Solving Image-Based Modelling Challenges

From 3D Images to Models

Philippe G. Young

R and D Director Synopsys Simpleware Product Group

Chair in Computational Mechanics University of Exeter
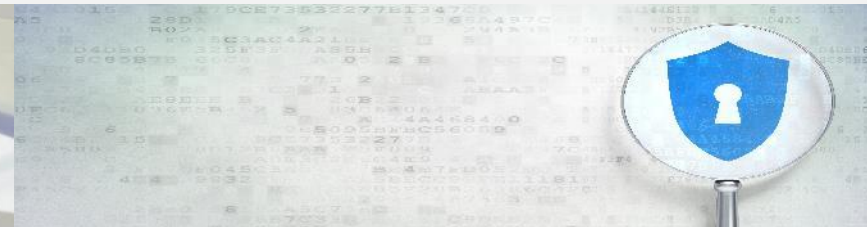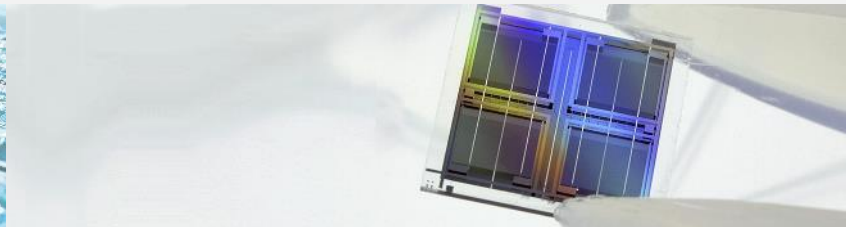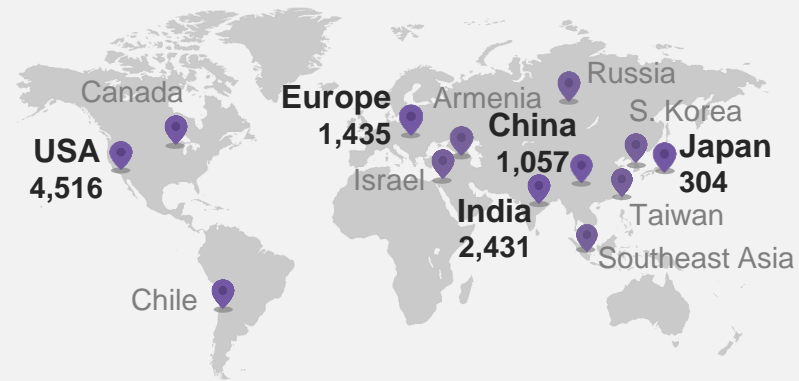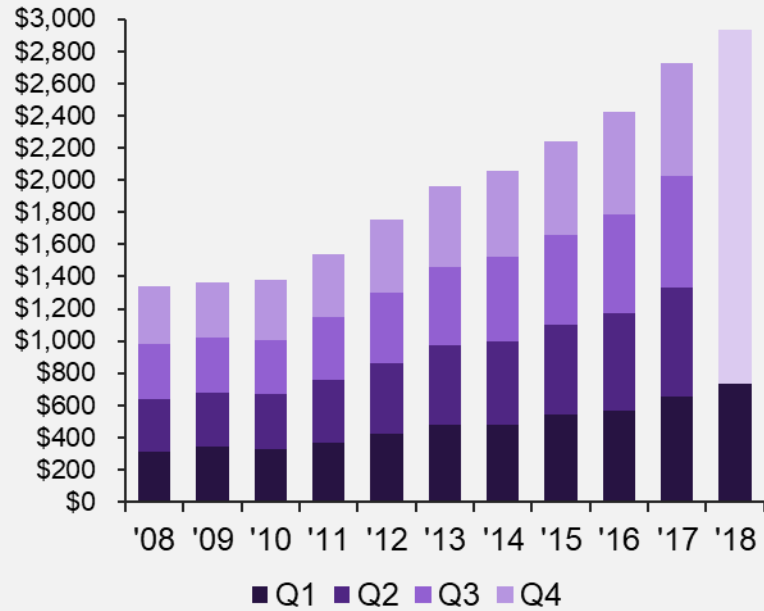
NAFEMS July 23rd 2018

Synopsys Today

FY17 Revenue: ~$2.7B

Employees: >12,200

Years: 30+

Revenue chart ($ millions) by quarter, FY'08 to FY'18. Legend: Q1, Q2, Q3, Q4.

World map of employee locations:
- USA 4,516
- Canada
- Chile
- Europe 1,435
- Israel
- Armenia
- Russia
- China 1,057
- India 2,431
- Southeast Asia
- Taiwan
- S. Korea
- Japan 304

SYNOPSYS®

Simpleware Product Group

- Developers of high-end 3D image processing software

- Dedicated Sales, Support and Service teams

- Global presence

- Customer base in life sciences, materials and manufacturing applications

Image-Based Modelling Workflow

3D Image Import & Visualization

Segmentation & Processing

Measurements & Analysis

CAD & Image Integration

Model Generation

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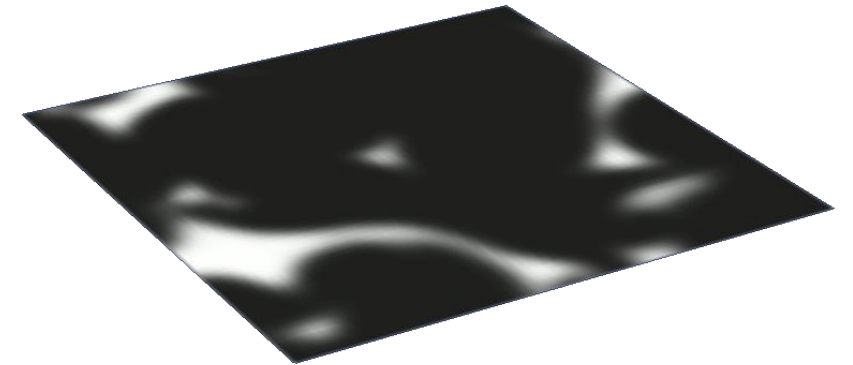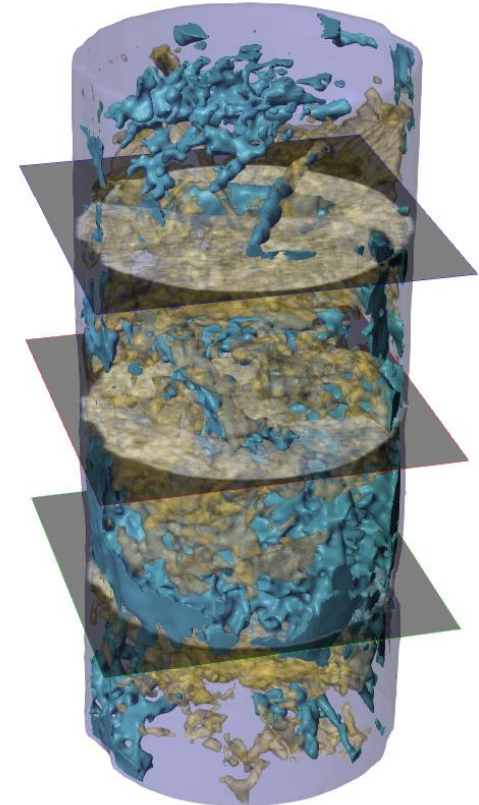
Image-Based Modelling Workflow

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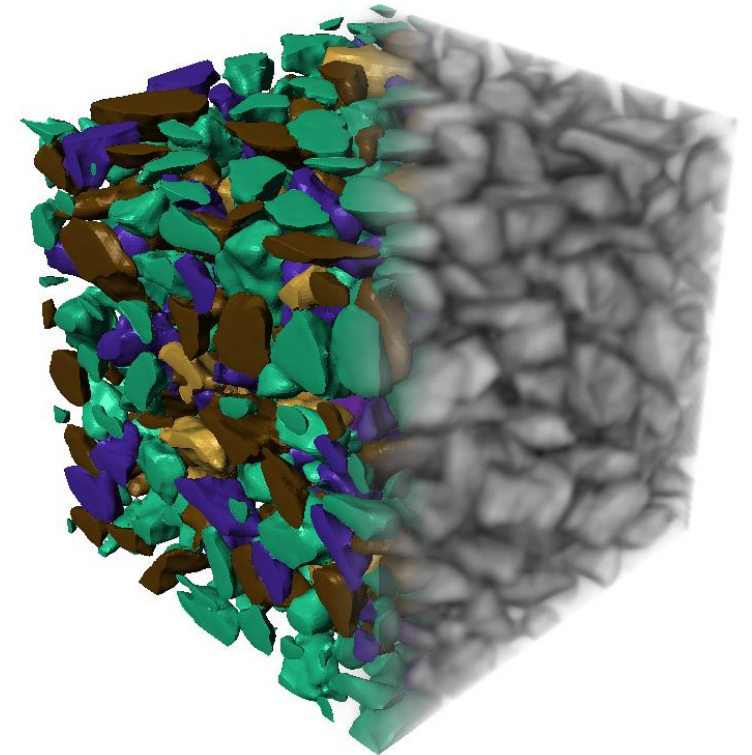- **CAD & Image Integration**
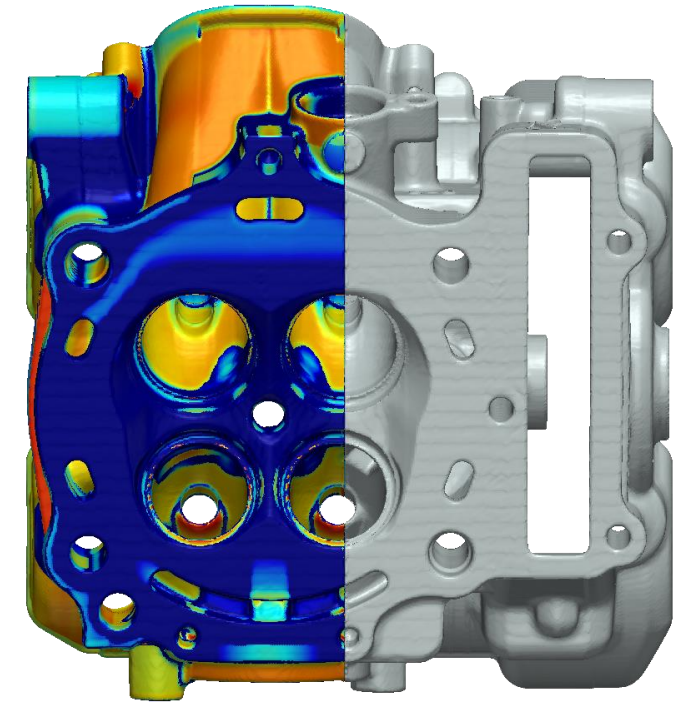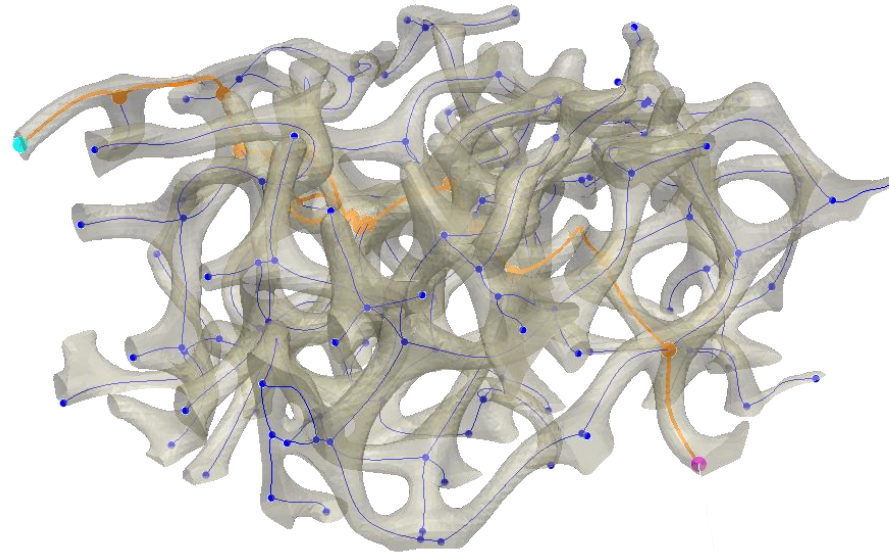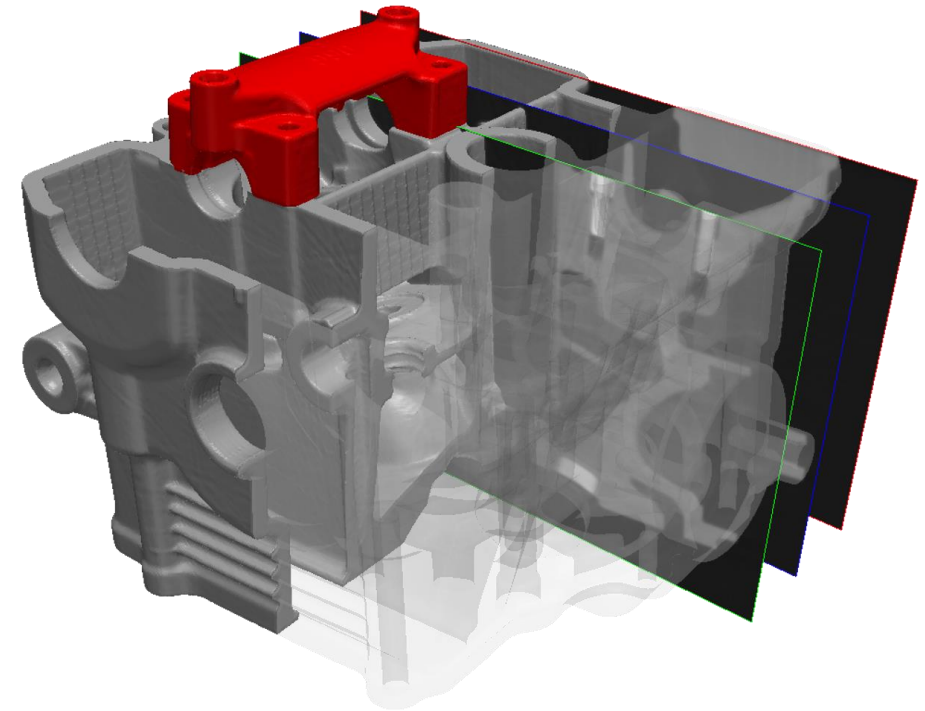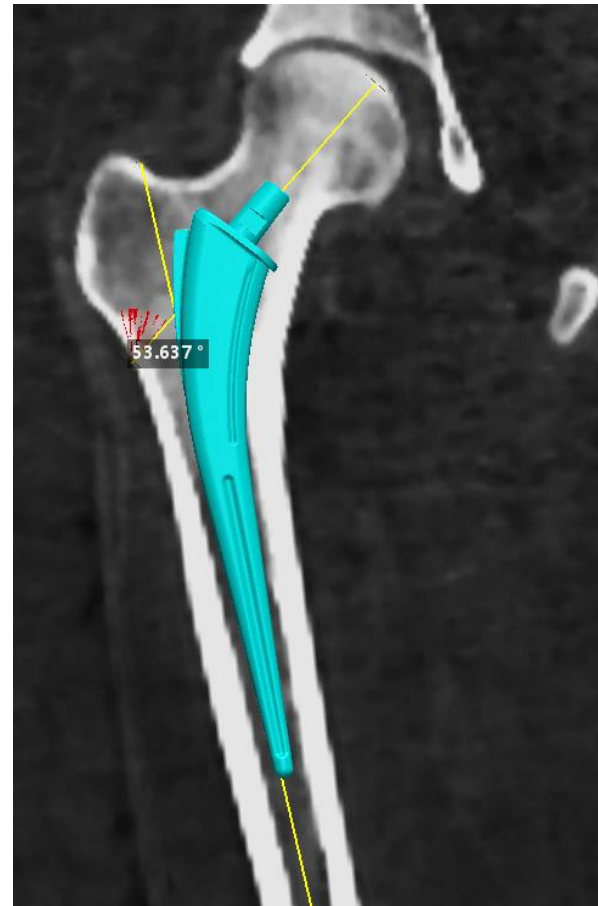- Model Generation

Image-Based Modelling Workflow

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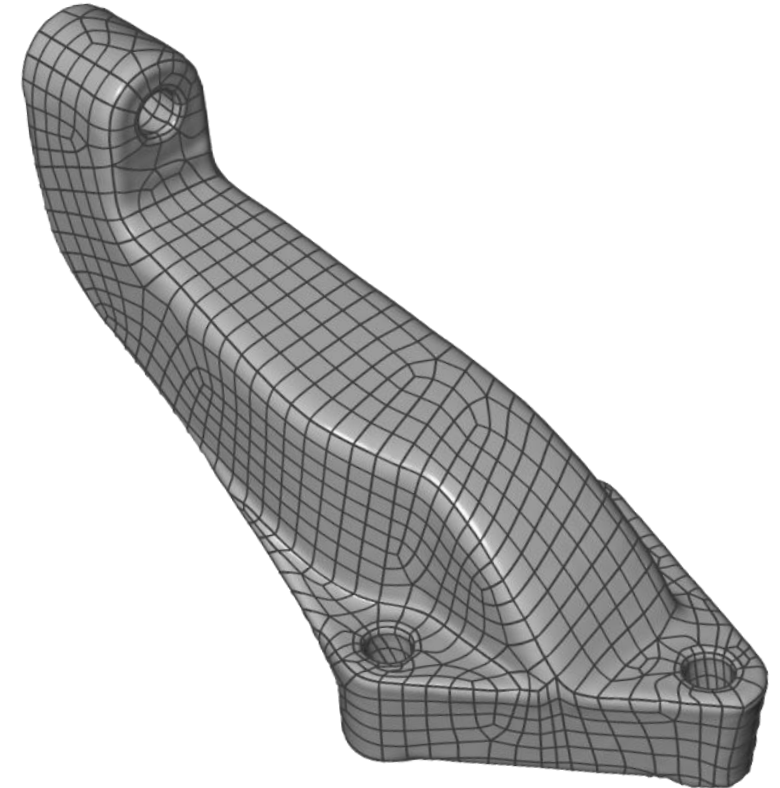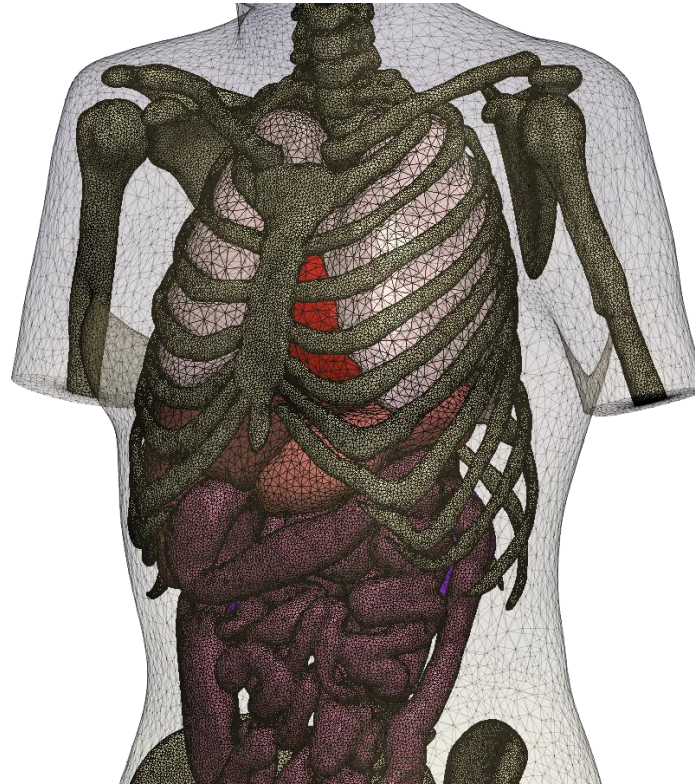
Applications of Image Based Modelling
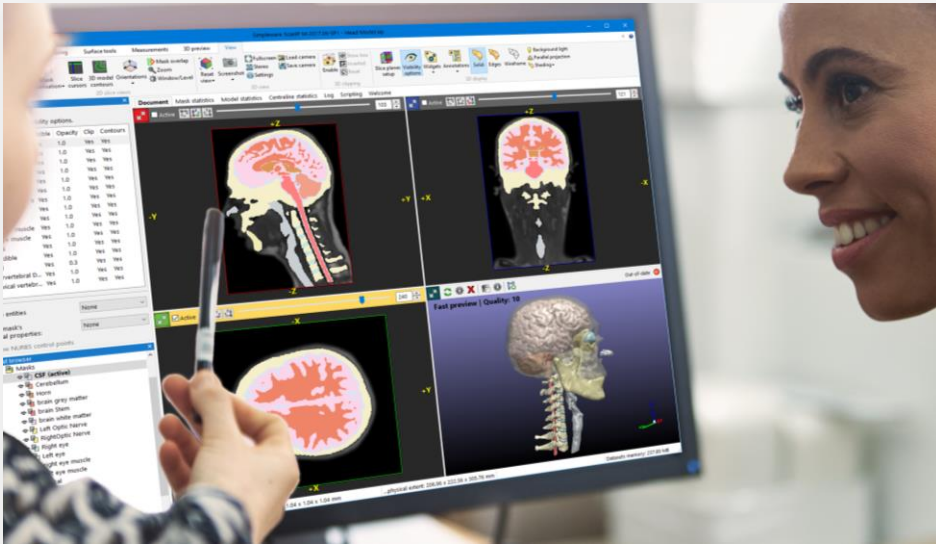
Life Sciences
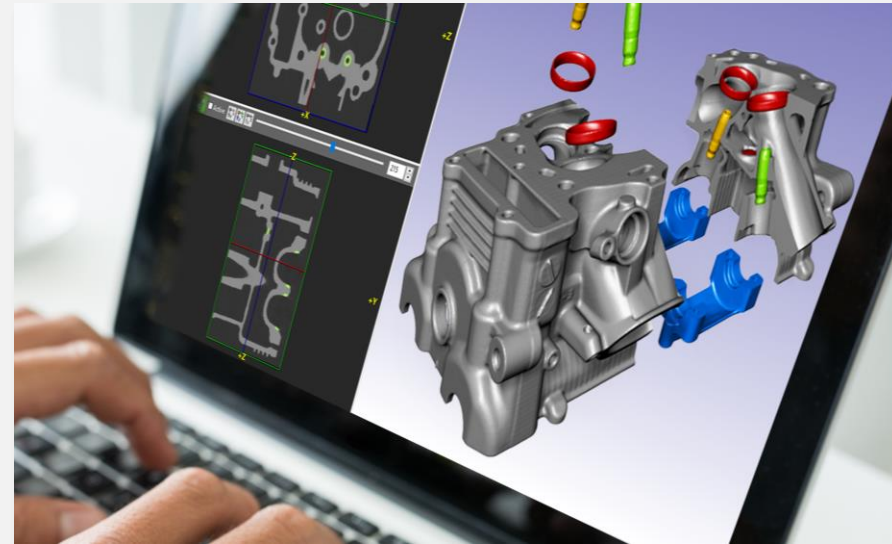
Manufacturing & Materials

Applications in Life Sciences / Product Integration
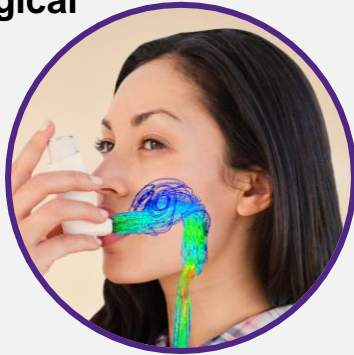
3D Printing

Protective Gear

Physiological Flows
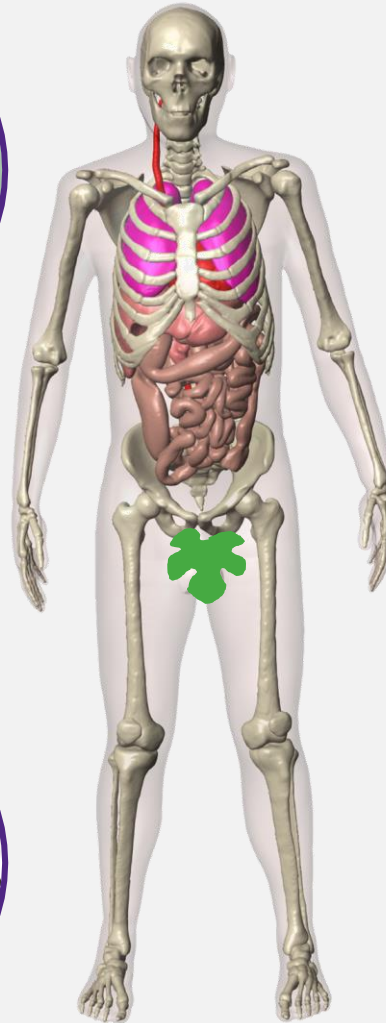
Wearable Electronics

Implants
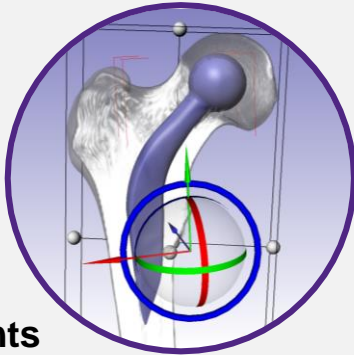
Pre-Surgical Planning
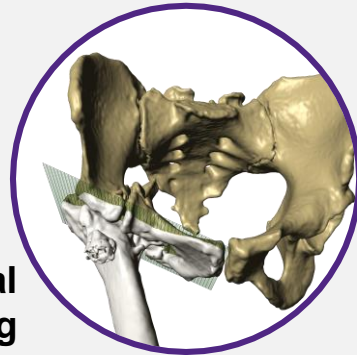
Shoes / Clothing

Beauty & Care Products

Applications in Materials & Manufacturing

Foams
Filters

Metals
Composites

Soils
Asphalt

Reverse
Engineering

Part
Inspection,
NDE/NDT

ALM /
3D Printing
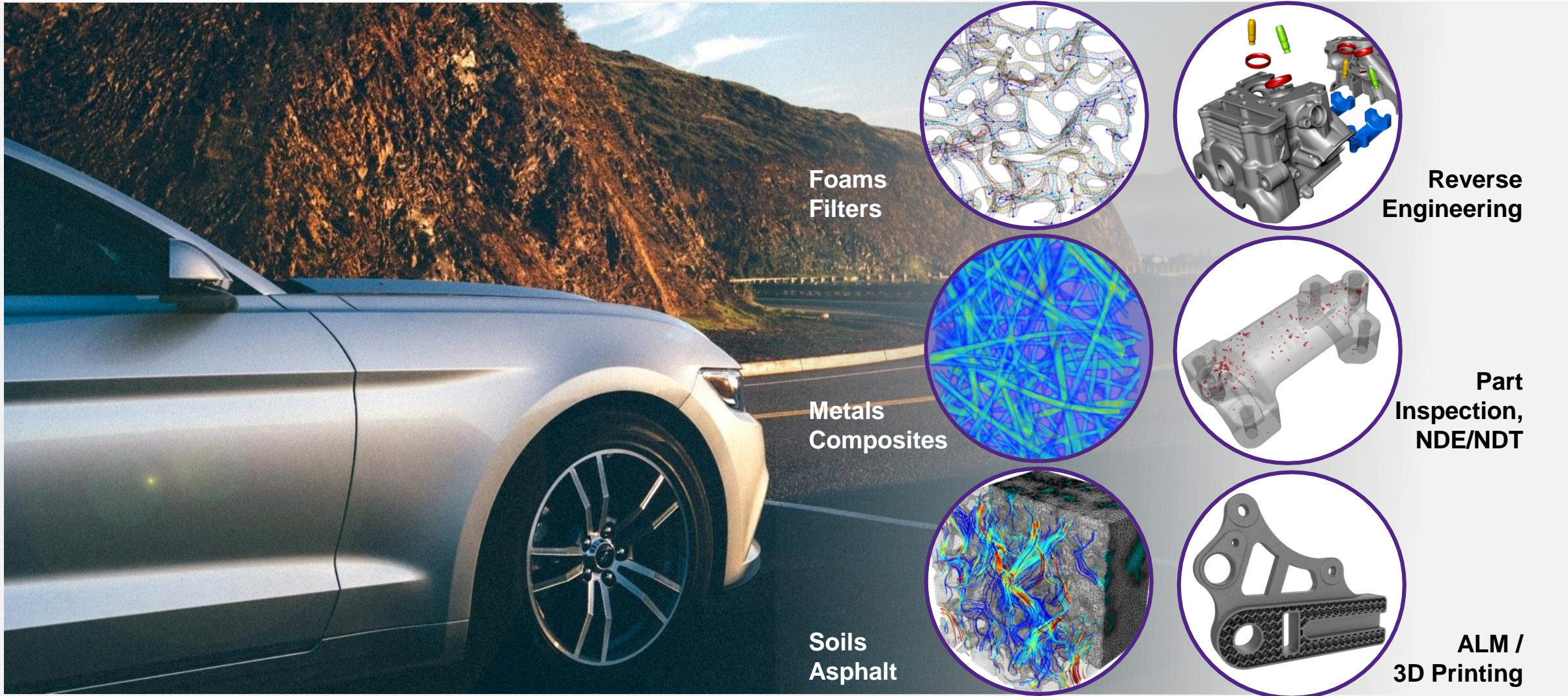
Simpleware Software Solutions

Quality Control of ALM Aerospace Part

ELEMCA & CNES

14

Quality Control of ALM Aerospace Part

Highlights

- ALM part used for the TARANIS satellite was analyzed to identify the location of porosities within the material

- Simpleware software was used to generate models for FEM to validate its structural integration

- Results validated ALM method for comparing CAD models and designed part, with space mission applications
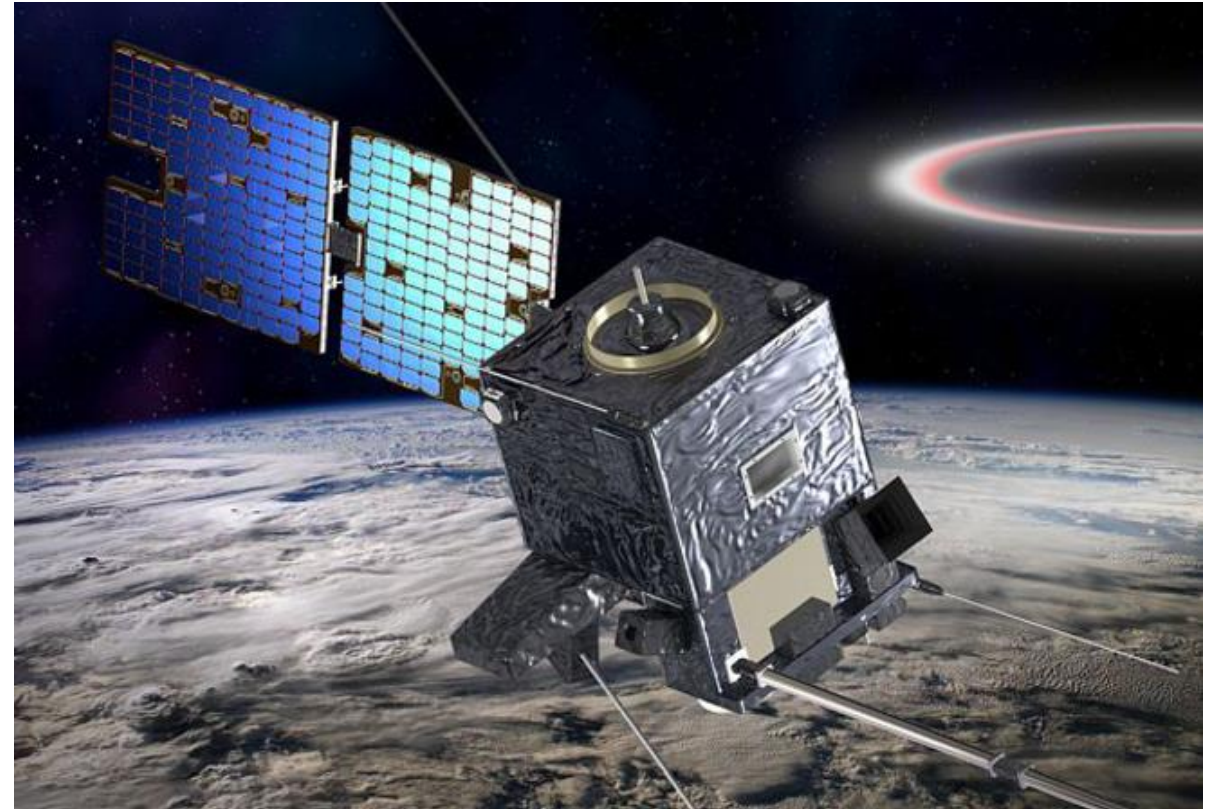
ELEMCA, CNES

Quality Control of ALM Aerospace Part

Workflow

• X-ray CT data of aluminium part part used for the TARANIS satellite were processed in Simpleware ScanIP
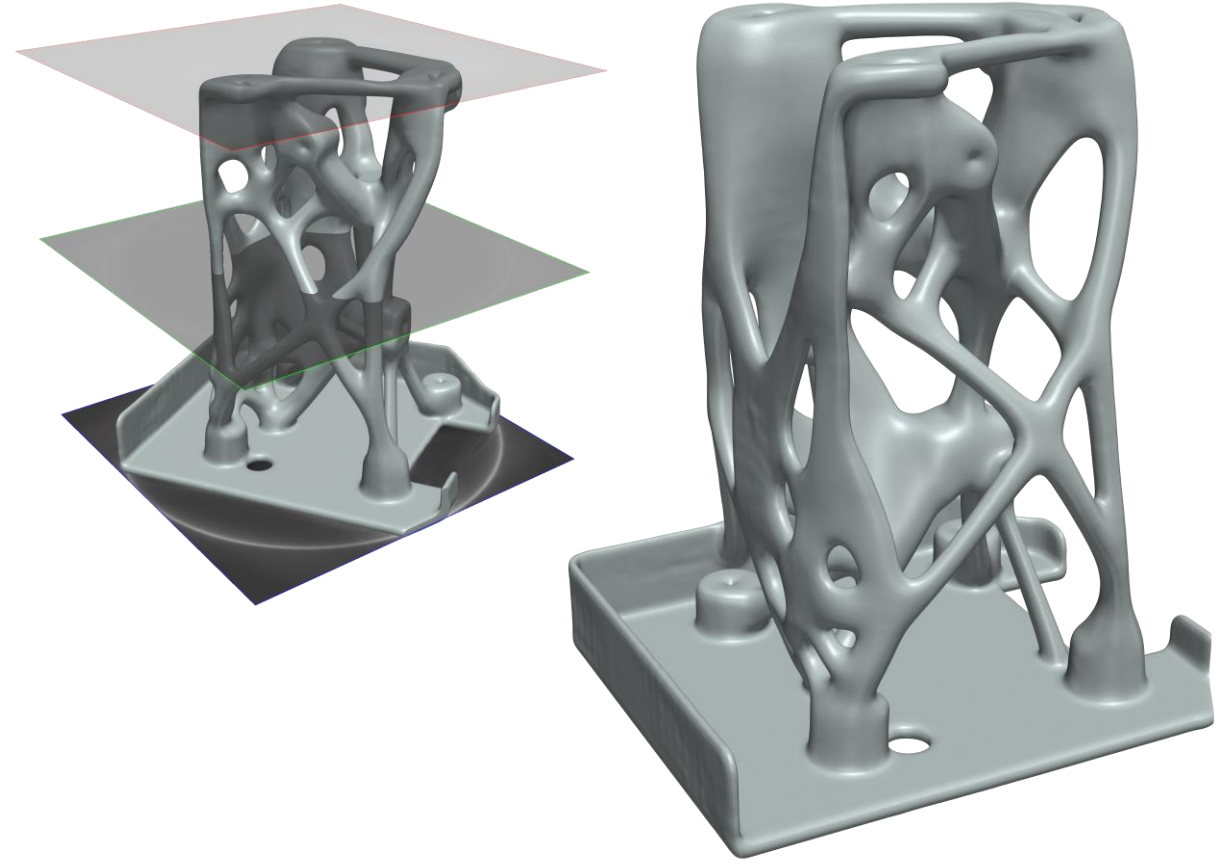
ELEMCA, CNES

Quality Control of ALM Aerospace Part

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- The model was simulated in ANSYS to analyze defects and compare scan data to previous simulations based on idealized CAD data
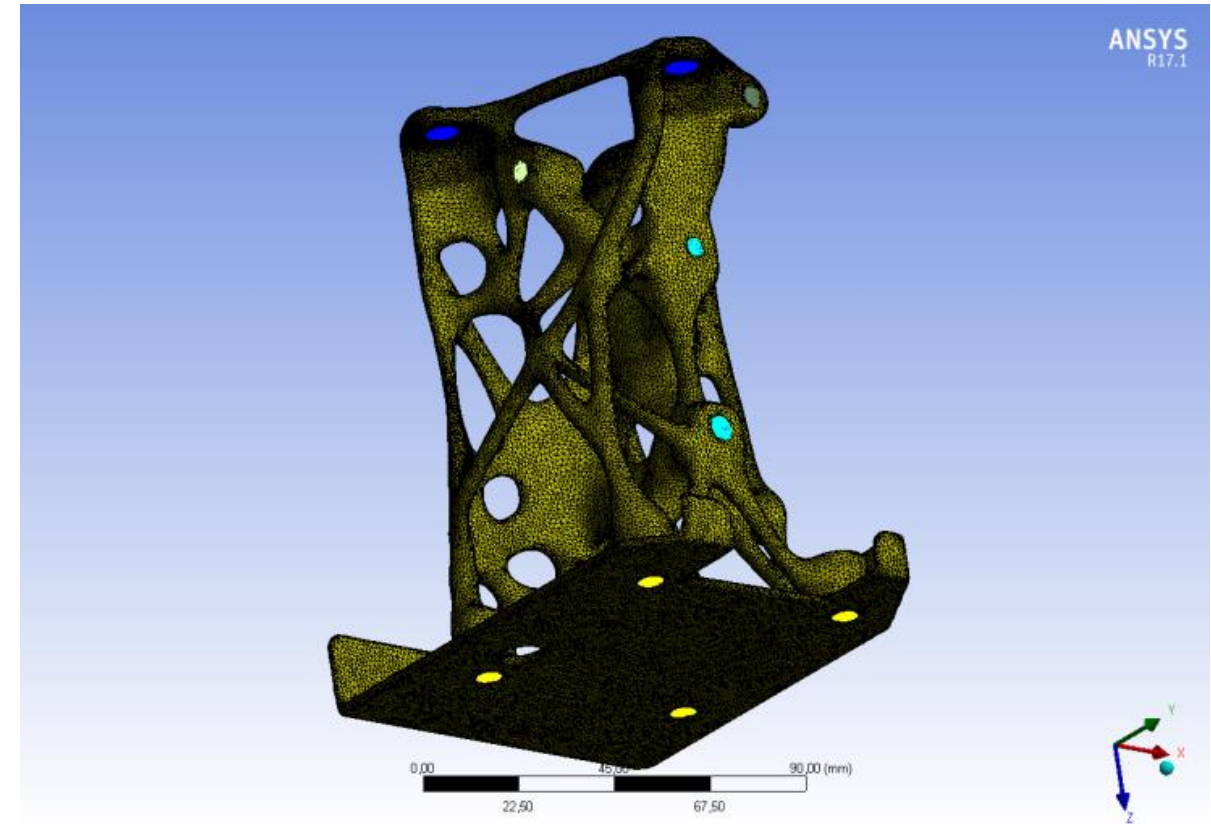
ELEMCA, CNES

Quality Control of ALM Aerospace Part

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- This workflow is useful for adding new levels of quality control and analysis to AM processes within the space industry. The part has been successfully tested, and may now be integrated into the space mission

0,015   0,030   0,045   0,060 (m)

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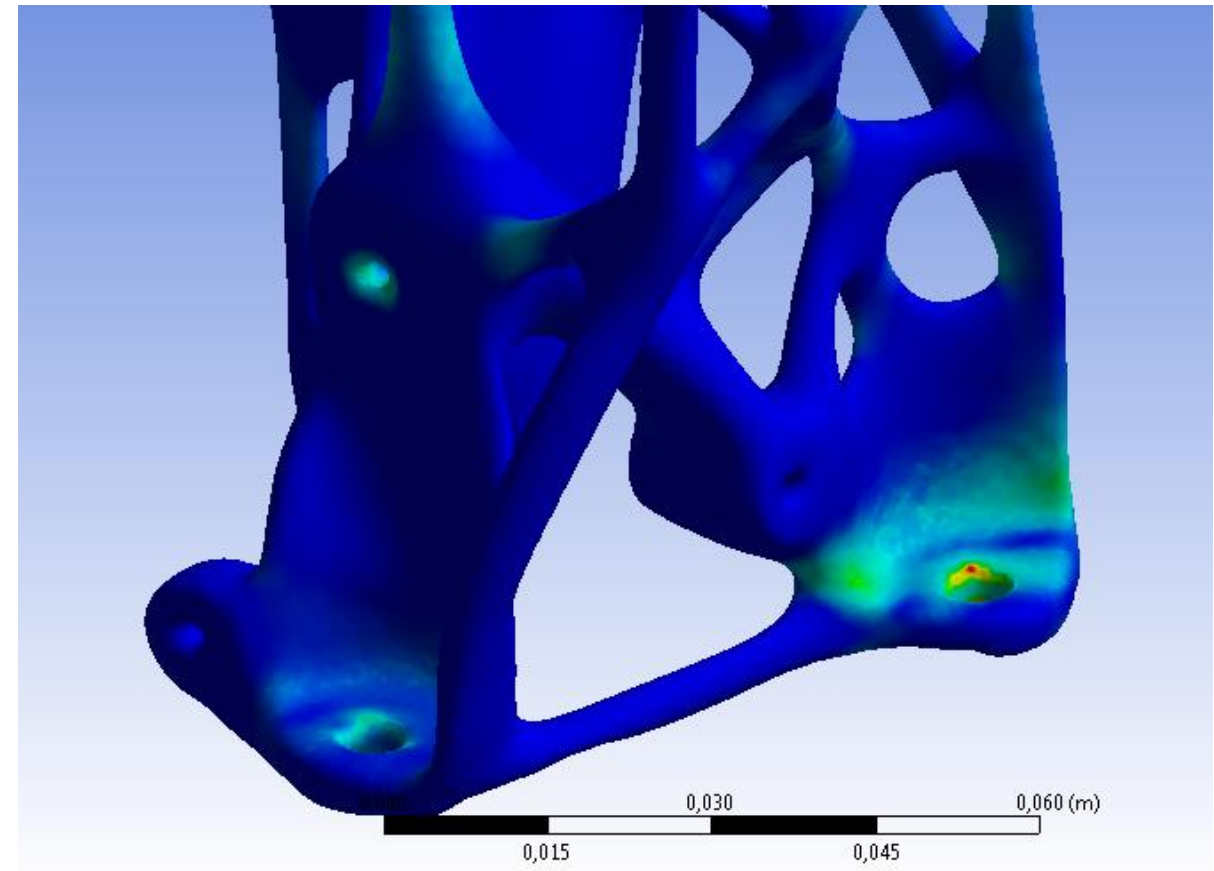
Giving Arthritis the Finger (Prosthetic Finger Joint)

Optimal Device, Endurica

SYNOPSYS®

Giving Arthritis the Finger (Prosthetic Finger Joint)

Highlights

- Total joint replacement can alleviate pain for rheumatoid arthritis; surgery involves removing the swollen joint tissue and replacing with an off the shelf prosthetic

- For development of a patient-specific silicone finger joint implant, Simpleware software was used to segment CT scan data of the hand

- Workflow describes why and how to leverage patient-specific anatomical data, non-linear structural simulation, fatigue simulation and shape optimization to enhance device design

Normal joint — Bone, Synovial membrane, Cartilage

Osteoarthritis

Rheumatoid arthritis

Optimal Device, Endurica

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Giving Arthritis the Finger (Prosthetic Finger Joint)

Workflow

- CT scan data of the right hand from the Visible Korean dataset used to segment bones from soft tissue in Simpleware ScanIP

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- Implant design in CATIA into middle metacarpal and proximal phalange

Optimal Device, Endurica

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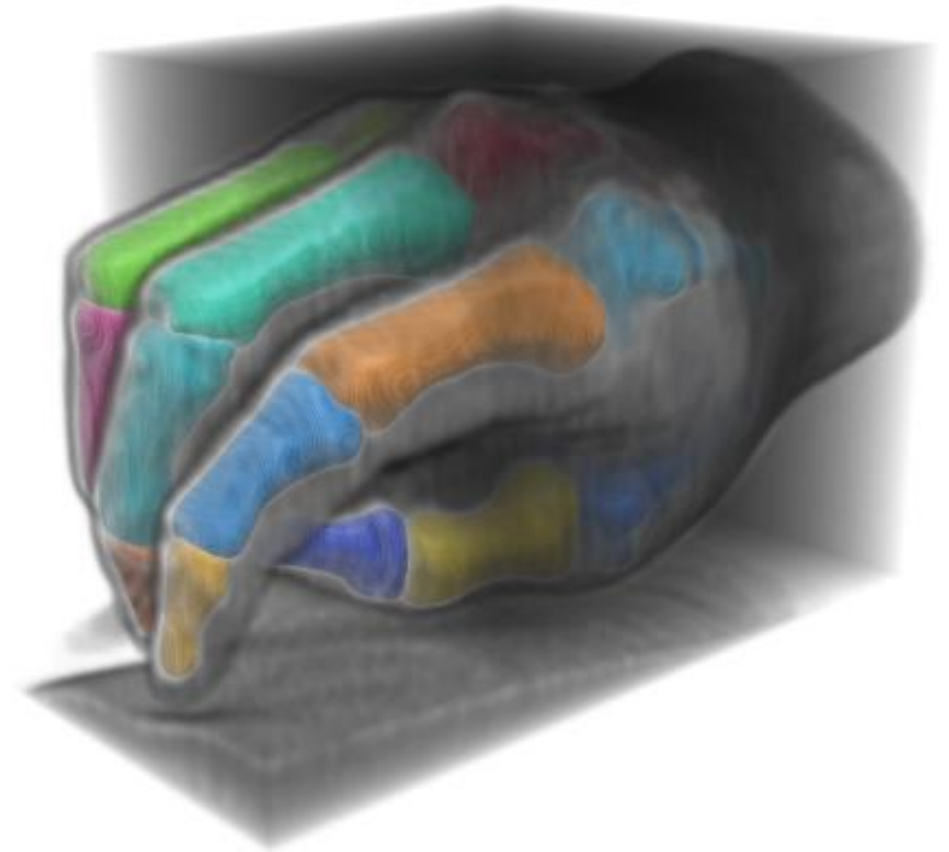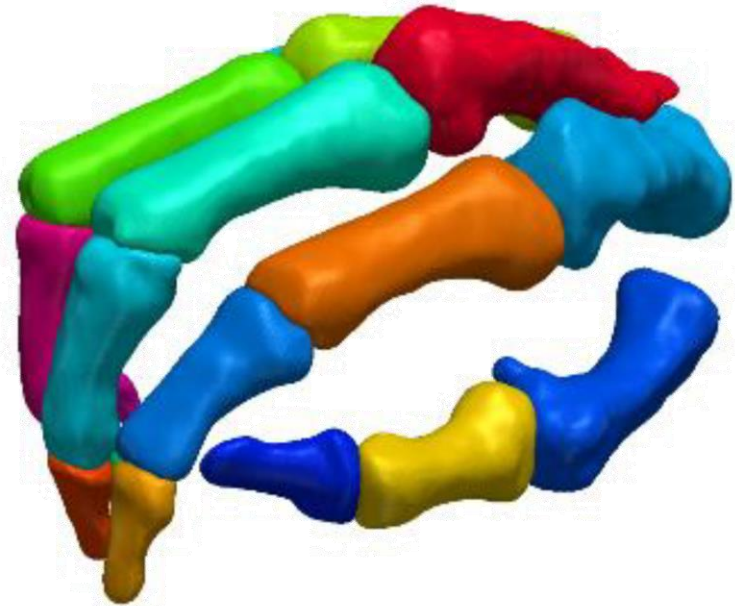
- Implant design in CATIA into middle metacarpal and proximal phalange

- Non-linear finite element model created in Abaqus/CAE that included large deformation, contact and a 3rd order Ogden hyperelastic material properties

Optimal Device, Endurica

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Giving Arthritis the Finger (Prosthetic Finger Joint)

Workflow

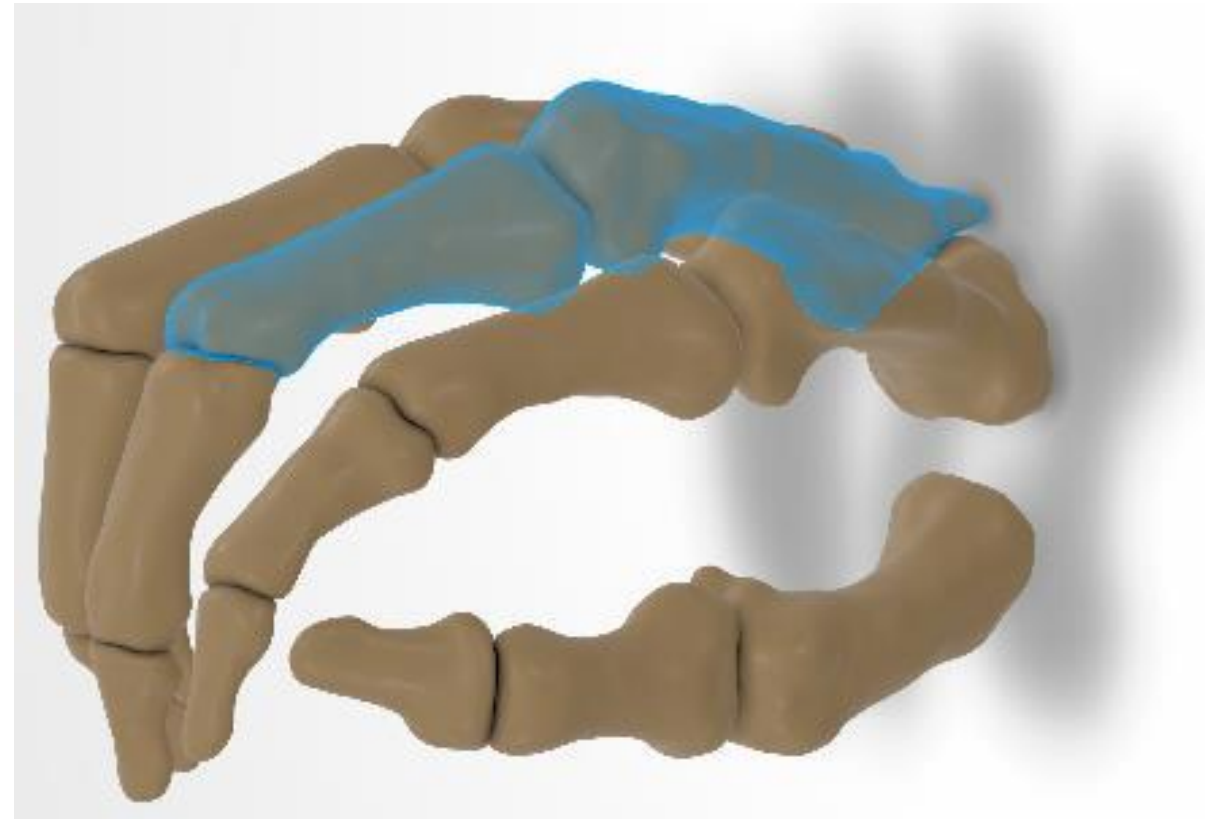- CT scan data of the right hand from the Visible Korean dataset used to segment bones from soft tissue in Simpleware ScanIP

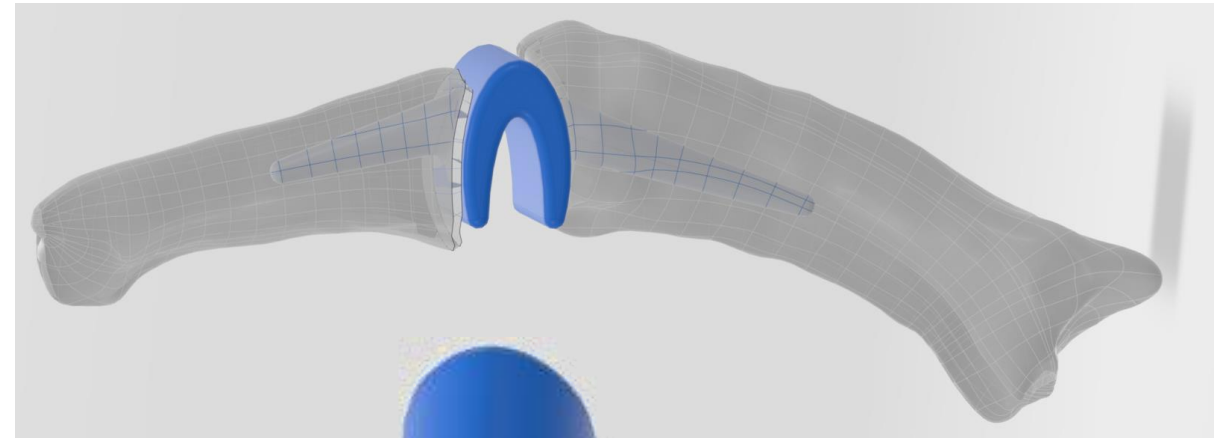- Implant design in CATIA into middle metacarpal and proximal phalange

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- Durability analysis in fe-safe/Rubber to calculate maximal strain locations for 20° extension and 70° flexion

Optimal Device, Endurica

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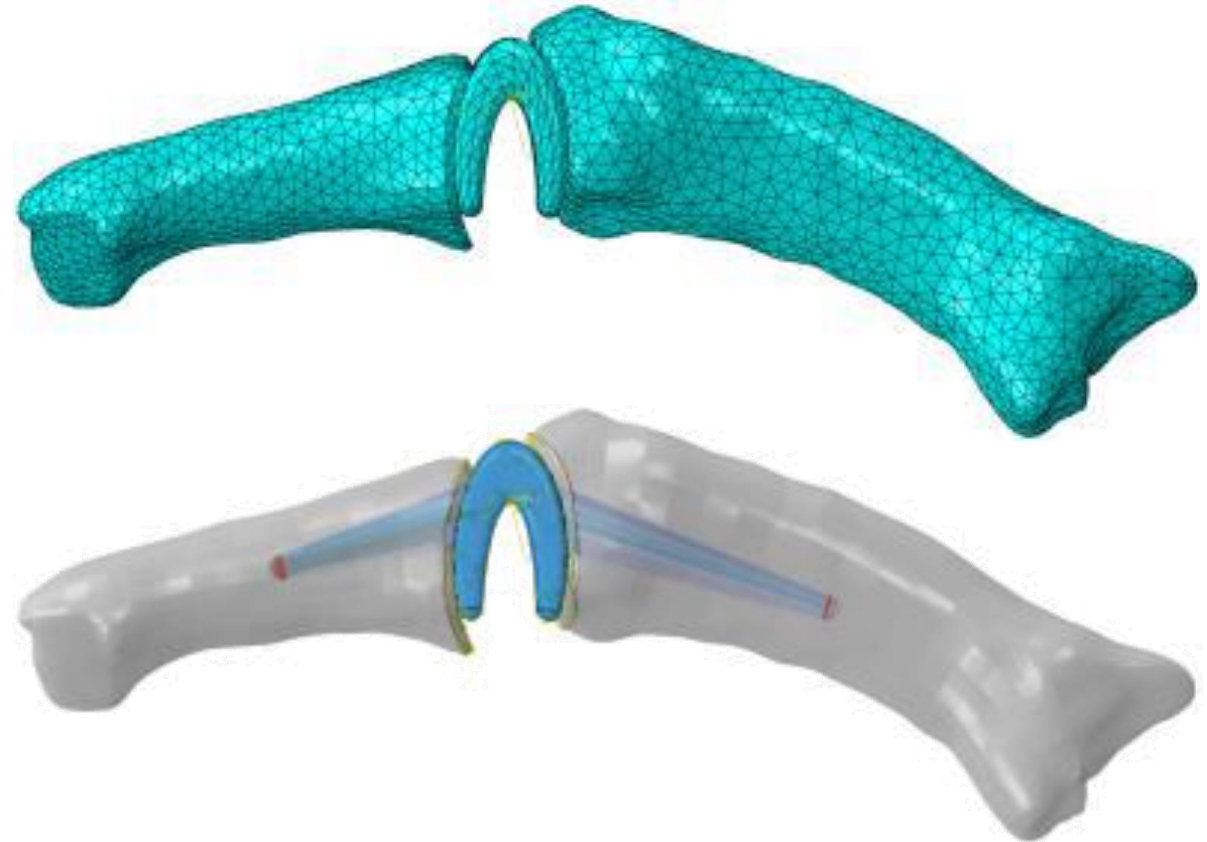• Implant design in CATIA into middle metacarpal and proximal phalange

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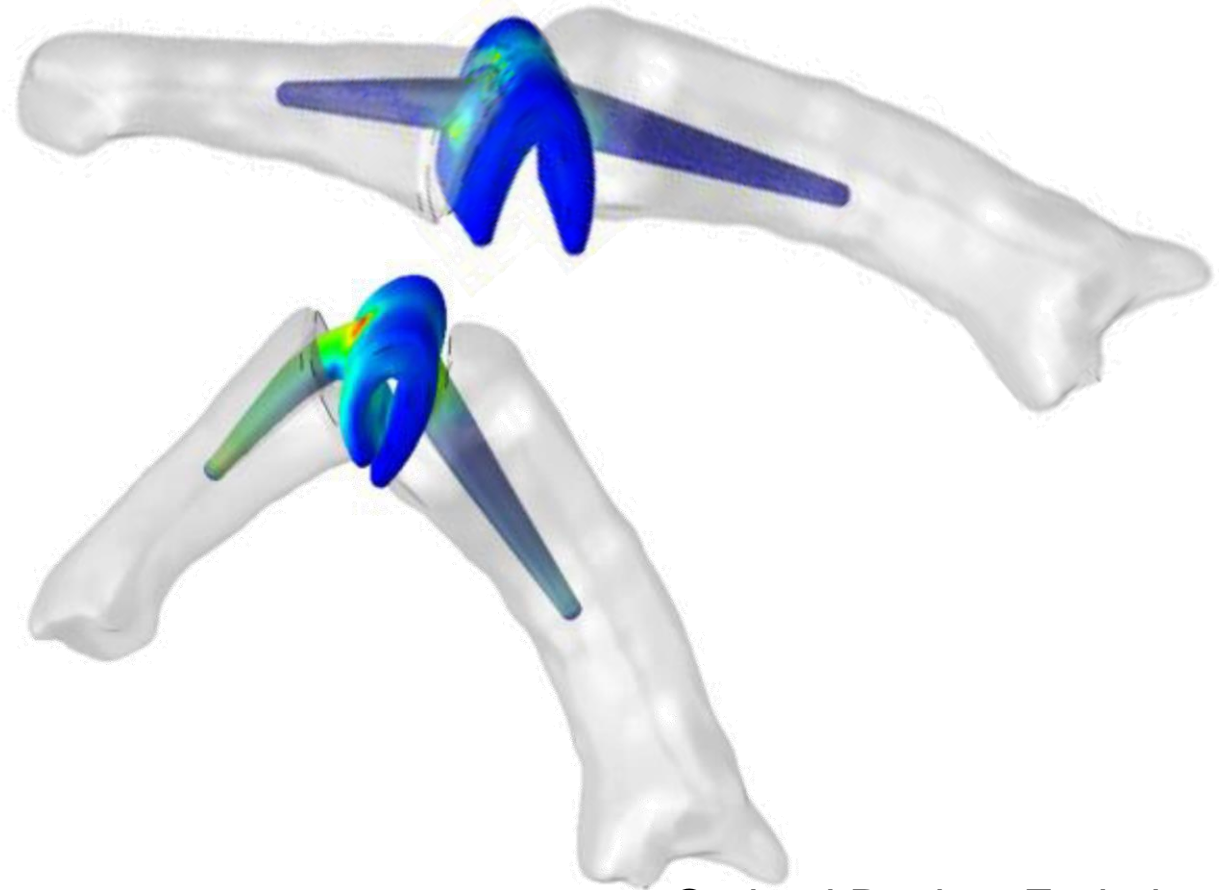
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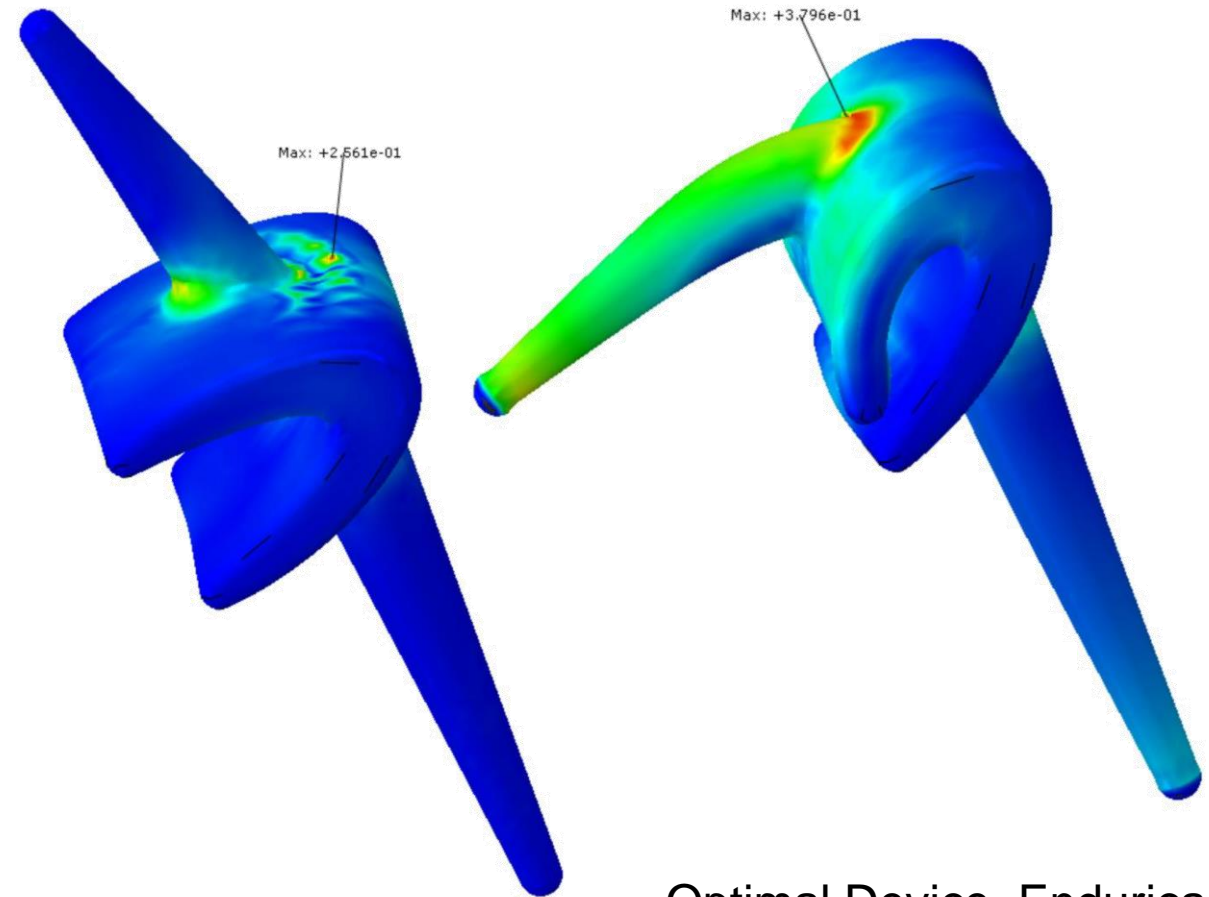

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Max: +3.796e-01

Optimal Device, Endurica

High-performance Computation in Solid Oxide Fuel Cell Microstructures

Carnegie Mellon University

High-performance Computation in Solid Oxide Fuel Cell Microstructure

Highlights

- High-performance methods using meshed 3D microstructures allows for quantification of local distributions of electrochemical properties from FIB-SEM data

- Simpleware software provides straightforward one-step conversion of microstructure data to meshes, speeding up previously time-consuming tasks for large meshes by using scripting

- Simulated local electrochemical performance throughout microstructure can provide insight into electrode degradation and failure behavior

Carnegie Mellon University

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High-performance Computation in Solid Oxide Fuel Cell Microstructure

Workflow

• Electrode microstructures obtained using Xe-plasma FIB-SEM serial sectioning to capture length scales on the order of 100-200 μm
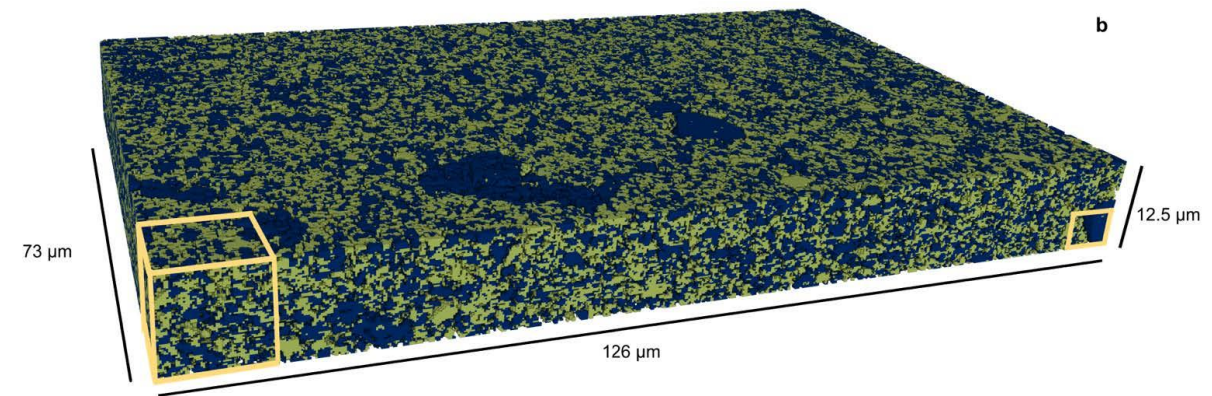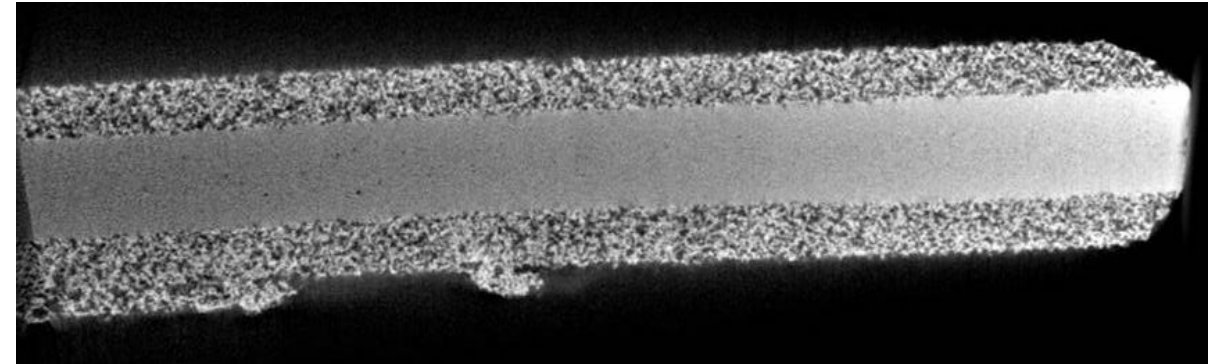

Carnegie Mellon University

High-performance Computation in Solid Oxide Fuel Cell Microstructure

Workflow

- Electrode microstructures obtained using Xe-plasma FIB-SEM serial sectioning to capture length scales on the order of 100-200 μm

- Simpleware software used to convert 3D scan data into microstructural, multi-domain and simulation-ready FE meshes. These models preserve the complex surface morphologies in three-phase SOFC electrodes

Cathode
(3-phase)

Electrolyte
(1-phase)

29,459,106 elements, all tetrahedra
: 10,766,809 elements, all tetrahedra
: 8,939,959 elements, all tetrahedra
: 6,444,502 elements, all tetrahedra
: 3,307,836 elements, all tetrahedra

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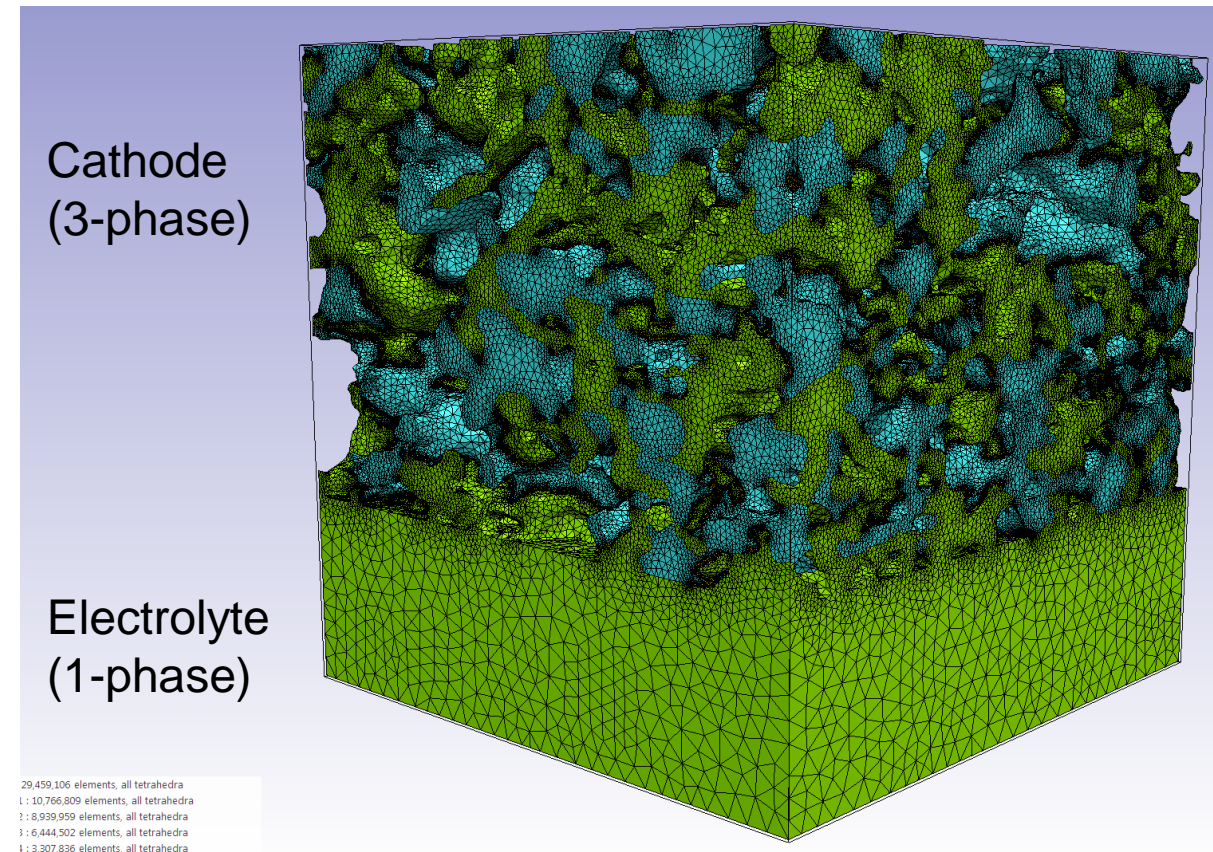
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Large-scale meshing:
30 x 30 x 10 [μm], 130 million mesh elements

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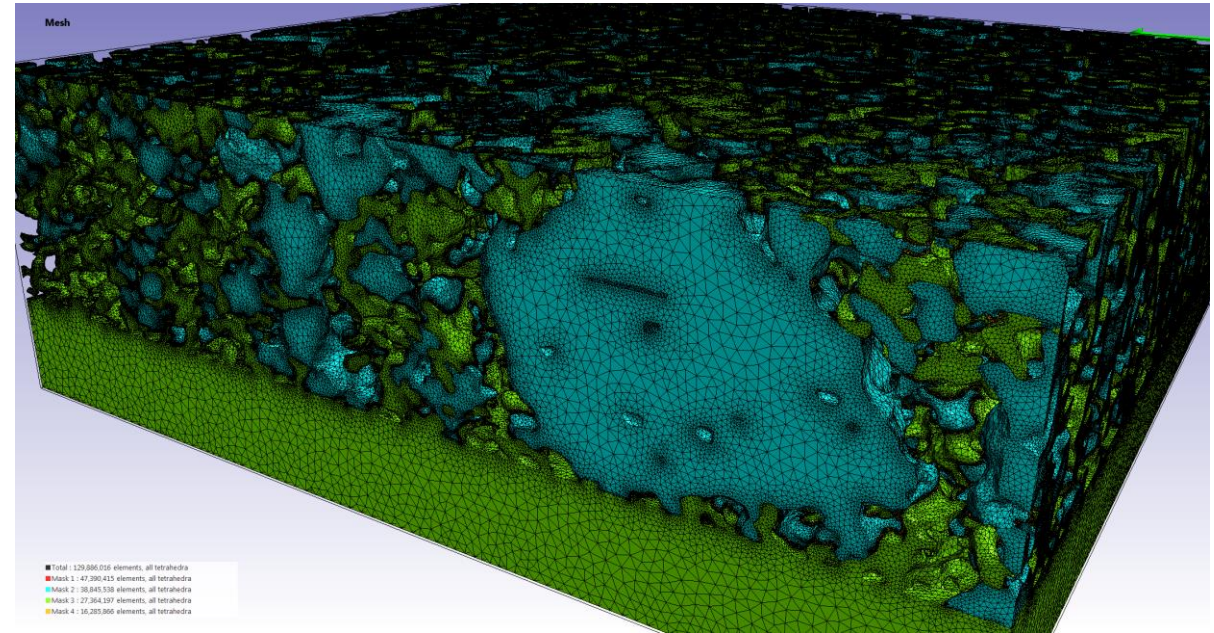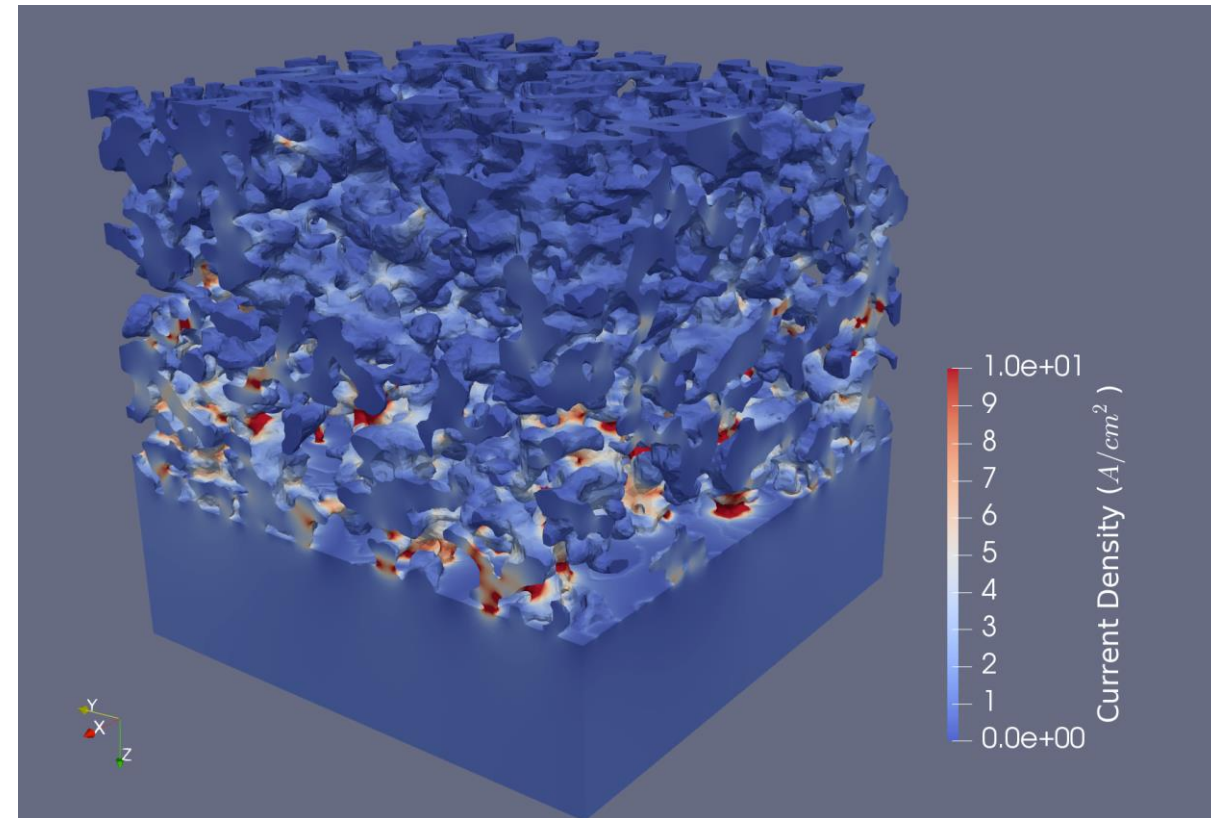
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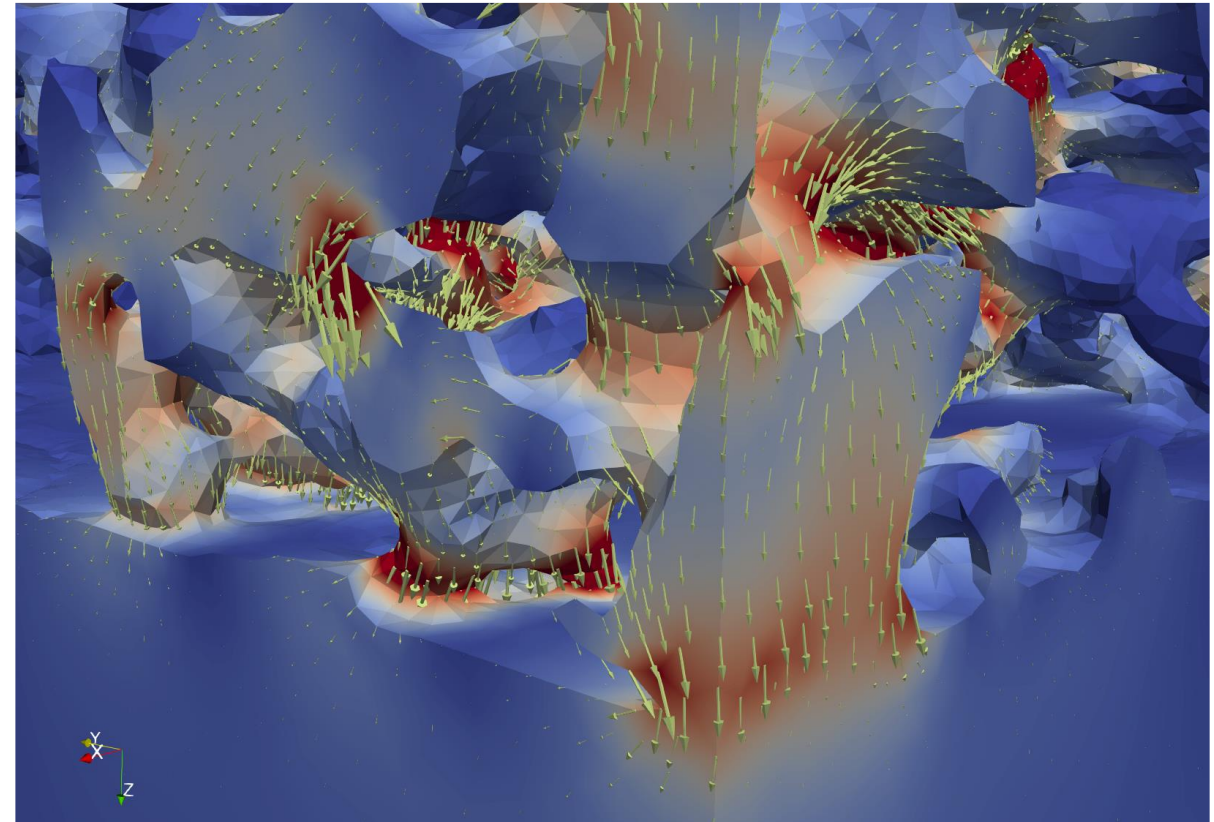

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Inspecting Deviation from Design in Manufactured Part

North Star Imaging, Ansys, MOOG

SYNOPSYS®

Inspecting Deviation from Design in Manufactured Part

Highlights

- Optimizing the design of an internal test manifold for a specific material and hydraulic configuration

- Simpleware software 3D image processing enabled visualization of defects, and comparison of the as-built part from the original CAD

- Simulation of maximum principal stress in ANSYS. The workflow enabled MOOG to quantify the fitness-for-purpose of the part and evaluate performance uncertainty
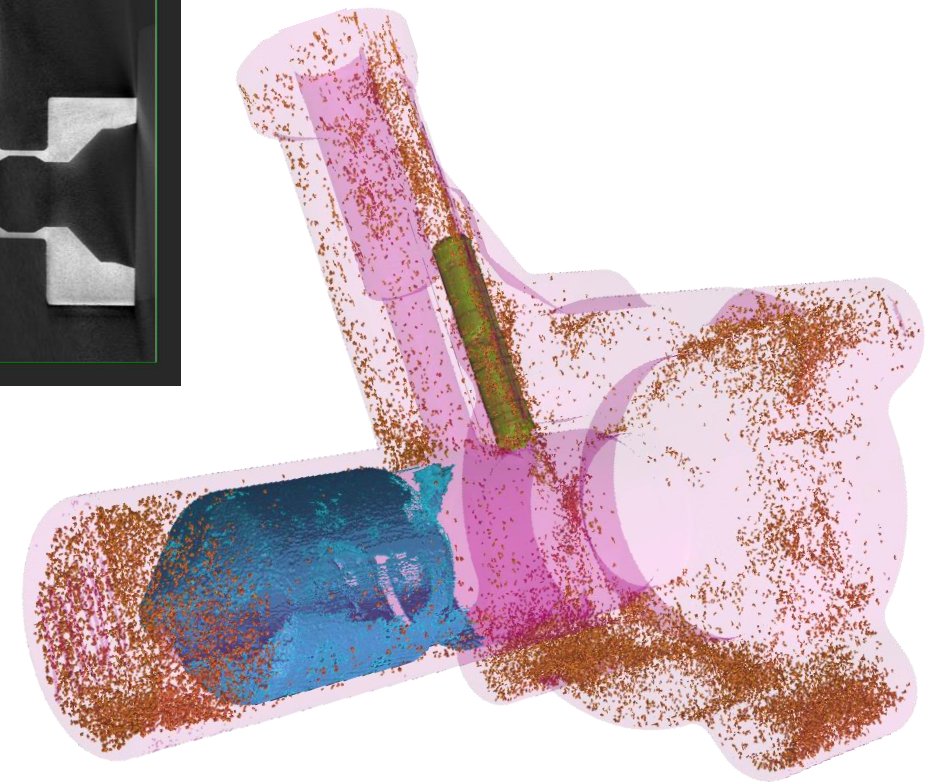
North Star Imaging, Ansys, MOOG

SYNOPSYS®

Inspecting Deviation from Design in Manufactured Part

Workflow

- CT scan data from NSI imported into Simpleware software. Visualization of pores, cracks and residual powder

North Star Imaging, Ansys, MOOG

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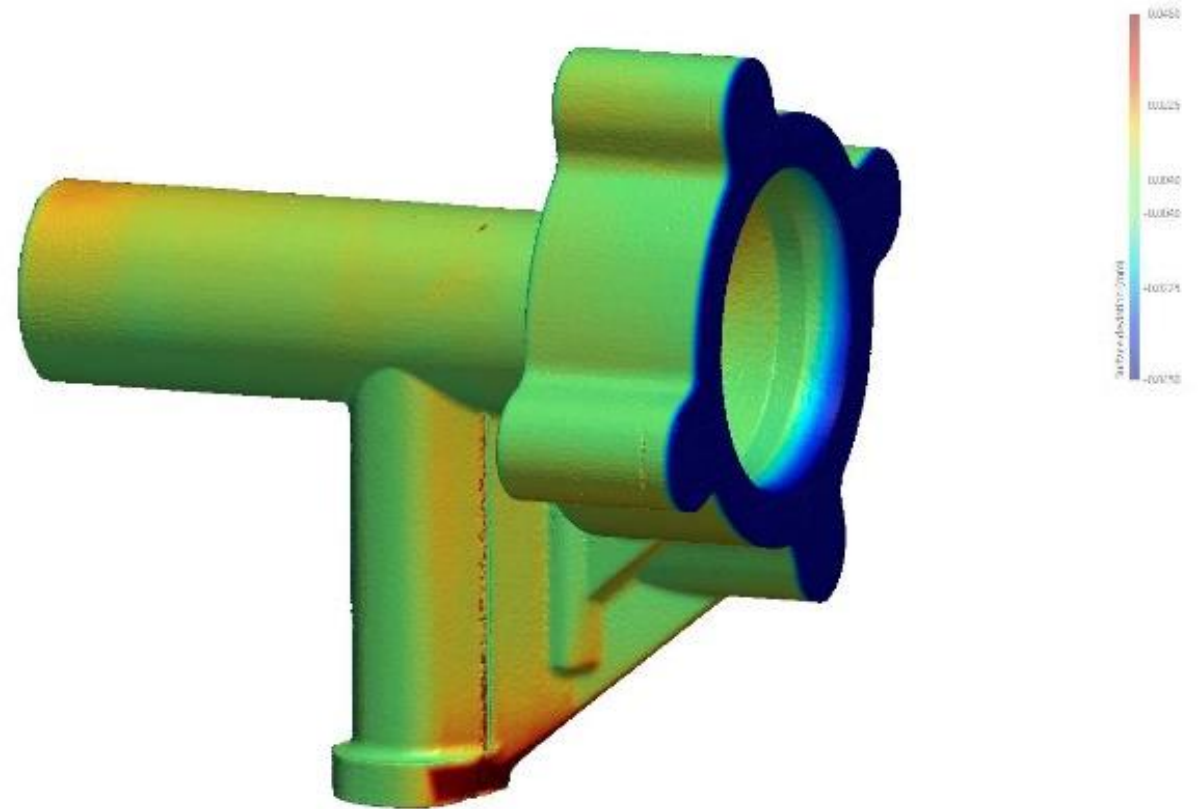
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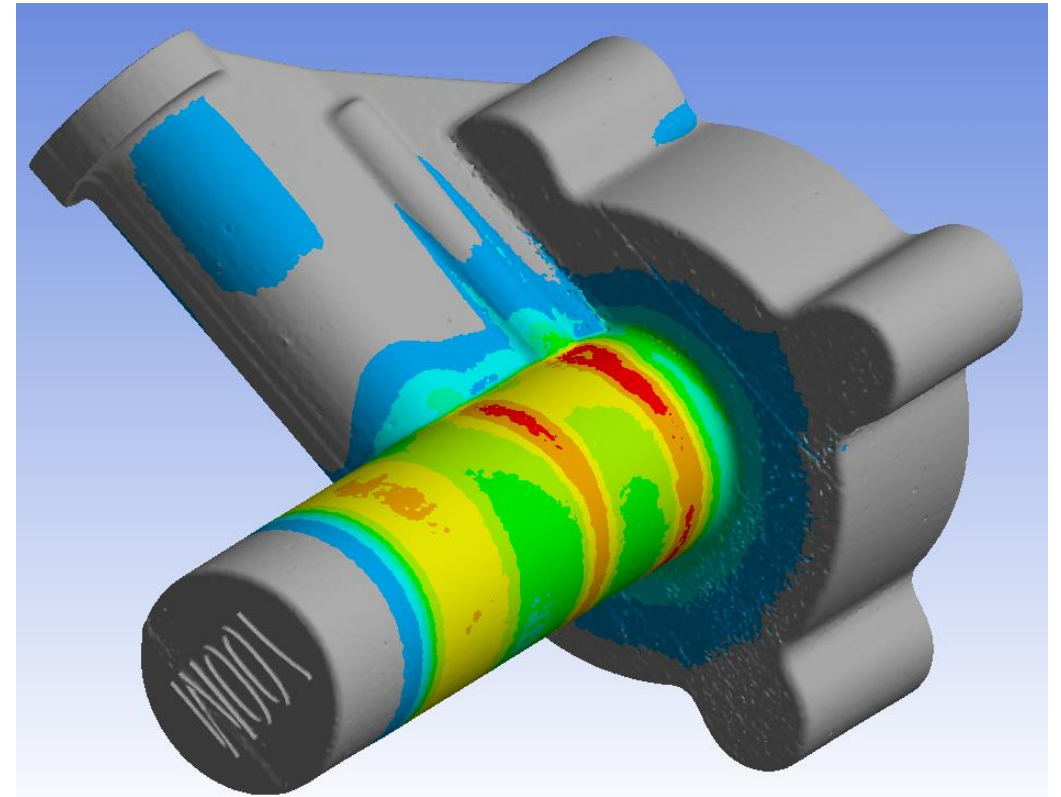
- Simulation results in Ansys showed that between the CAD and image-based model there was a 23.18% increase in maximum principal stress, likely due to cracks and pores in the as-built geometry

North Star Imaging, Ansys, MOOG

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Thank You