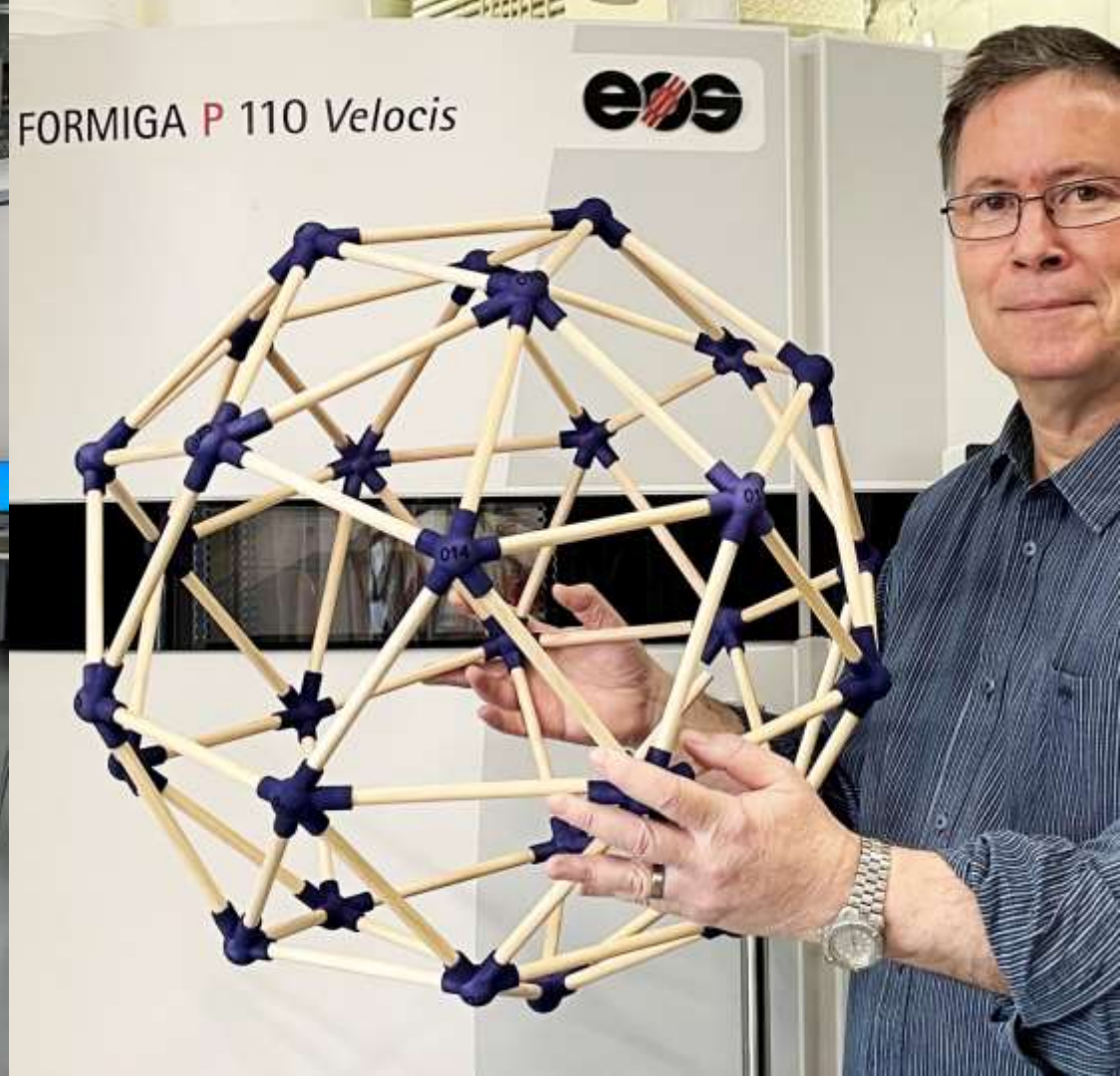


Radiator and heat exchanger developed for FSAE race car



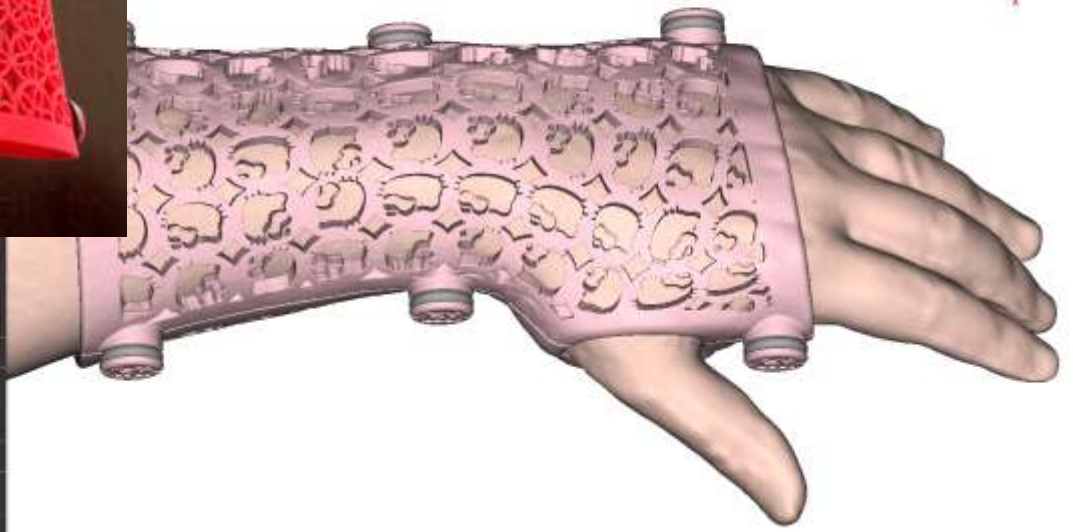



space frame generator 2023
space frame g
Add Block... (Ctrl+L
Add description...
Inputs
import CAD part ma
Note rod lenght sho
CAD body + sketch
Set up the variables
Set your rod radius
rod radius
30
mm
set space by which to separate rods at intersctions.
The smaller this is, the smaller the nodes, but the
more pipe overlaps you will get angles.
rod space
Add
50.00 mm
set node sphere radius. Sel to same as pipe radius
if sphere not desired
Node sphere
Add
50.00 mm
13 to 13
set pipe radius by adding thickne
pipe radius
Add
Set how much the node overlaps the r
Pipe length
Add
Create the lattices
CAD Body
CAD body + s
Output:
Utilities
Manufacturing
Beta
Additive Manufa
Update Available
Booleans
Remap
Evaluation
Utilities
FRONT
1000
2000
3000
4000
5000
6000
7000
Highest Res

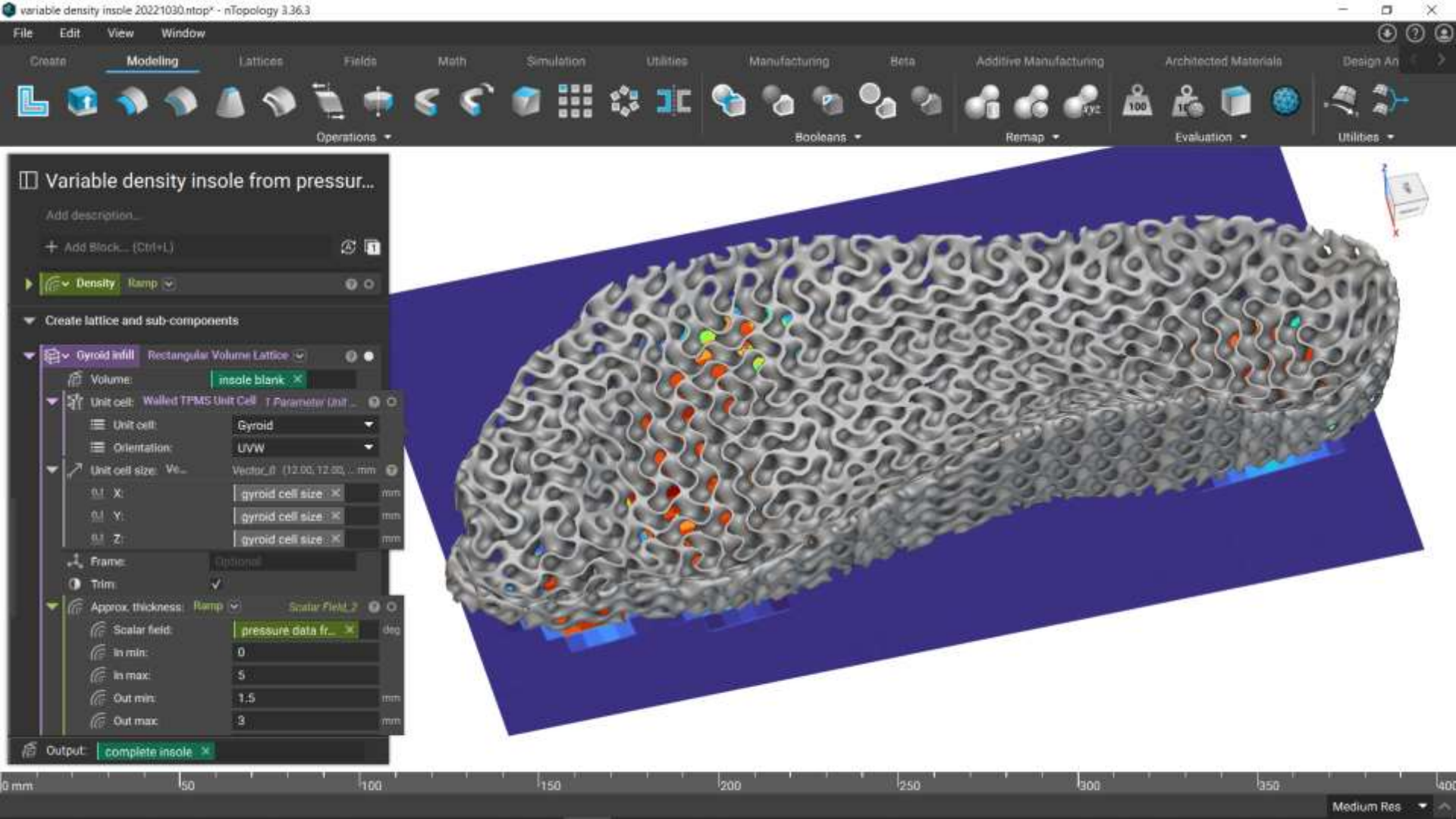

FORMIGA P 110 Velocis
eos


Booleans
Remap
Evaluation
Utilities


arm/hand rim width
12
thumb rim width
5
seam width
10
STEP 2: Set up pressure relief points
Arm scan
Arm scan
STEP 3: Set up all the cutting trim lines
Trimmed arm section
Output

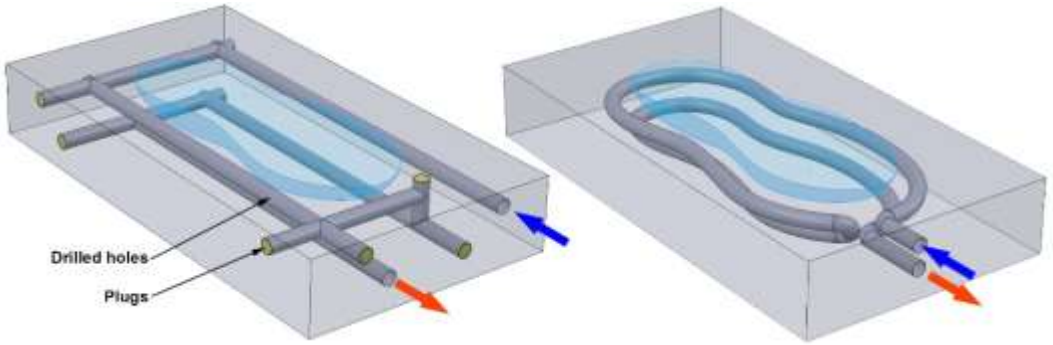



0 mm
50
100
150
200
250
300
350
400
Highest Res


variable density insole 20221030.ntop* - nTopology 3.36.3
File
Edit
View
Window
Create
Modeling
Lattices
Fields
Math
Simulation
Utilities
Manufacturing
Beta
Additive Manufacturing
Architected Materials
Design An
Operations
Booleans
Remap
Evaluation
Utilities
Variable density insole from pressur...
Add description...
Add Block... (Ctrl+L)
Density
Ramp
Create lattice and sub-components
Gyroid infill
Rectangular Volume Lattice
Volume:
insole blank
Unit cell:
Walled TPMS Unit Cell
1 Parameter Unit ...
Unit cell:
Gyroid
Orientation:
UVW
Unit cell size:
Ve...
Vector_0 (12.00, 12.00, ... mm
X:
gyroid cell size
mm
Y:
gyroid cell size
mm
Z:
gyroid cell size
mm
Frame:
Optional
Trim:
Approx. thickness:
Ramp
Scalar Field_2
Scalar field:
pressure data fr...
deg
In min:
0
In max:
5
Out min:
1.5
mm
Out max:
3
mm
Output:
complete insole
0 mm
50
100
150
200
250
300
350
400
Medium Res

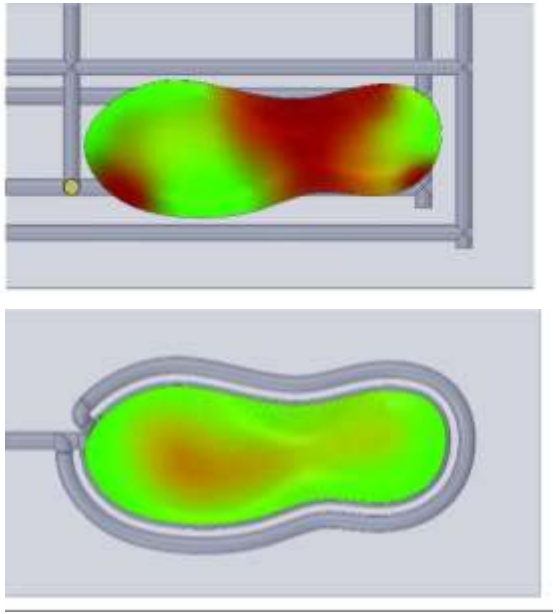
We do lots of work in AM for injection molding

- Because of the complexity allowed by AM, we can print **conformal cooling channels** in injection molding tools.
- This can improve cycle time by 20% to 40% and produce part with up to 20% less distortion.

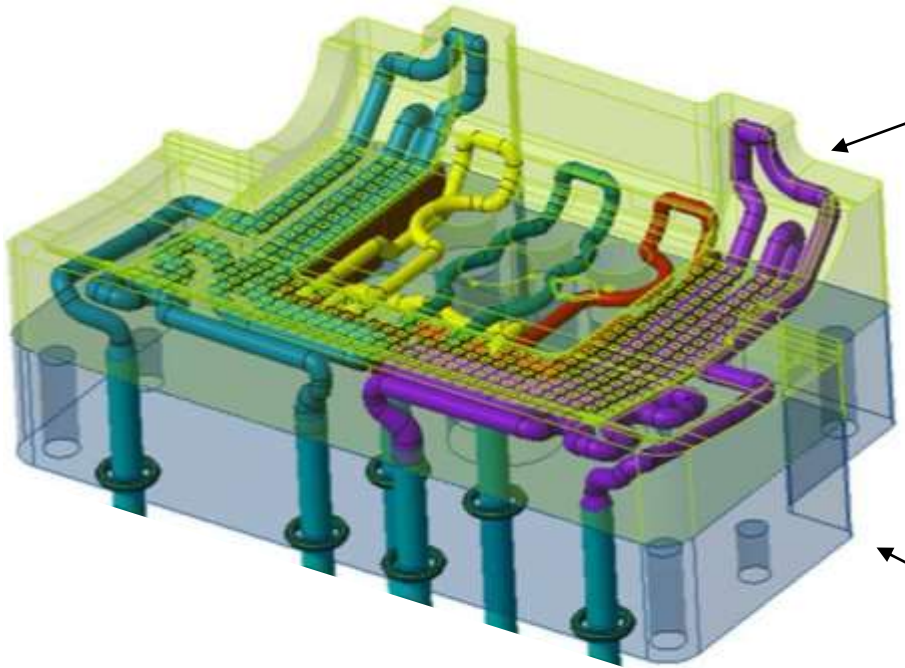


The old fashioned way

The conformal cooling channel way



Hybrid conventional/metal AM molds

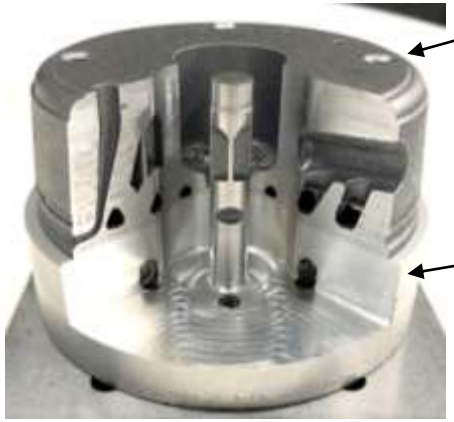


This part of tool is complex, so ideal for Metal AM

This part is simple, so make on CNC machine and build AM part on it

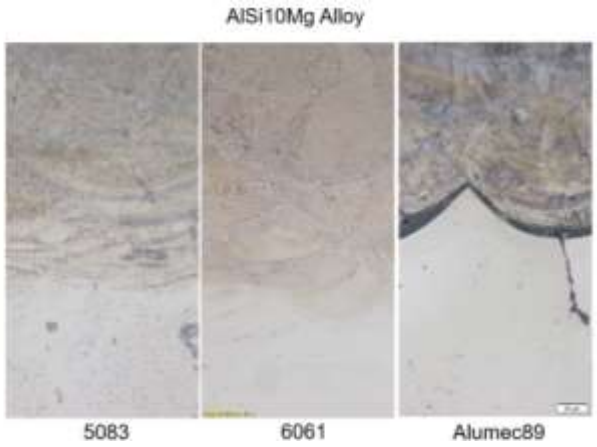
Hybrid AM Tooling: The interface

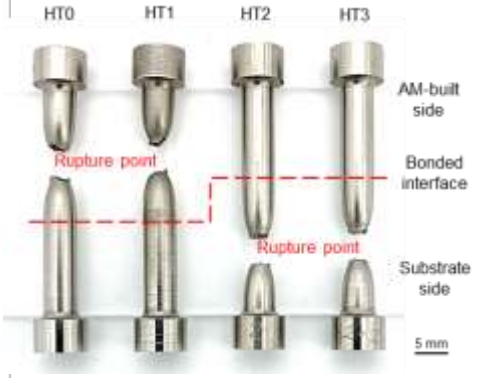
- We are developing hybrid AM tools with conformal cooling to be cost-comparable with conventional tools but with faster cycle times.
- A lot of work investigating the interface between the printed and machined metal.
- The good news is that we never rupture at the interface, but always on the weaker material.



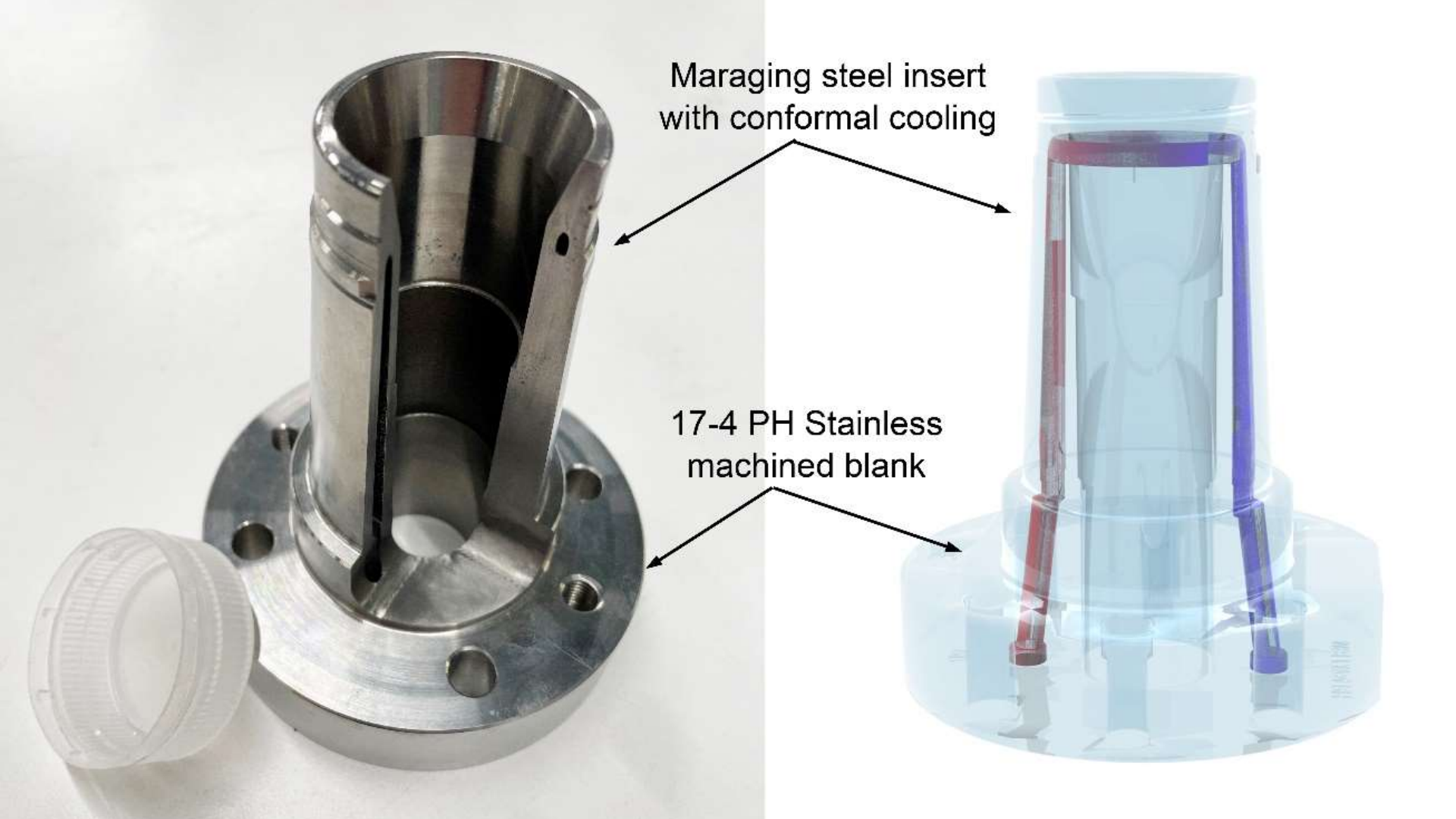
Interesting part of tool, with conformal cooling channels so adds enough value to print

Boring lump of metal so expensive to print





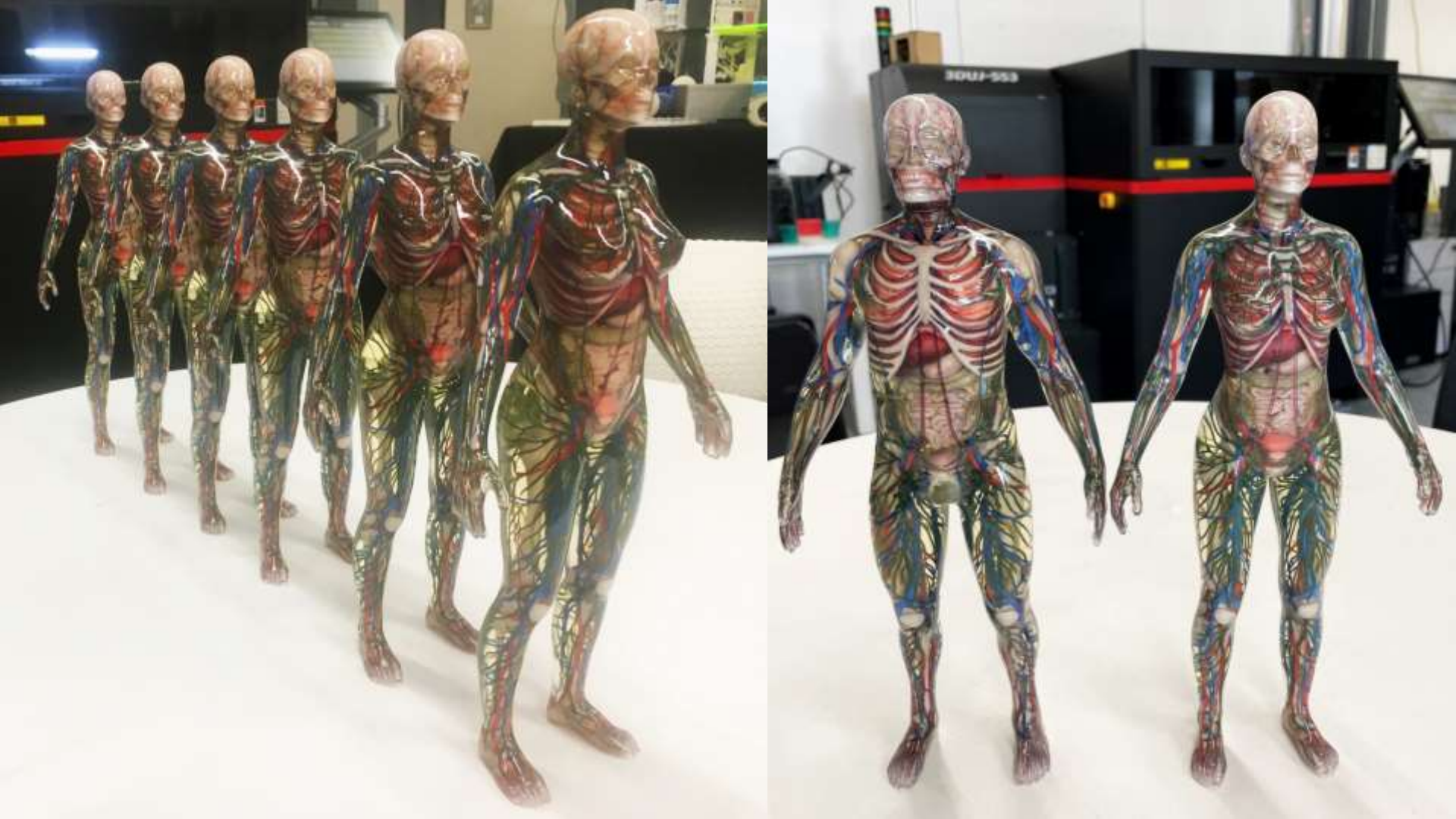
18Ni300-17-4 PH


Maraging steel insert
with conformal cooling
17-4 PH Stainless
machined blank

In a project undertaken for local tool maker Camex, cooling time was reduced from 4.5 secs to 1.7 secs.

Tool has been running almost continuously for over 2 years and has produced well over 40 million caps

The tool paid for itself in less than a month of operation!




OLAF DIEGEL DESIGNS
Official Manufacturer of Happiness
Making musicians awesome
since 2011

Cultural artefact preservation


The reproduction of a Māori Pūkāea
wooden trumpet


AM truly is AMazing…
If you design for it.
olaf.diegel@auckland.ac.nz
THE UNIVERSITY OF AUCKLAND NEW ZEALAND
CENTRE FOR ADVANCED MATERIALS MANUFACTURING & DESIGN
Creative Design and Additive Manufacturing Lab