

Simpleware Software Solutions

Image-based meshing and model generation with the Simpleware software

Matt Howard – Applications Engineer

IBFEM-4i 2019



Synopsys and the Simpleware Product Group



Synopsys



FY18 Revenue:
~\$3.121B



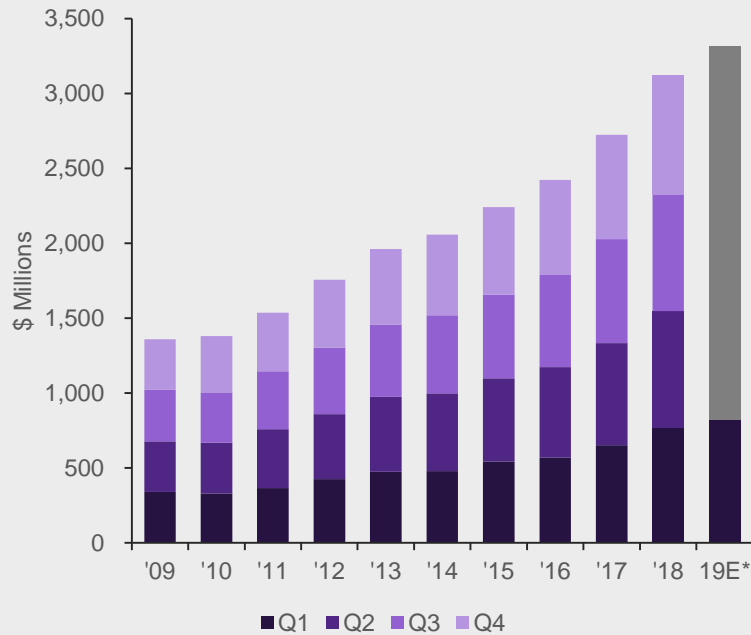
Employees:
>13,457



Patents:
3,129



Offices:
120



#1 electronic design automation tools & services

Broadest IP portfolio and **#1** interface, analog, embedded memories & physical IP

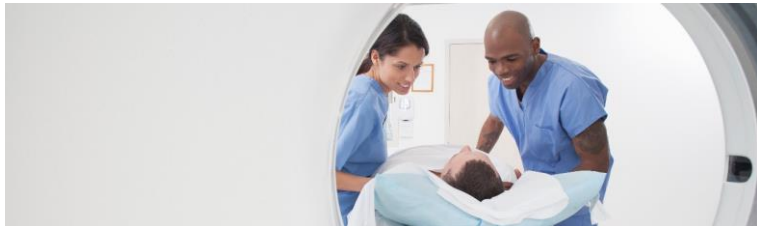
'Leader' in Gartner's Magic Quadrant for application security testing

Simpleware Product Group

- Developers of high-end 3D image processing software
- Dedicated sales, support and service teams
- Global presence
- Clinical and broader life sciences / materials / industrial components applications



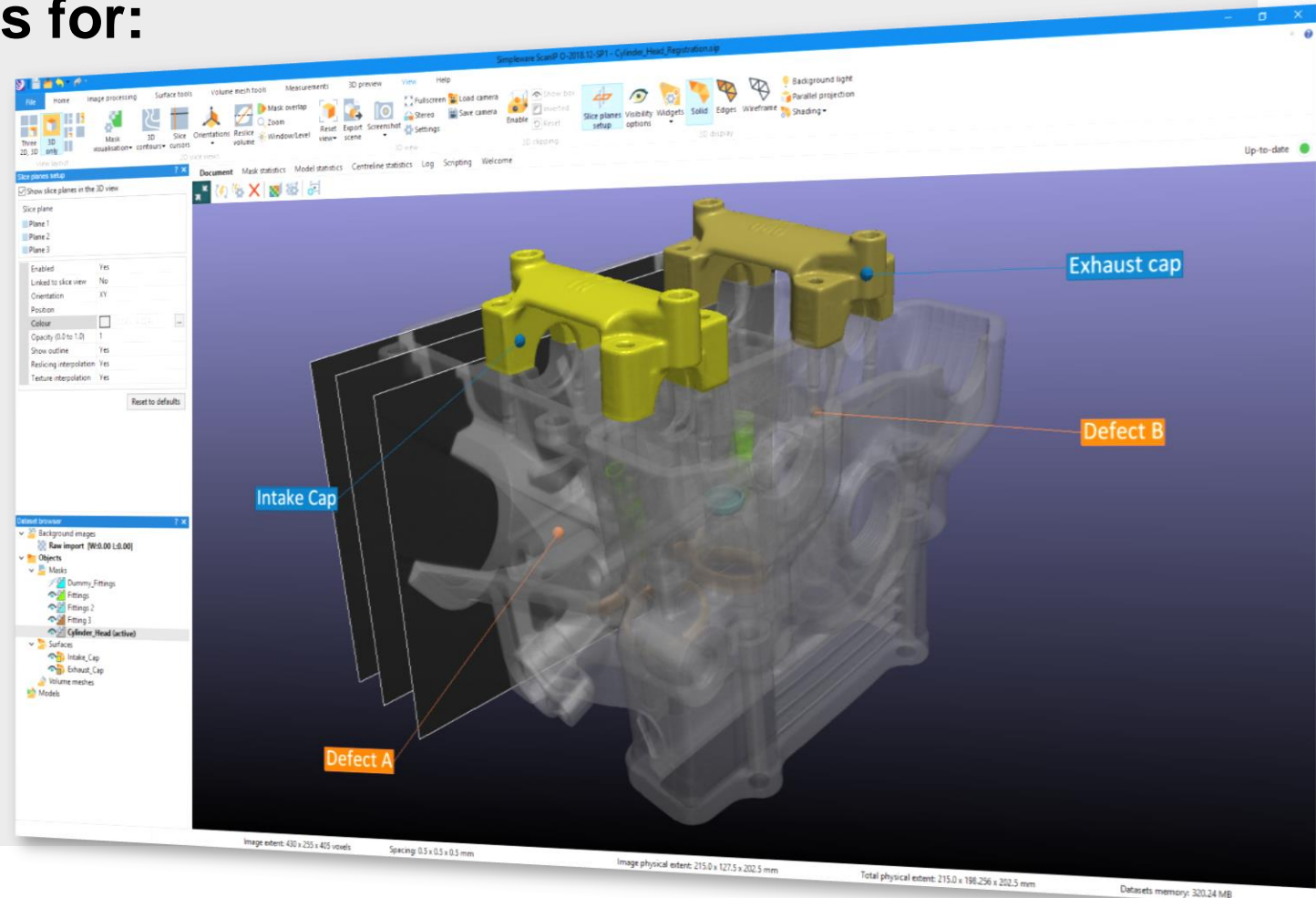
SYNOPSYS[®] | SIMPLEWARE PRODUCT GROUP



Simpleware Software Solutions

GUI-based High-end 3D Image Processing Platform which provides Comprehensive Range of Tools for:

- Visualization including animations
- Filtering and segmentation
- Measurement and quantification
- CAD and image integration
- 3D print, CAD and FEA/CFD model export

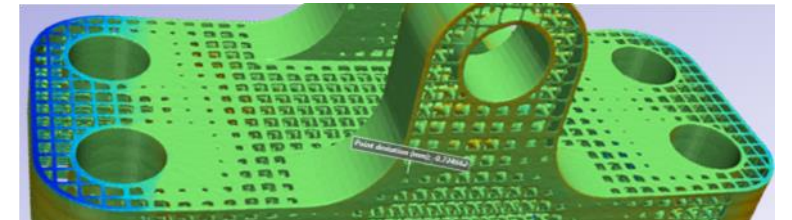
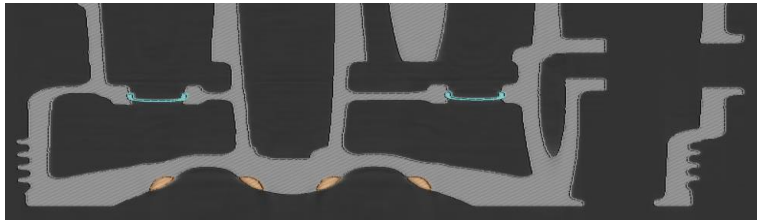


What does the Simpleware Product Group offer for me?

Industrial Reverse Engineering:

Inspect and validate as-built parts and compare to designs

- Take scans of a manufactured part, e.g. casting, ALM, injection moulding...
- Non destructive 3D visualisation, e.g. to quantify defects
- Carry out geometric metrology, measurements, compare to original CAD
- Facilitate simulation on as built or damaged part to check still fit for purpose

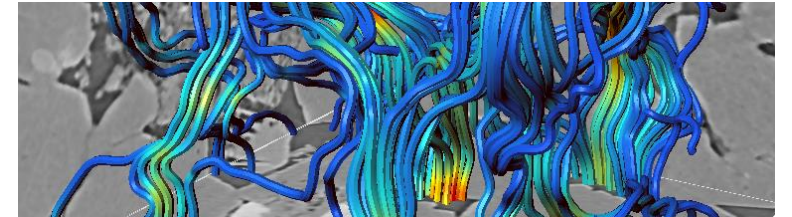
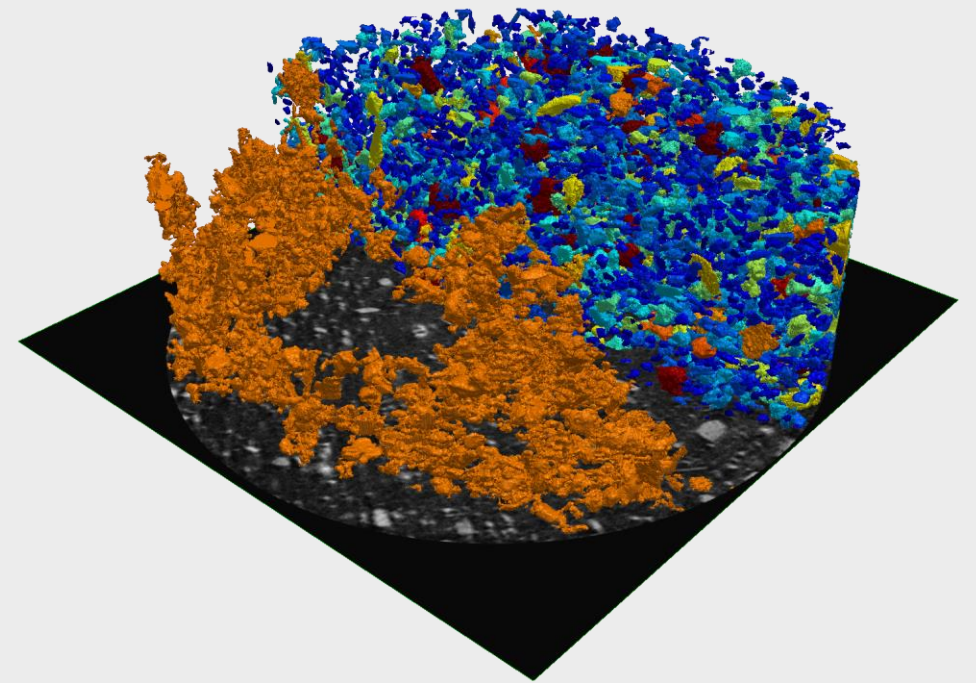


What does the Simpleware Product Group offer for me?

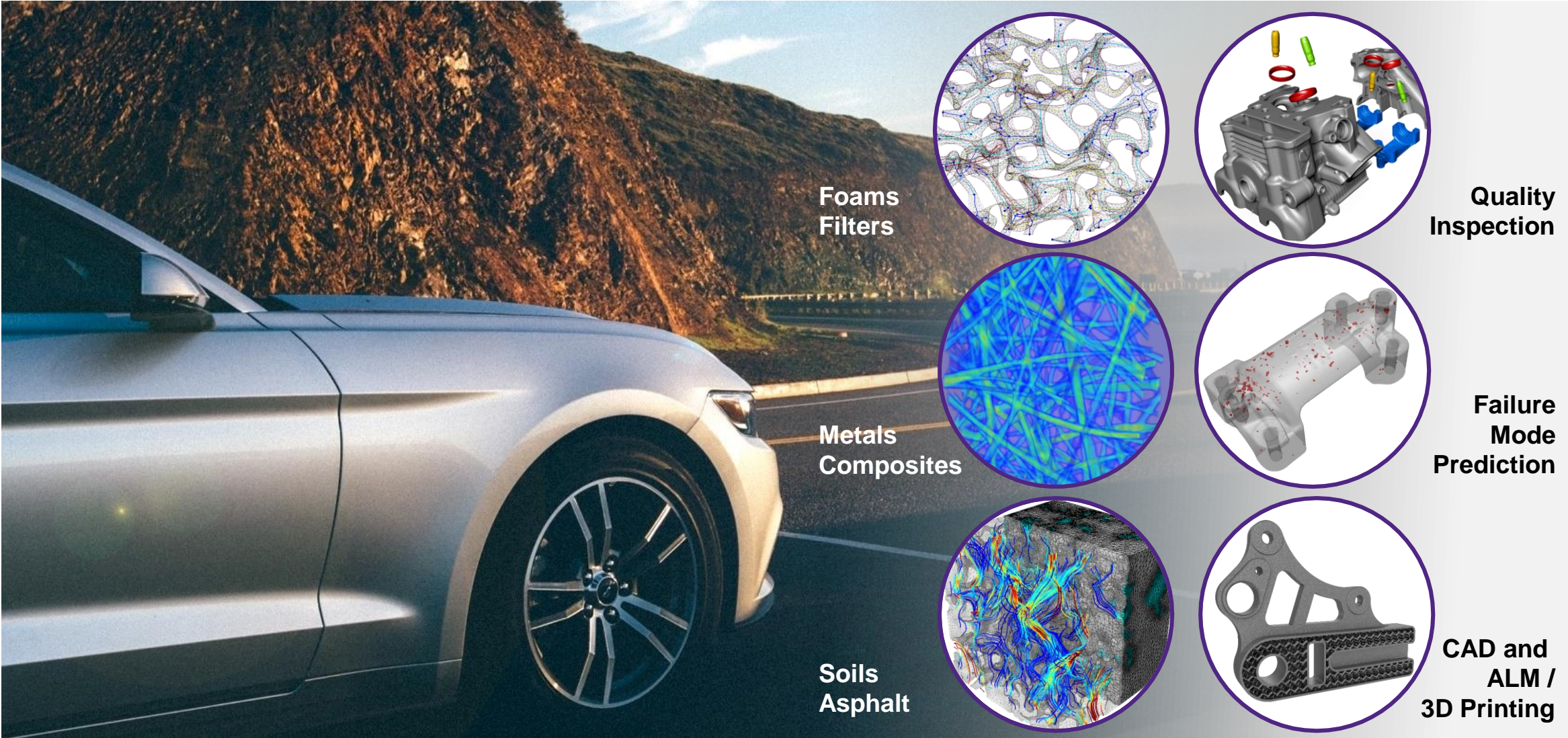
Materials Industry:

Understand or improve performance of a microstructure, e.g. filter, foam, composite, textile, soil, asphalt...

- Visualise internal structure from scans or synthetic data
- Calculate porosity, surface area, pore/particle distribution, fibre orientation...
- Analyse network structures, e.g. centrelines, shortest routes...
- Obtain homogenised material properties, e.g. effective permeability, Young's Modulus...



Applications in Materials & Manufacturing

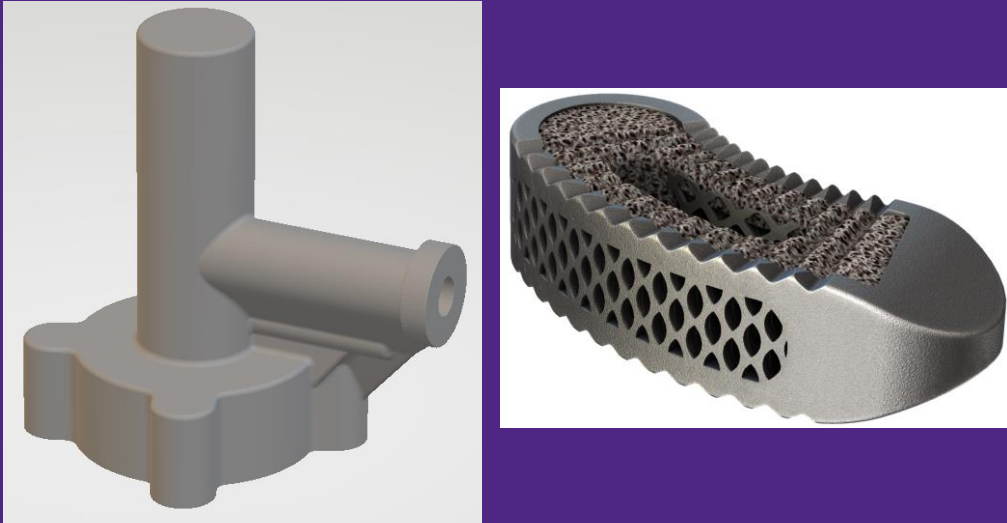


The image shows a silver car on a road with a rocky hillside in the background. Six circular callouts are overlaid on the image, each representing a different application of the software:

- Foams Filters**: A circular inset showing a complex, porous network structure.
- Metals Composites**: A circular inset showing a dense, fibrous network structure.
- Soils Asphalt**: A circular inset showing a network structure within a textured, grey material.
- Quality Inspection**: A circular inset showing a 3D model of an engine with various colored components (yellow, green, red, blue) highlighted.
- Failure Mode Prediction**: A circular inset showing a 3D model of a mechanical part with red spots indicating areas of stress or failure.
- CAD and ALM / 3D Printing**: A circular inset showing a 3D model of a mechanical part with a textured surface, likely representing a 3D printed component.

BIG QUESTIONS

As-Designed



VS

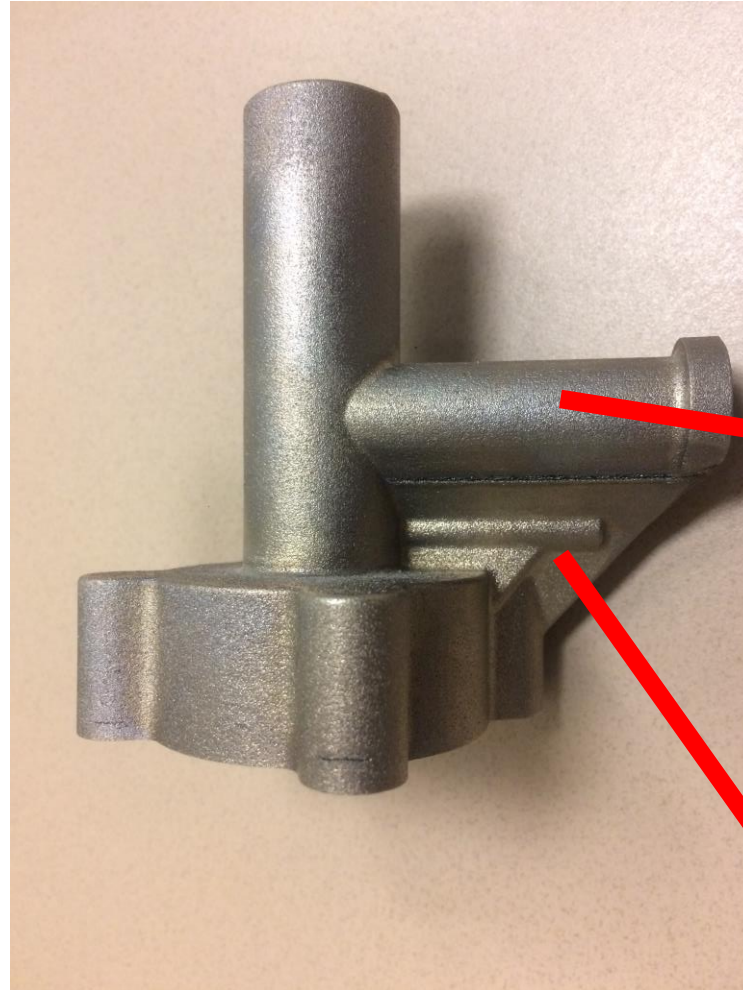
As-Built



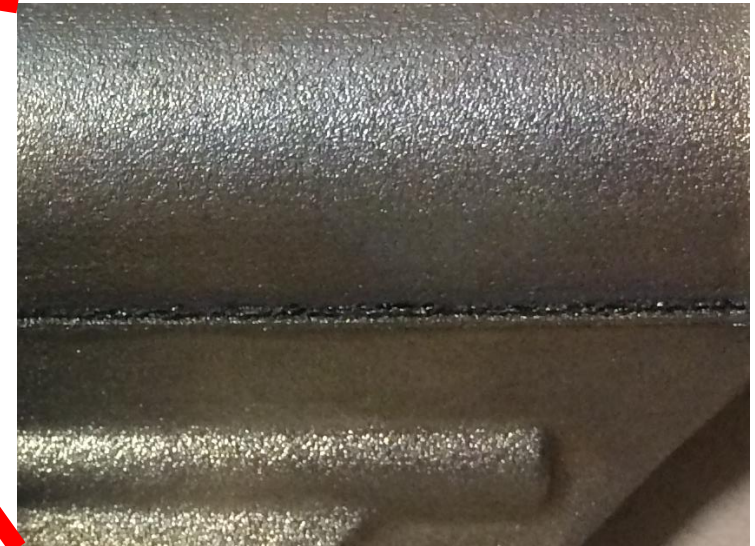
What are the differences?
How do these differences affect **performance**?
Are these properly accounted for in the design?

MOOG

Designer/manufacturer of control systems for aerospace, defense, industrial and medical devices.



Pressure Manifold
Renishaw AM250
Laser Powder Bed Fusion (LPBF)



Part → CT Scan → 3D Image Data

First step - CT Scanning to generate 3D images of part



CT Scan of AM Part

Optimizing the scan for Simulation

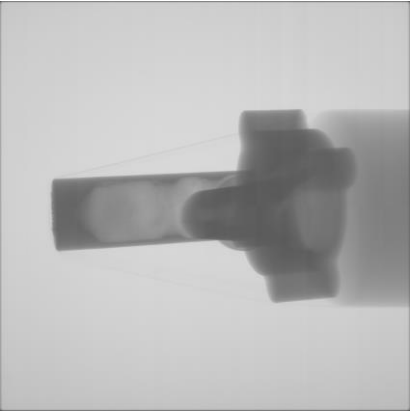
Manifold
(Ti6Al4V)



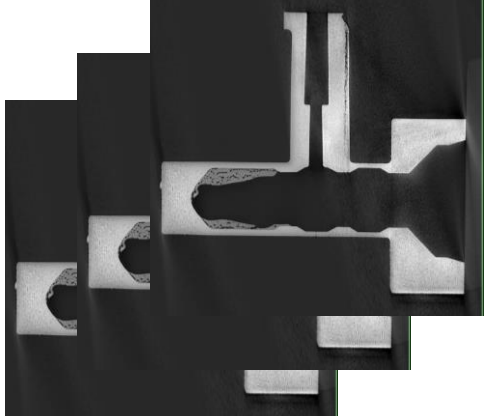
North Star Imaging
(NSI) CT Scanner



Radiographs



Exported Slices



Reconstruction



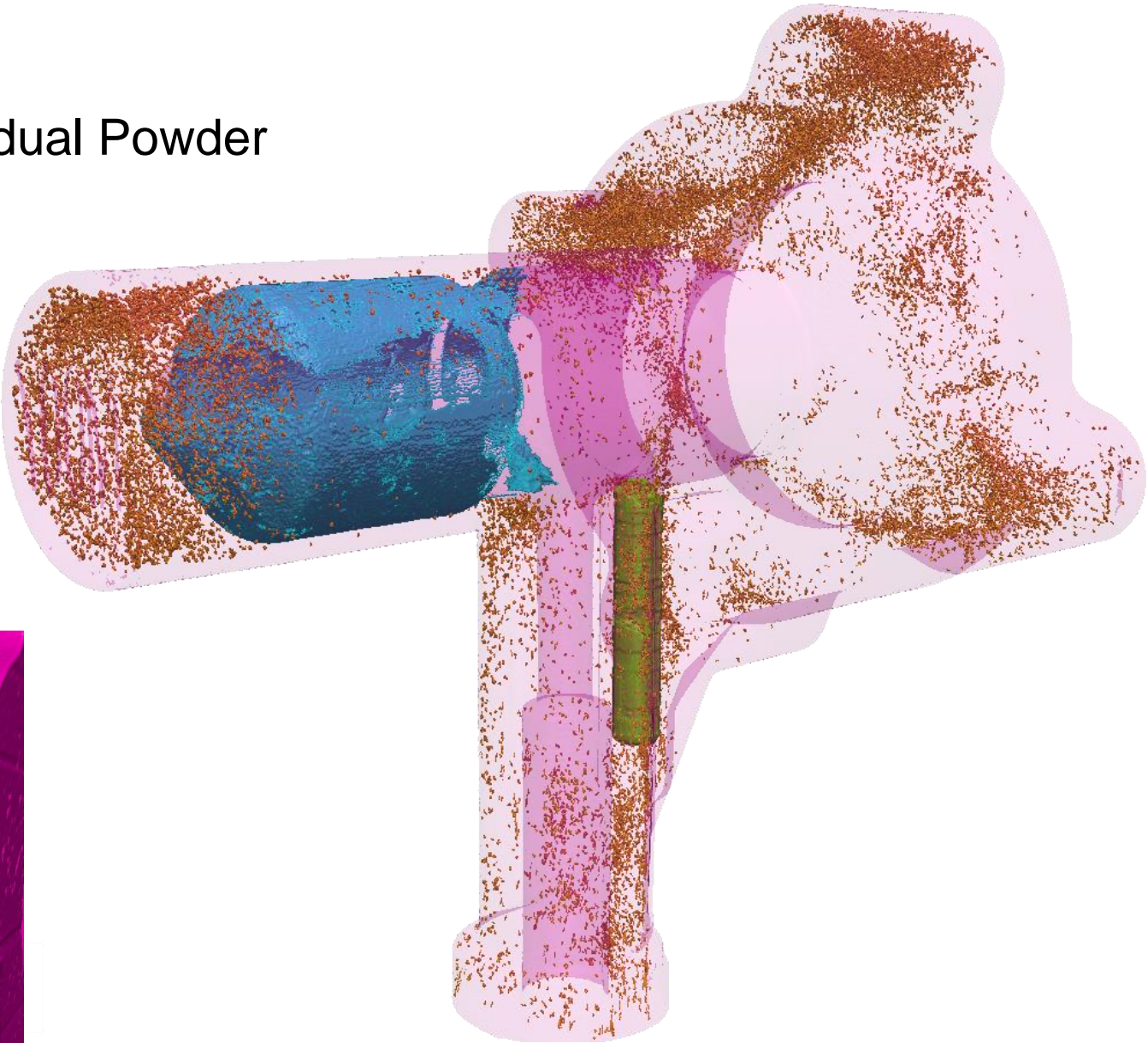
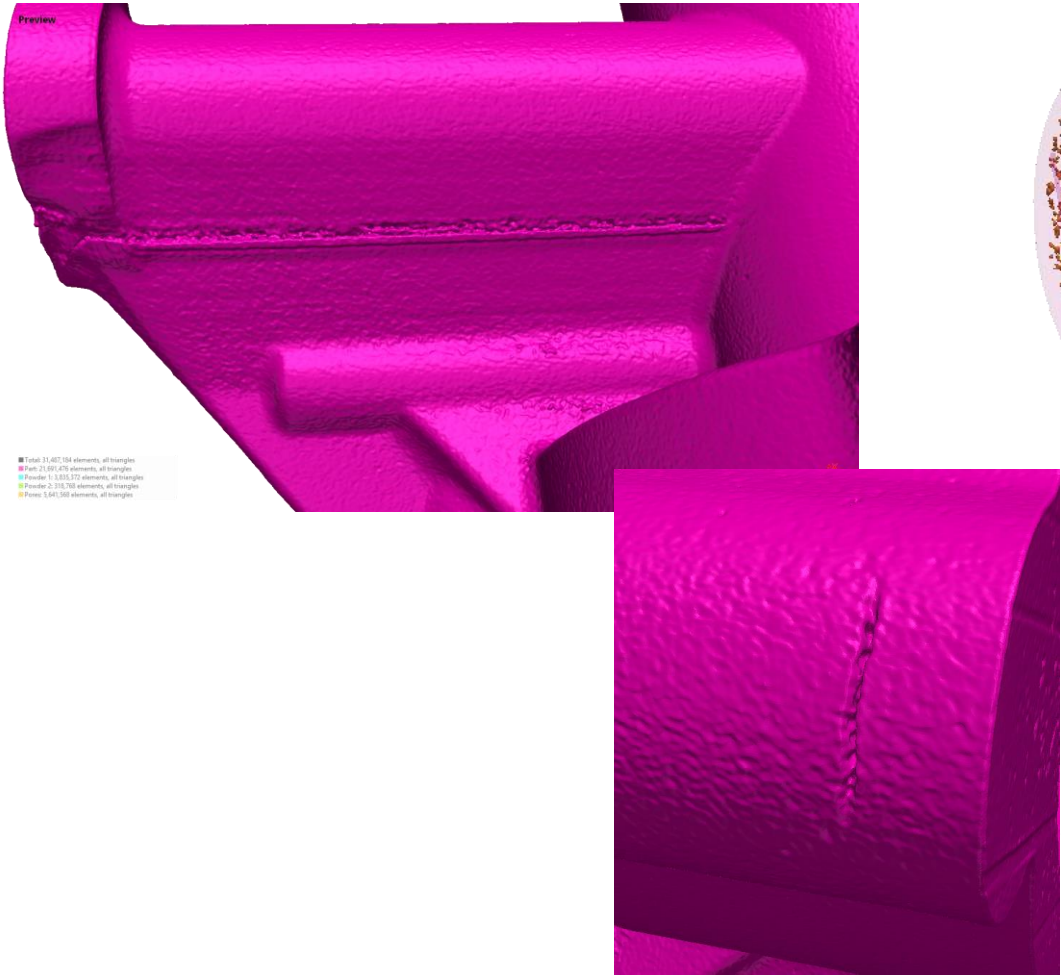
3D Image Data → Simpleware → Fe Model

Second step - leverage Simpleware to reconstruct the “as-built” geometry



Creating a digital twin

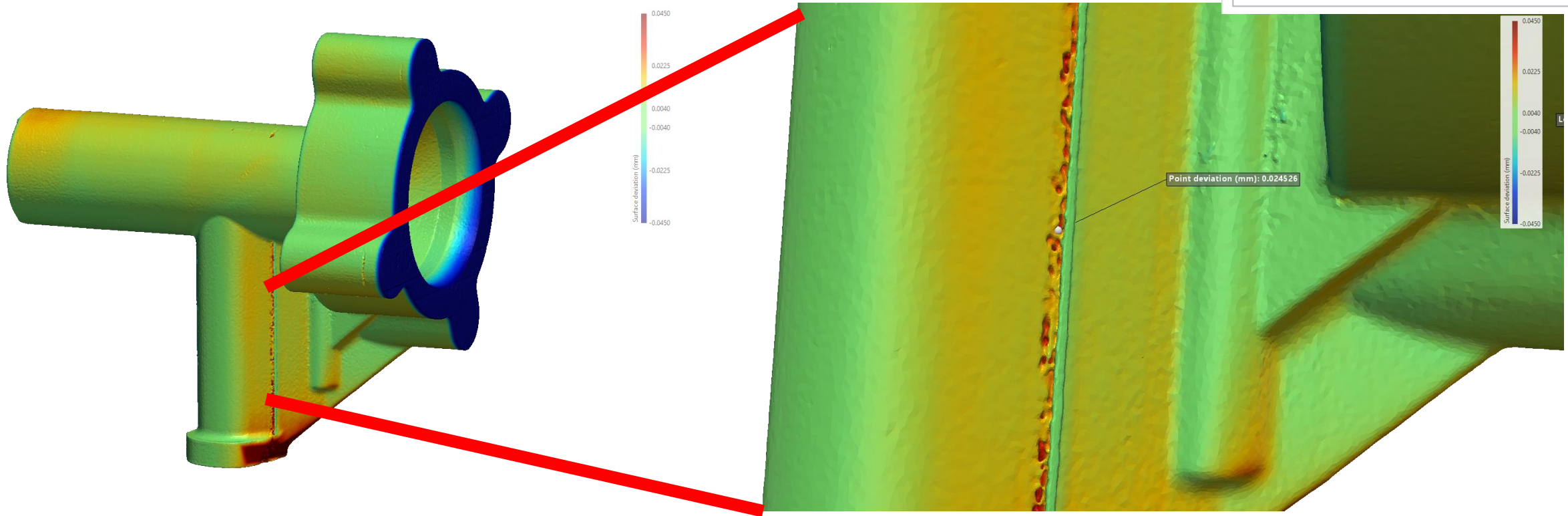
Visualization of Pores, Cracks and Residual Powder



Comparison to Design

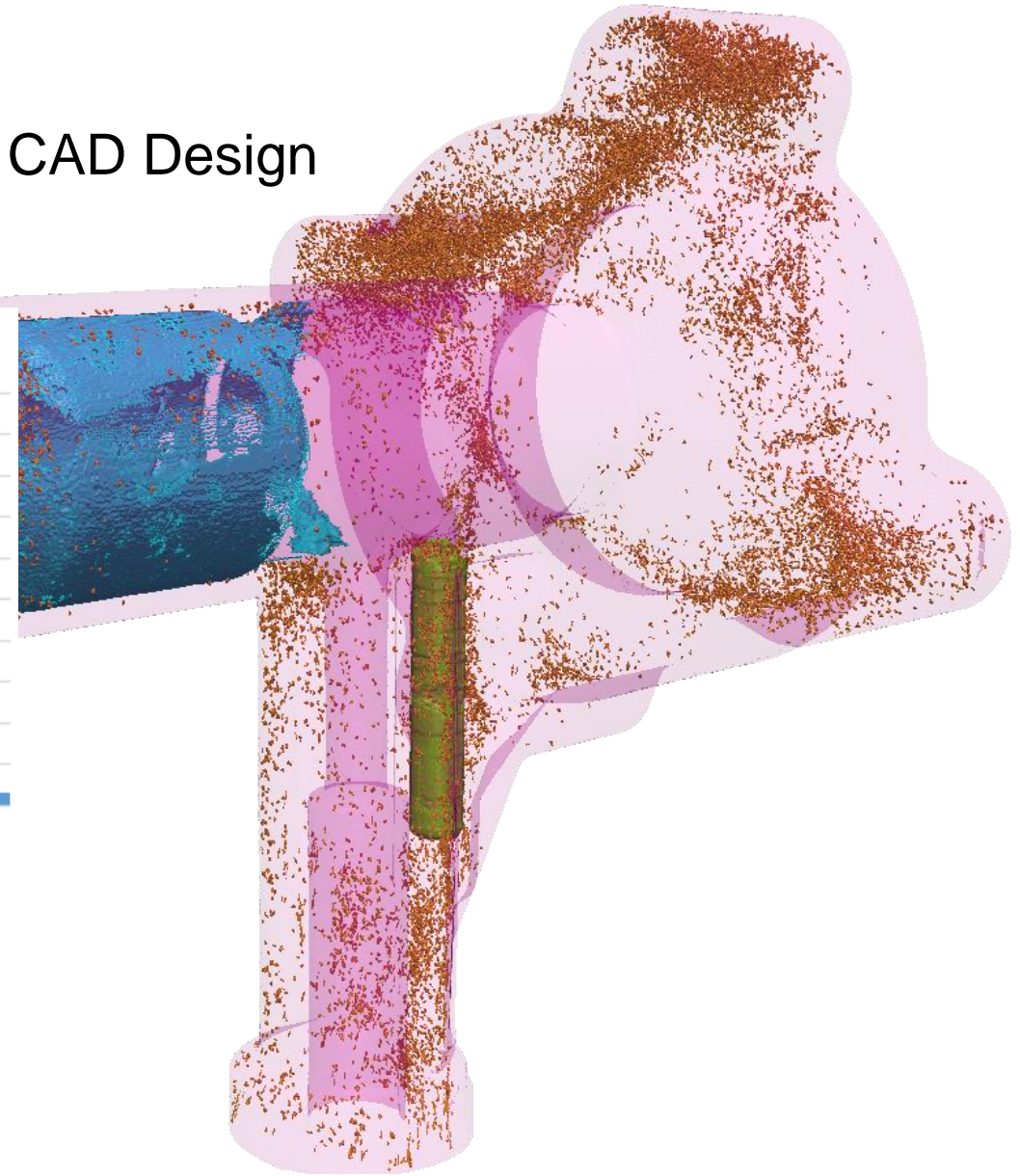
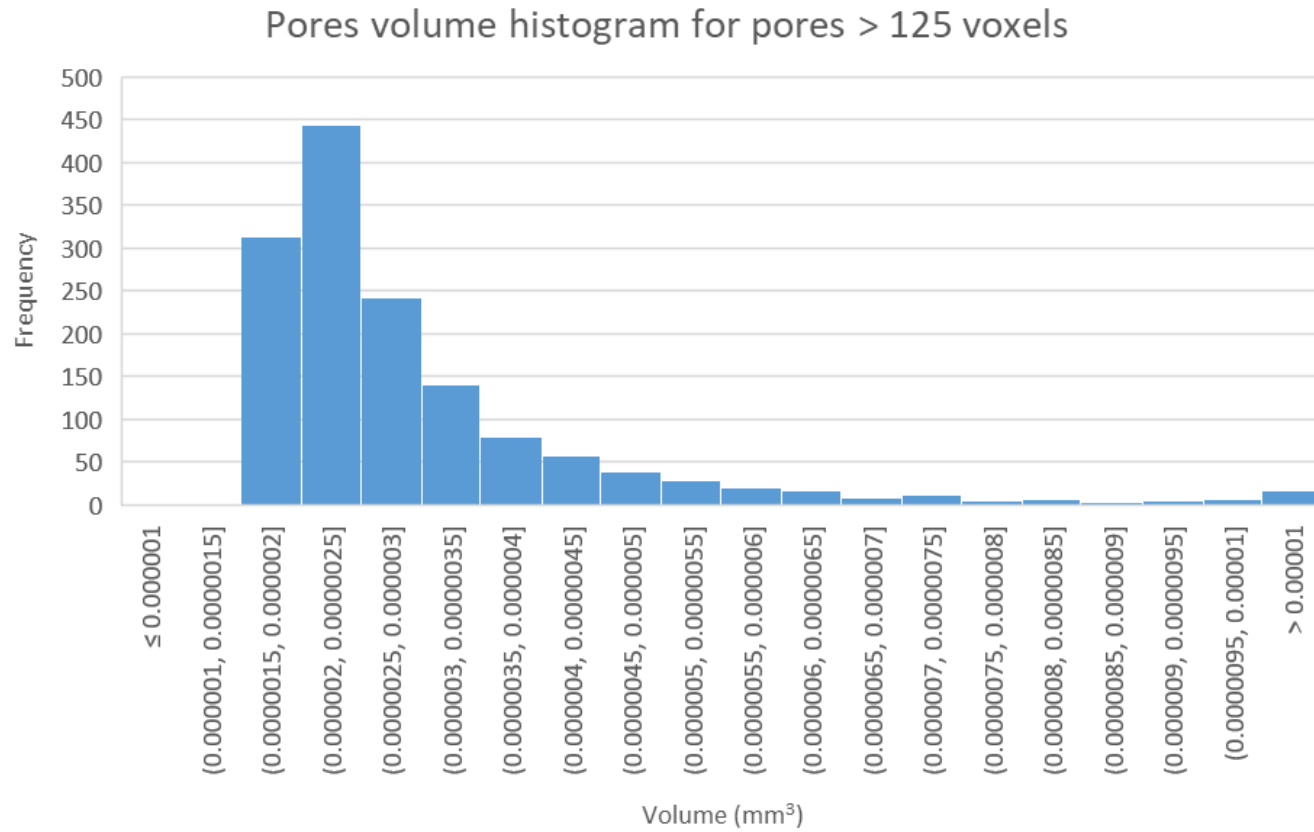
Quantifying As-Built Geometric Deviations from the CAD Design

Surface deviation	
Input	Visualisation
Statistics	
Deviation (mm)	
Upper deviation	0.097422
Lower deviation	-0.057781
Mean	-0.000123
Mean positive	0.005296
Mean negative	-0.005418
Root mean square error (RMSE)	0.015796
Area (%)	
Above critical positive deviation	0.164572
Above nominal positive deviation	47.865467
Below nominal negative deviation	23.373880
Below critical negative deviation	5.098041



Porosity Analysis

Quantifying As-Built Geometric Deviations from the CAD Design

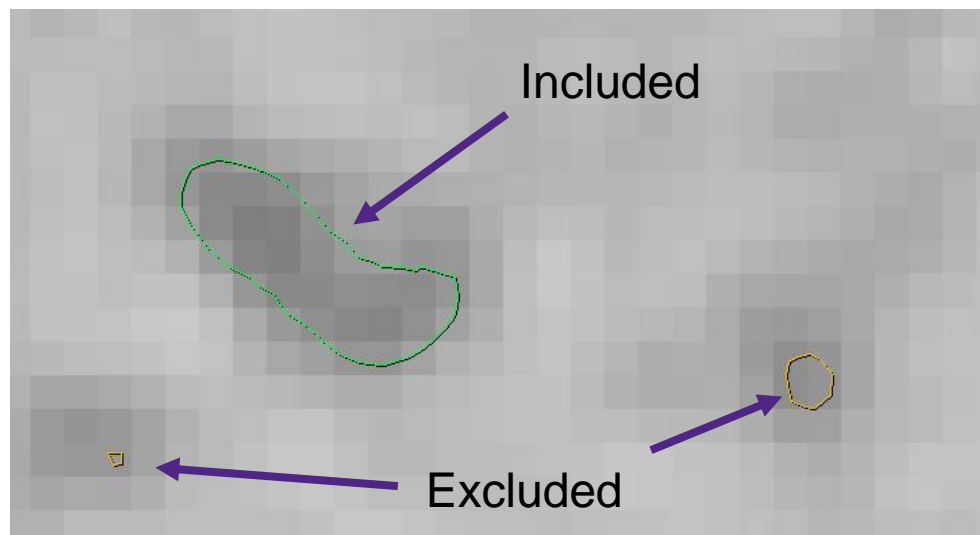


FE Meshing

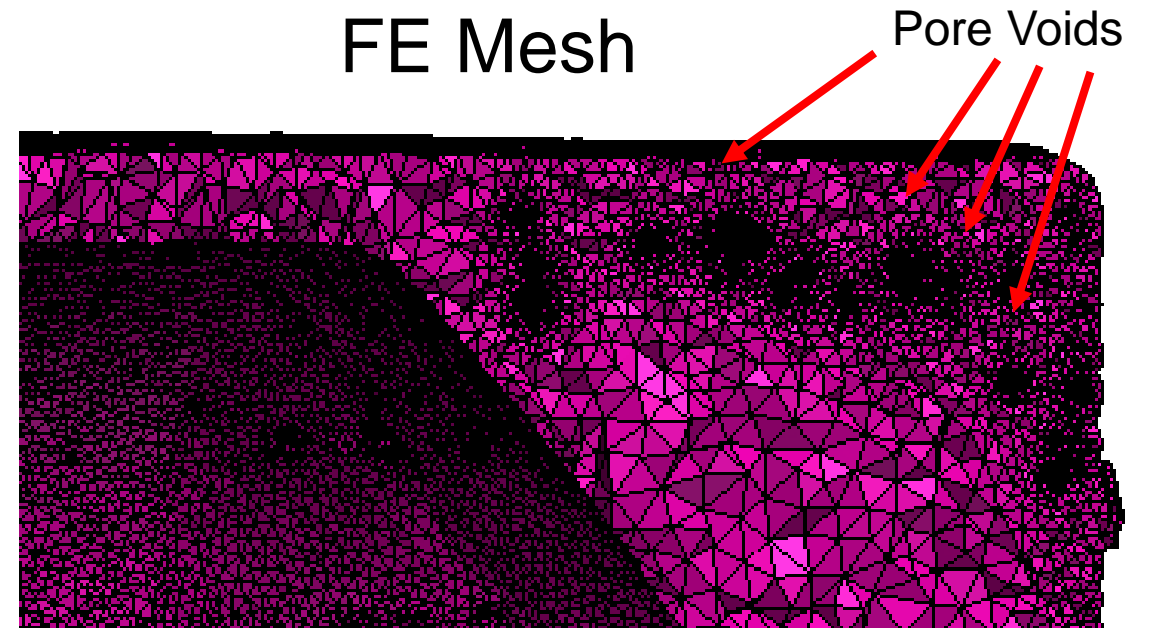
Generate Volume FE Mesh Directly From CAD and Segmented Data with Simpleware FE Module

- What is the minimum size pore to include? Feasibility vs Accuracy
- At 5 voxels across a sphere, we see ~2-4% error (internal study)
- Any pore below 125voxels in size (53), are not included for the current study
- Mesh Size = 8.5million elements – Mesh Time = 2.5hrs (Off the shelf PC - 64GB RAM, Intel 3.5GHz)

Zoom-in of CT Image



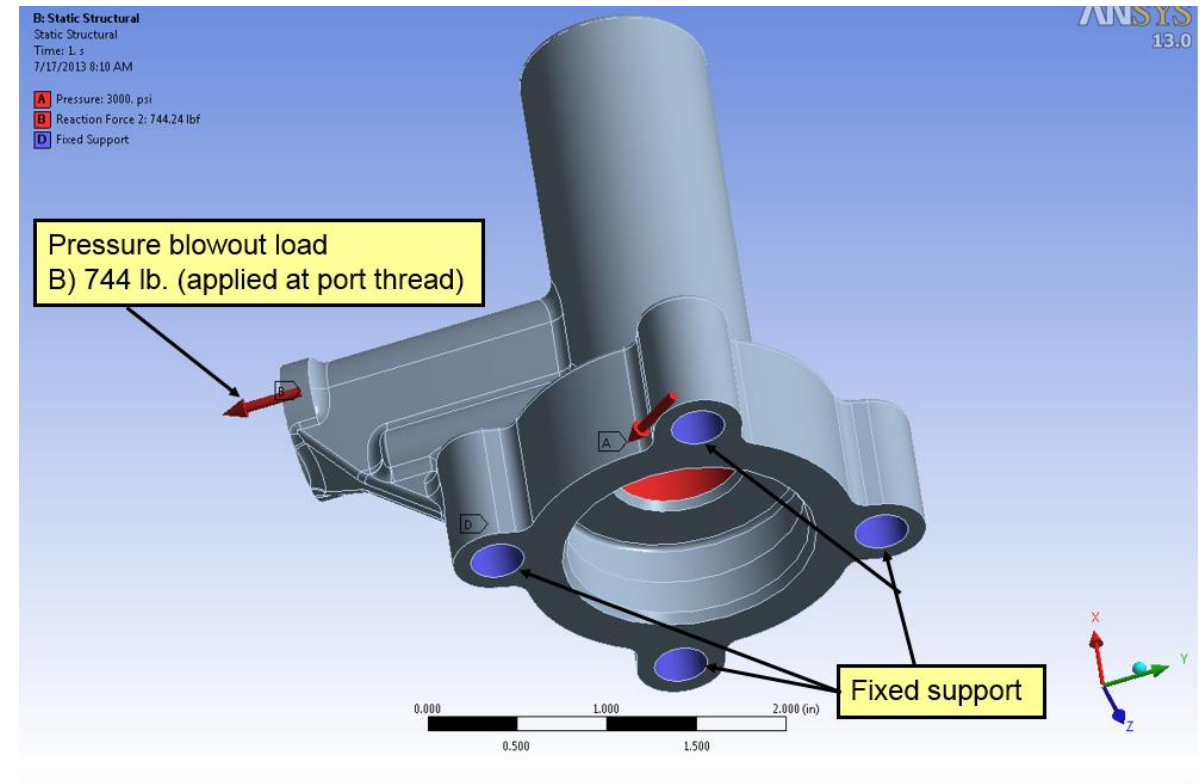
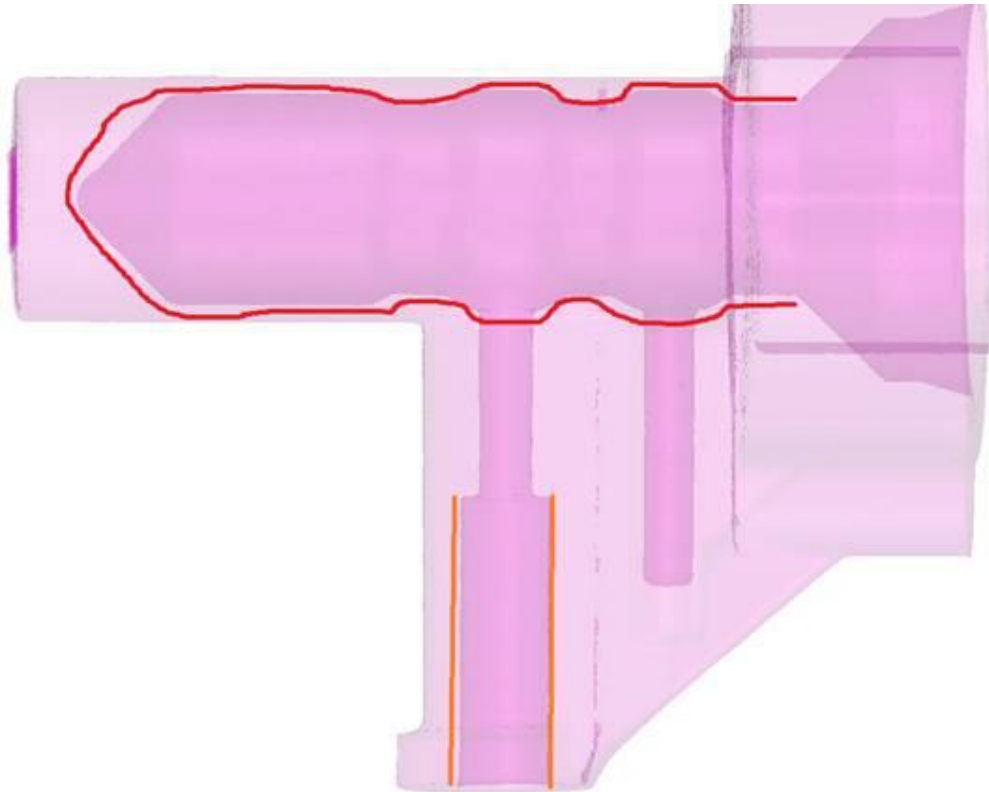
FE Mesh



FE Meshing

Generate Volume FE Mesh Directly From CAD and Segmented Data with Simpleware

- Boundary Conditions
 - CAD and Image-Based model set up with identical boundary conditions

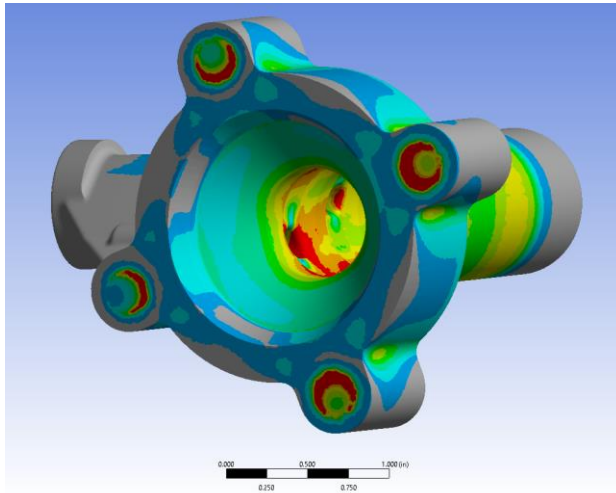


Moog Proprietary – See Cover Page

MOOG
SPACE AND DEFENSE GROUP

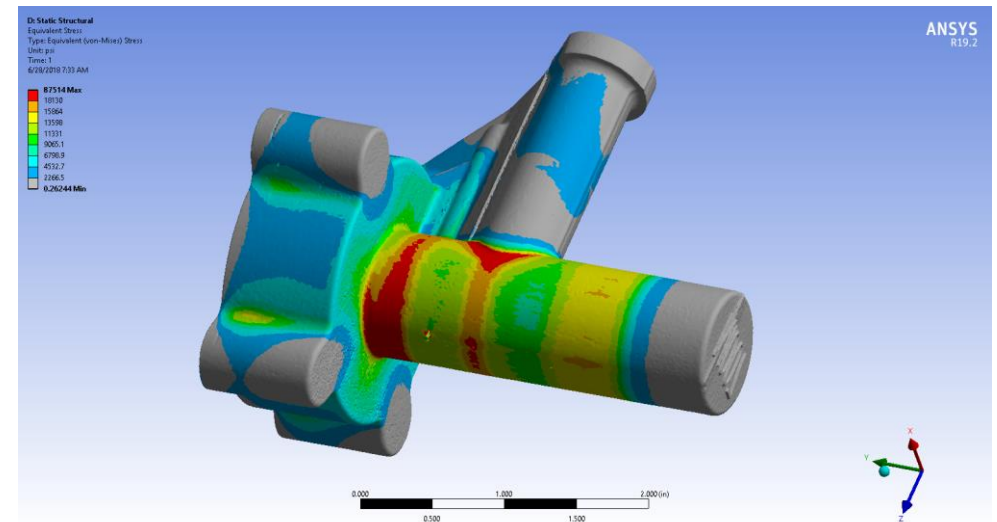
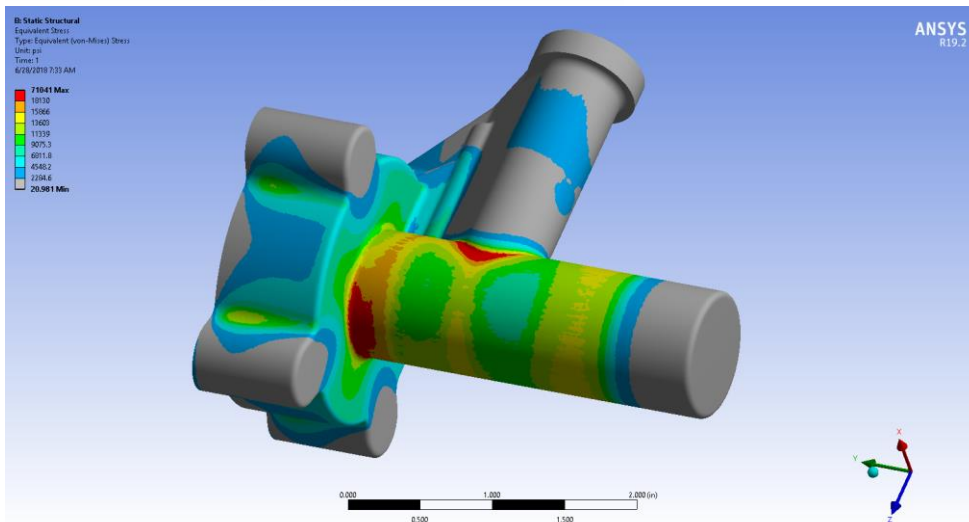
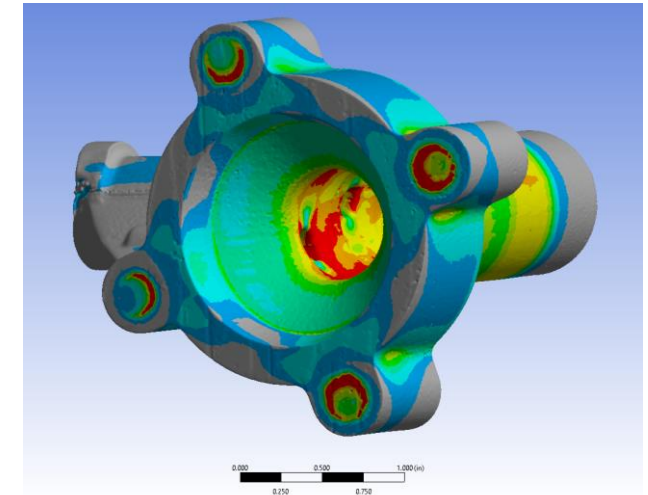
FE Simulation Results

Quantifying As-Built Simulation Deviations from the CAD Design



CAD → Image Based Model

- CAD – 56 seconds
- Image mesh – 6min, 40sec
- 23.18% increases in maximum principal stress
- Likely due to Cracks and Pores in as-built geometry

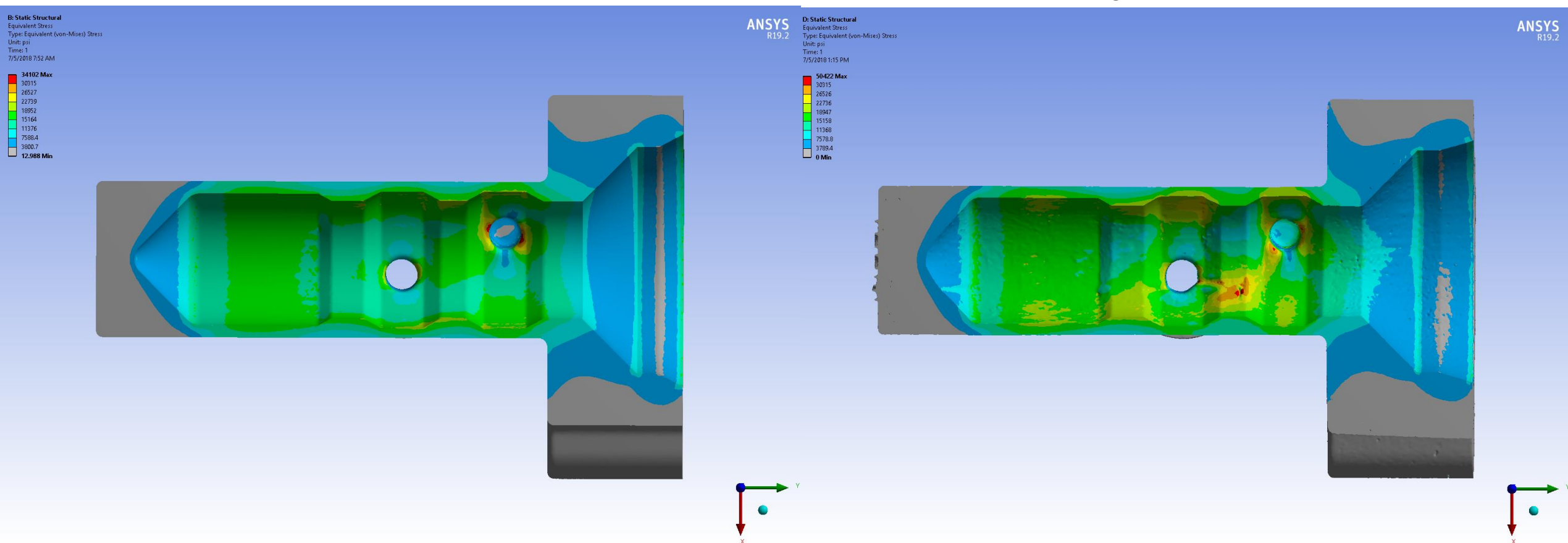


FE simulation results

Quantifying As-Built Simulation Deviations from the CAD Design

CAD-Based Model

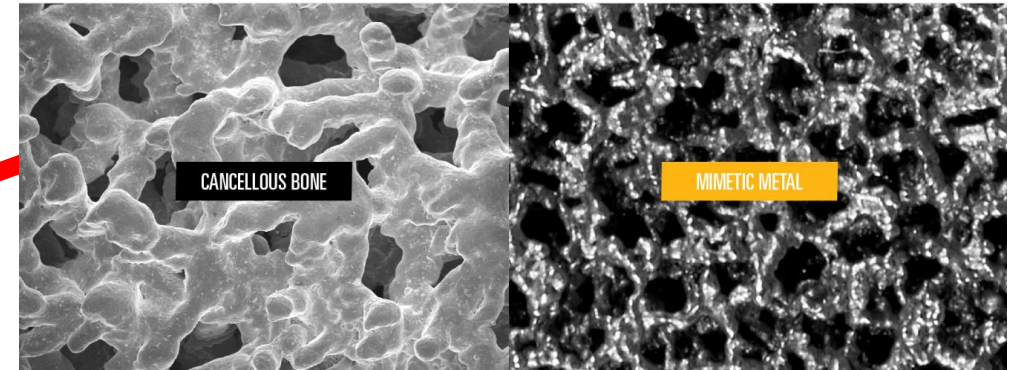
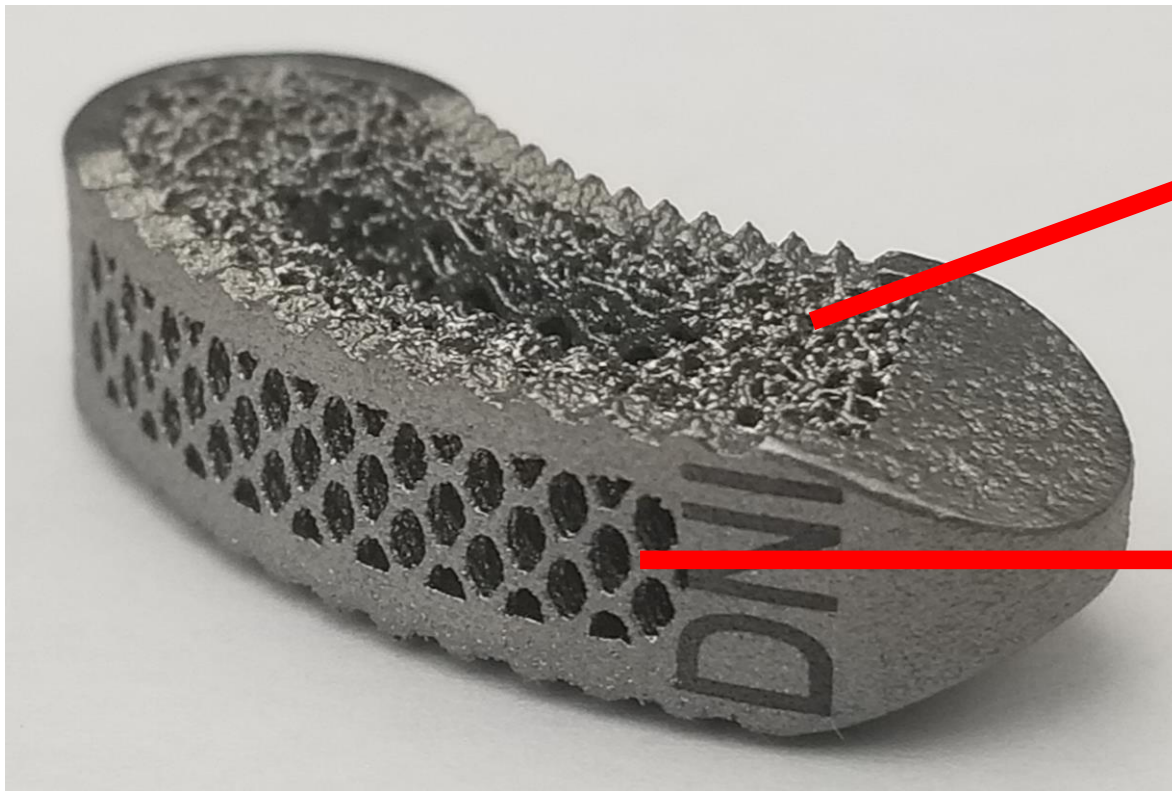
Image-Based Model



CoreLink[®]

Designer/manufacturer of spinal implants, instruments and posterior fixation systems.

The CoreLink F3D Curved Lumbar Cage

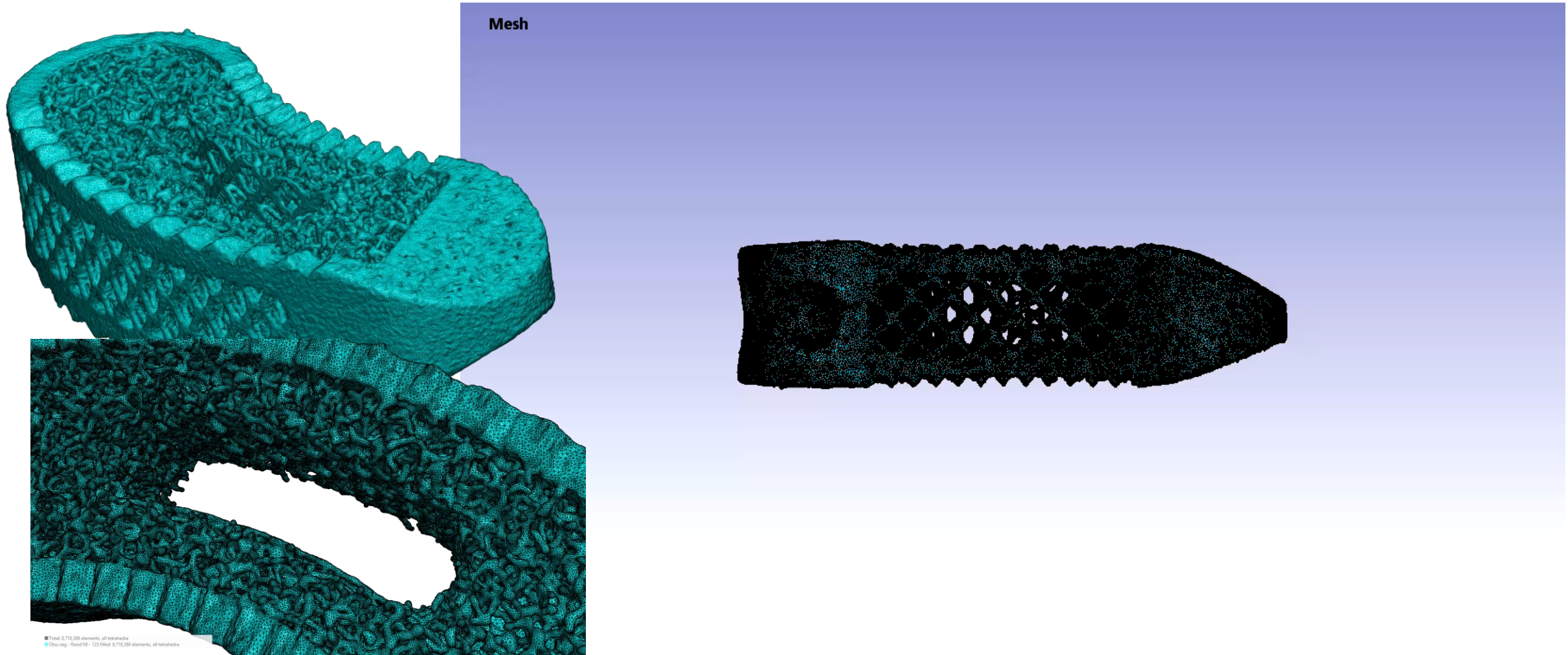


<https://corelinksurgical.com/>



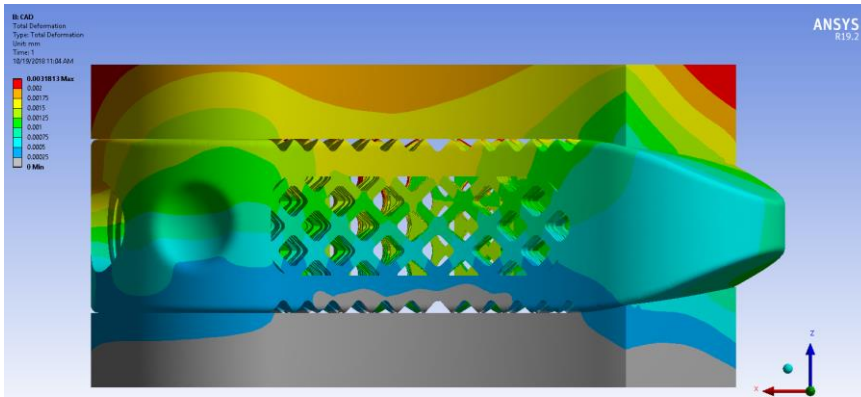
<https://corelinksurgical.com/>

Segmentation and meshing

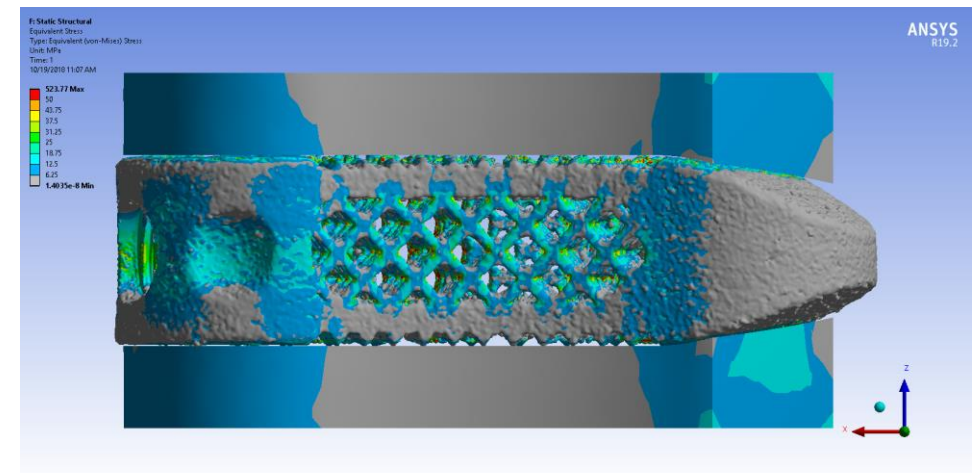
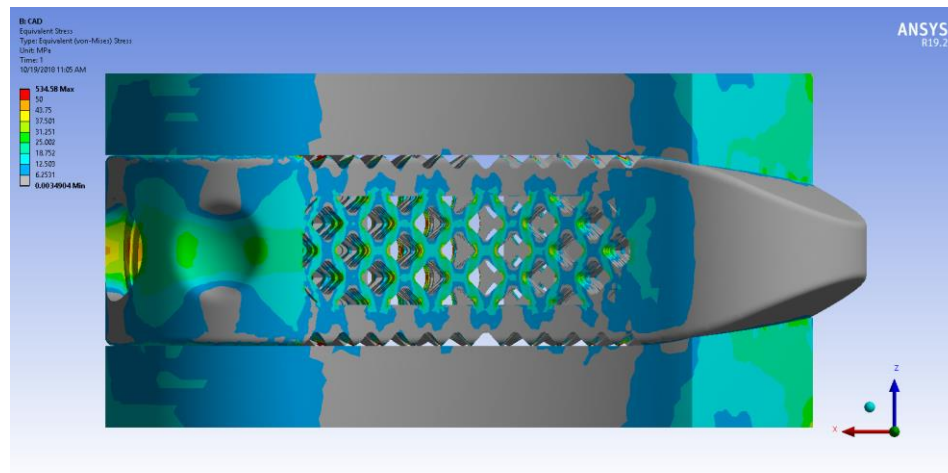
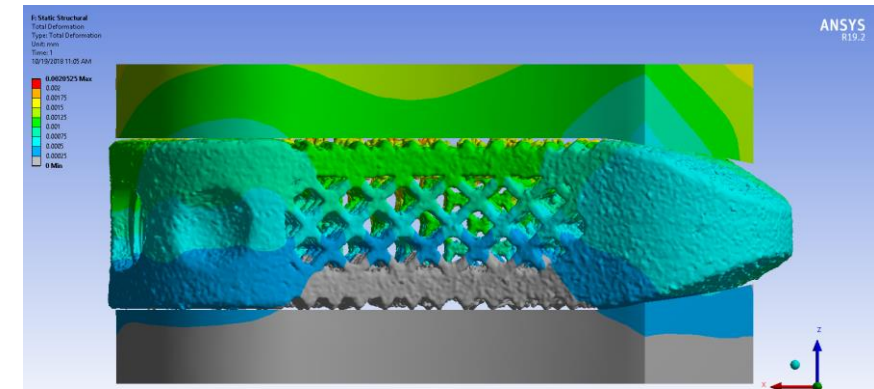


FE Simulation Results

Quantifying As-Built Simulation Deviations from the CAD Design



CAD based FE model
Max deformation = 0.0032mm
Max prin. stress of 534.6 MPa
Image-based model
Max deformation = 0.0021mm
Max prin. stress of 523.8 MPa
Well within acceptable range



Advancements that improve these workflows

Recent updates to the Simpleware toolkit

New release on Sep 9th!



Technical advances: Improved surface determination

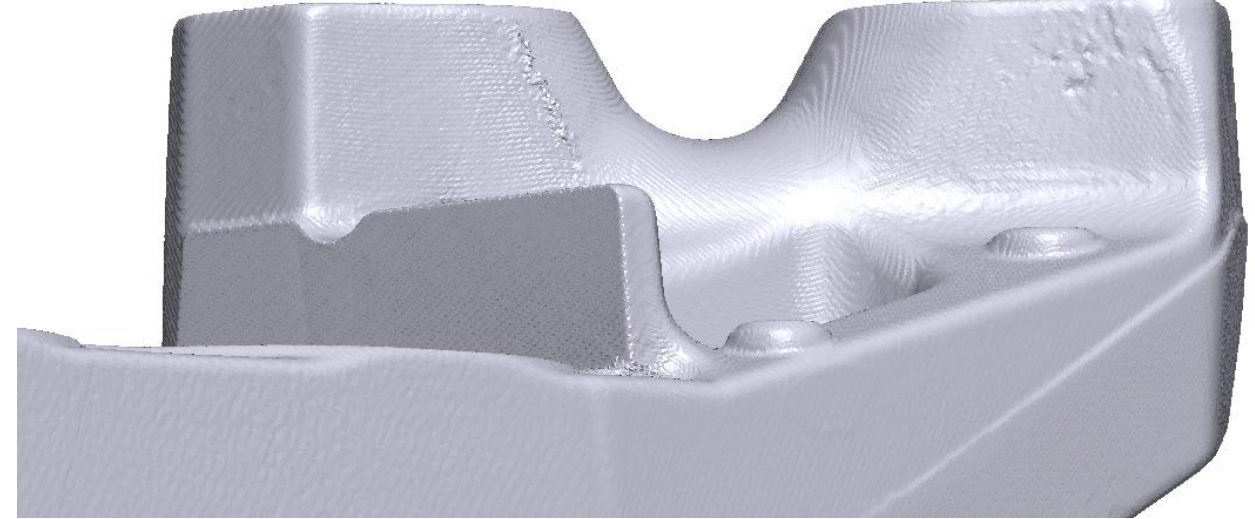
Correct mask surface position based on more advanced techniques than “Threshold”

- Local greyscale-informed surface correction
- Automatic detection of “true” surface
- Corrects artefacts causing inconsistent grey-scale variation
- Parameters to fine tune the result

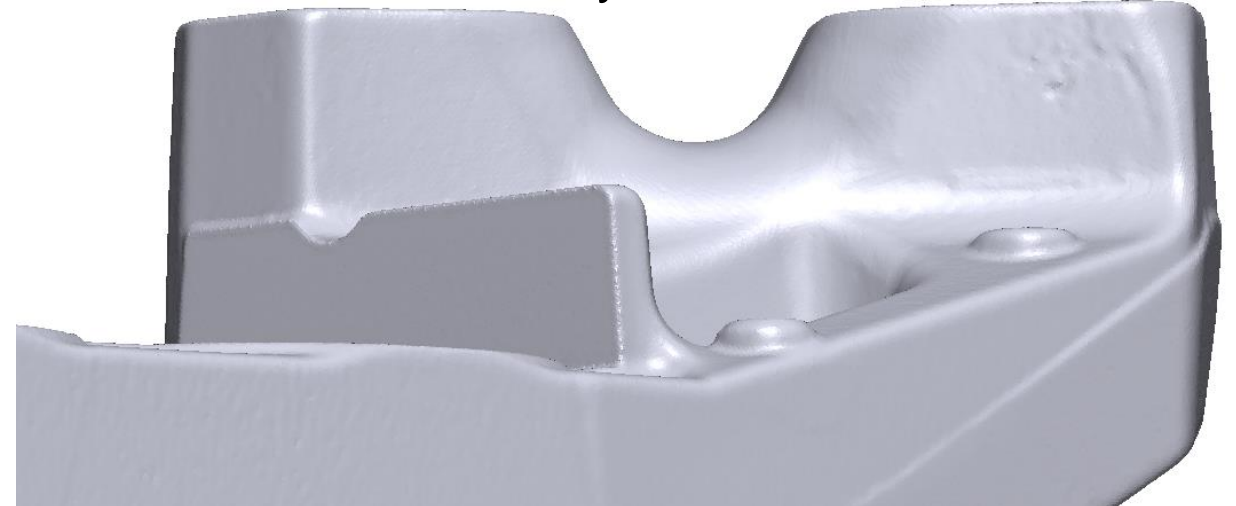
Smart smoothing

- Volume and topology preserving
- Multi-part smoothing – Preserves interfaces
- Iterative smoothing approach
- Highly controllable

ISO 50 Threshold



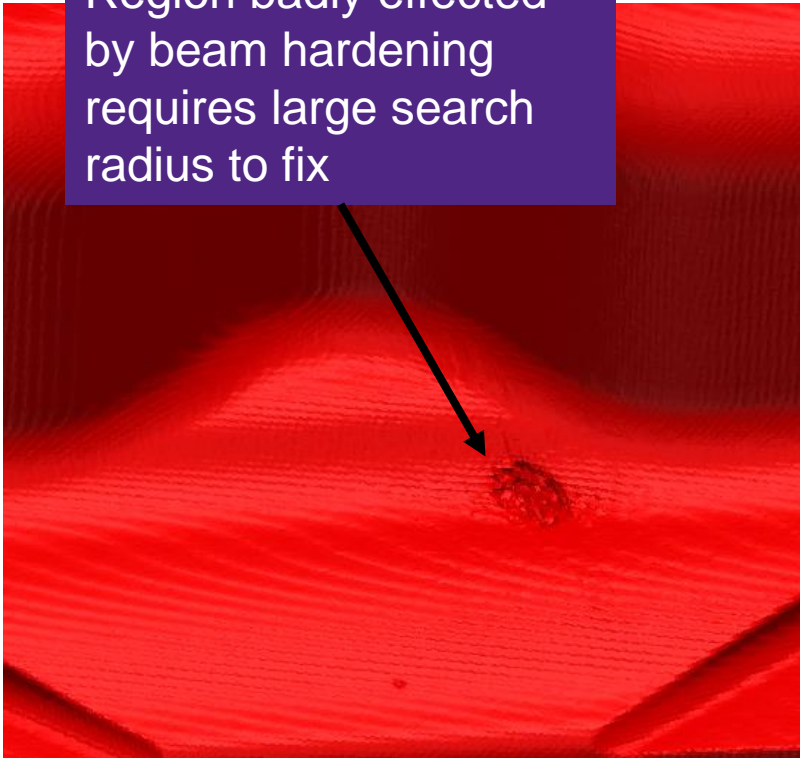
Locally corrected and smoothed



Technical advances: Local correction of artefacts

- Filter excellently improves surface determination where beam hardening and other artefacts create inconsistent greyscales
- With the addition of region of interest options, problem areas can be selected and fixed locally.
- Offers more flexibility: Apply with the right parameters for each problem area. Exclude regions which may otherwise give an undesirable result.

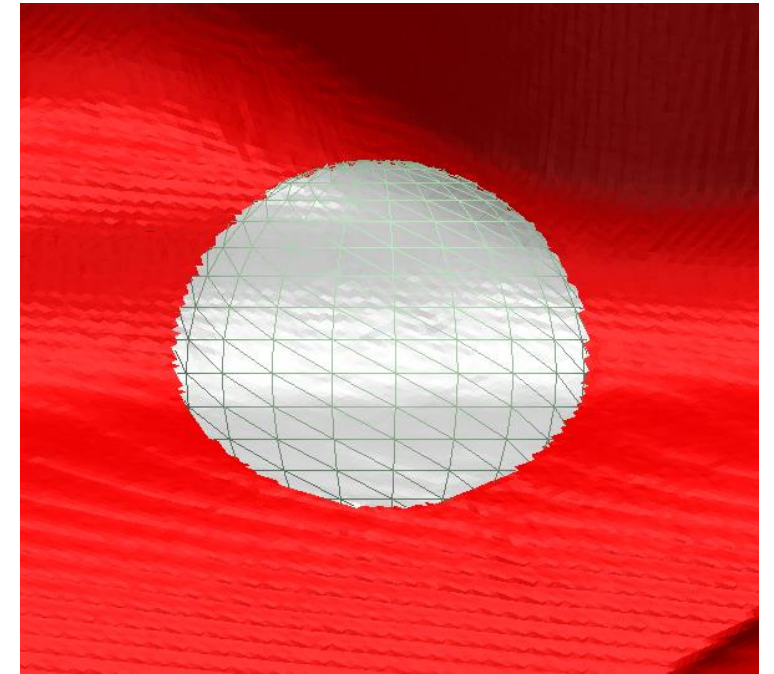
Region badly effected by beam hardening requires large search radius to fix



Select region with ROI



Apply local surface correction



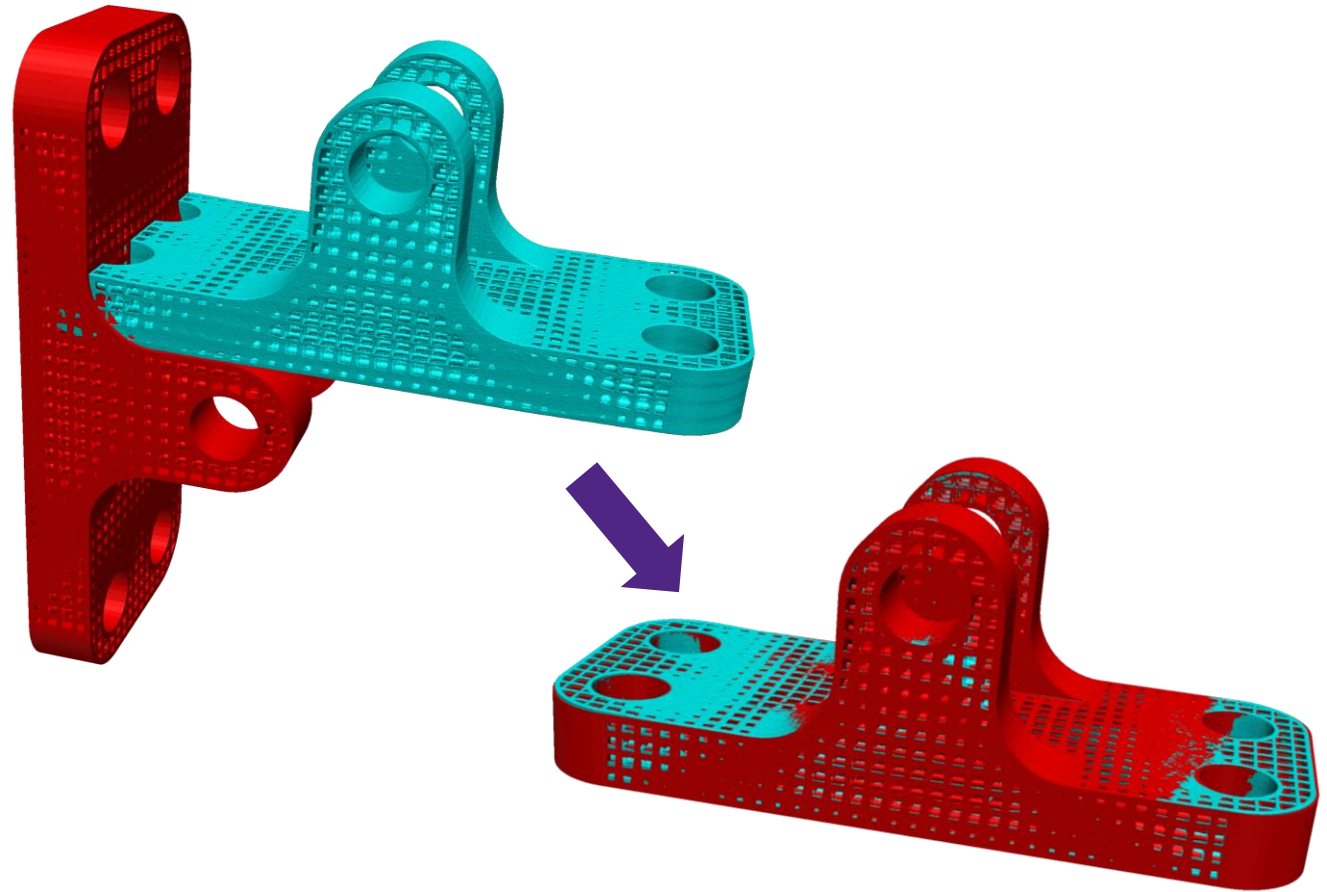
Technical advances: Generic dataset-to-dataset registration

Co-register any dataset types

- Register any dataset type (image, mask, surface or volume mesh) to any other*
- Landmark, automatic, and landmark and automatic modes
- Partial surface/mask registration – define region for registration

Register datasets from current or foreign project files

- Easily import datasets from other project files



* Note: to register surface objects requires a licence of the Simpleware CAD module and to register volume meshes requires a licence of the Simpleware FE module.

Computing advances: Console ScanIP

Run ScanIP without the GUI

- Run ScanIP from the command line with scripted workflows
- Almost all functionality available in the scripting API can be used with Console ScanIP
- Better incorporation of ScanIP in batch-processing workflows

```
C:\Program Files\Synopsys\Simpleware\O-2018.12\ConsoleScanIP.exe --run-script="AuxFoam.py"
C:\Scripts>"C:\Program Files\Synopsys\Simpleware\O-2018.12\ConsoleScanIP.exe" --run-script="AuxFoam.py"

Simpleware(TM) ScanIP

Version 0-2018.12 for win64

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Chapter 6
6.3.1 Importing the data
Loading project... [#####] , 100%
Chapter 6
6.3.2 Segmenting regions of interest
Mask creation [#####] , 100%
Saving data for undo... [#####] , 100%
Applying algorithm... [#####] , 100%
Applying algorithm... [#####] , 100%
Smart mask smoothing... [#####] , 100%
Generating surface... [#####] , 100%
Post-processing... [#####] , 100%
Chapter 6
6.4.1 Creating and exporting a surface model for 3D printing
Smart mask smoothing... [#####] ] Estimated time remaining: 00:00:05, 46%
```

The Simpleware Advantage

- **State-of-the Art Technology:**

- Robust proprietary algorithms (patented)
- Best in class segmentation tools

- **Ease-of-use:**

- User-friendly interface
- Customizing through scripting

- **Support:**

- Expert support (dedicated point of contact)
- One-to-one sessions, web-meetings and tailor-made training courses

See and Try Simpleware Software

- **Get a 30-day Free Trial:**

- Receive a fully functional trial version of the full Simpleware product suite
- Sign up at: <https://www.synopsys.com/simpleware>
- Contact support with any questions, for advice or help in setting up your workflow

- **Visit our Workshops, Webinars and Exhibition Booths:**

- See our list of upcoming events: www.synopsys.com/simpleware/news-and-events/events.html

- **Arrange a Personal Software Demonstration:**

- Get in touch with us to arrange a personalized software demonstration via WebEx with one of our expert Application Engineers using your own data

- **Contact Us:**

- simpleware@synopsys.com

Thank You

