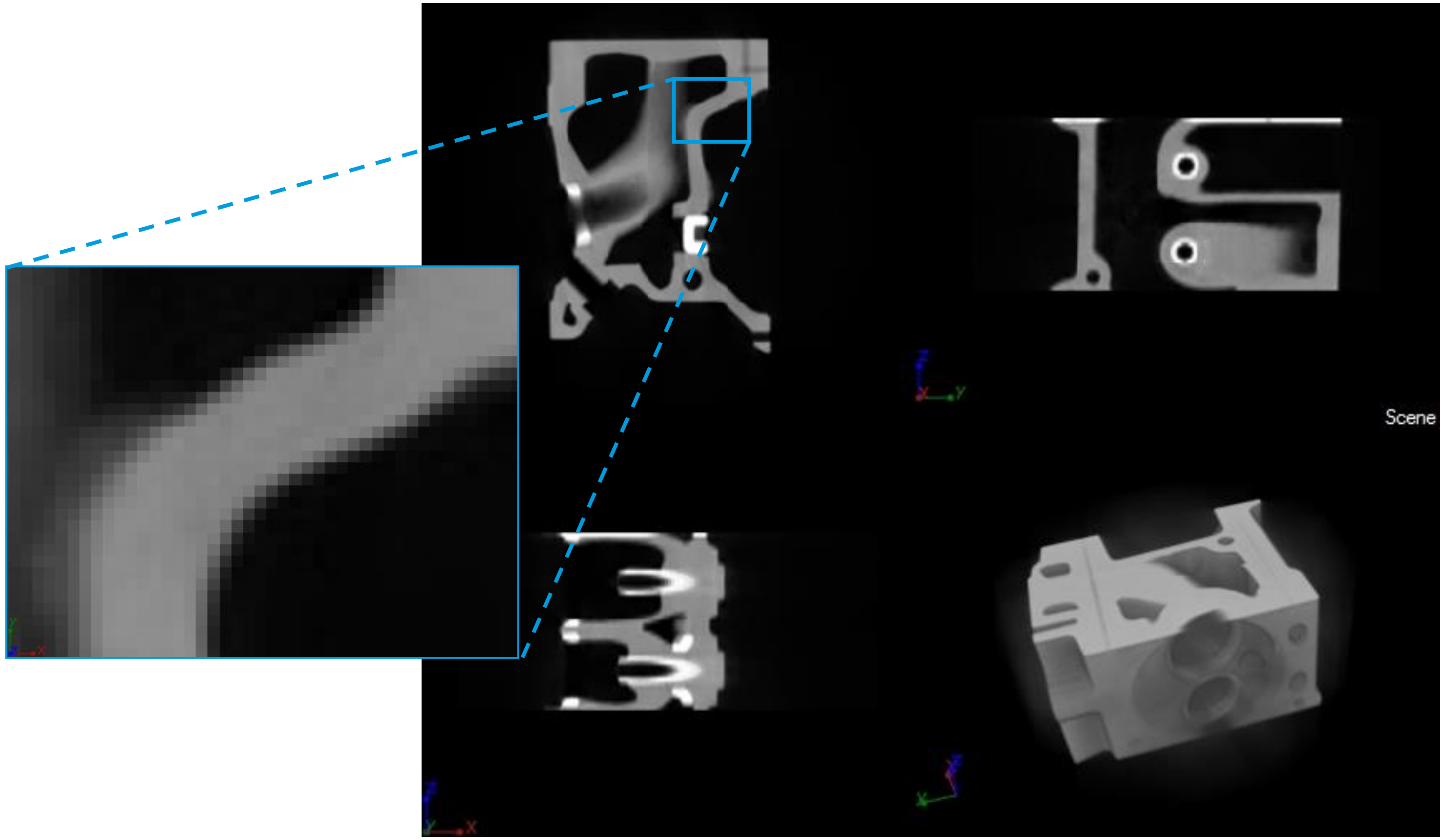
Polling Question #1

What is ISO-50 surface determination?

All precision comes with the image data!



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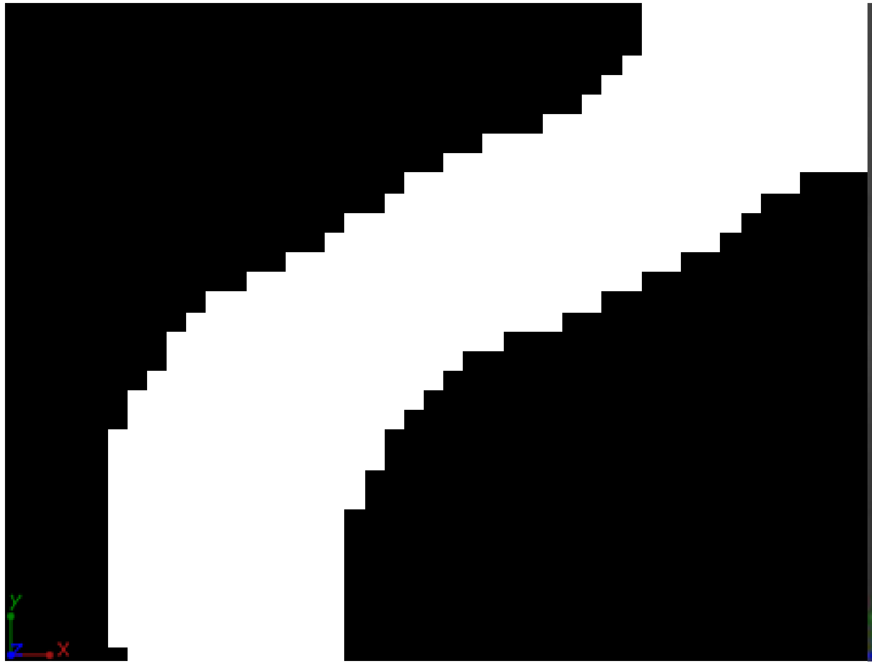
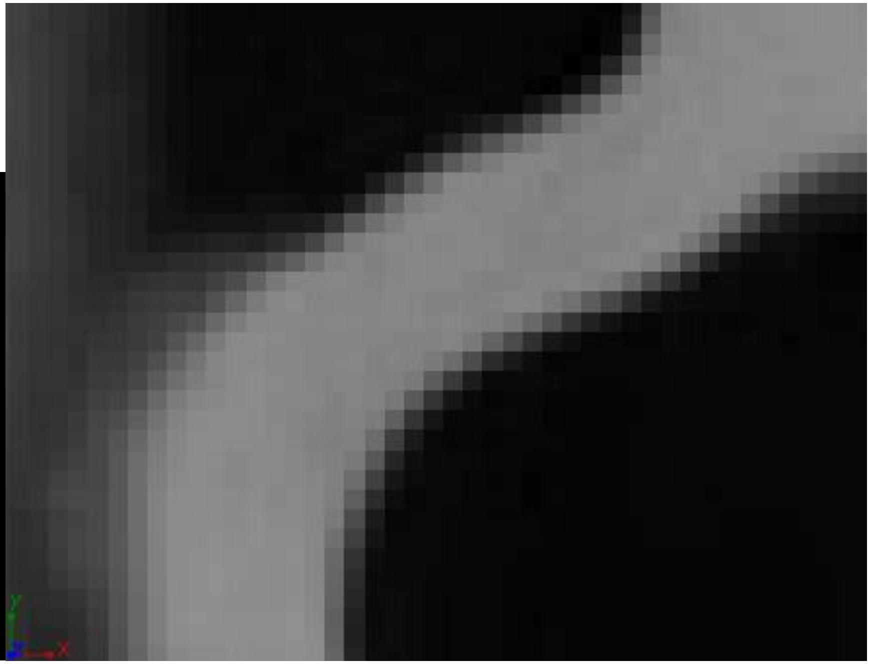
Luckily CT data contains more information than just the “voxel” _ we also get the grey values information

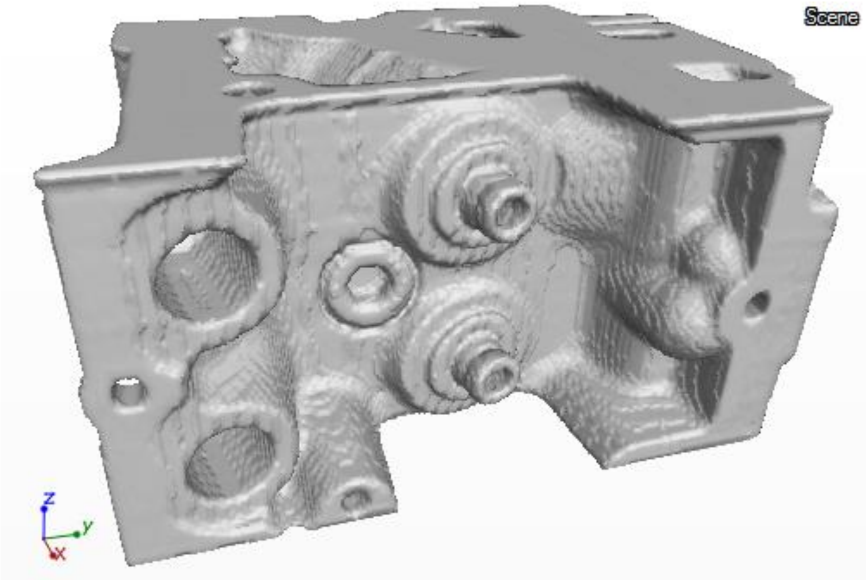


Voxels

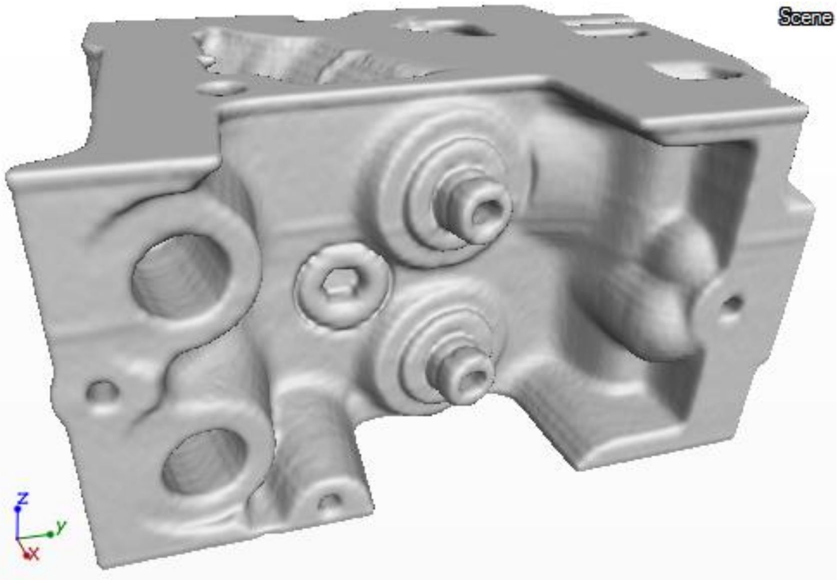


Grey Values

We can take advantage of the grey value information to make images look better and more important to make data analysis more precise

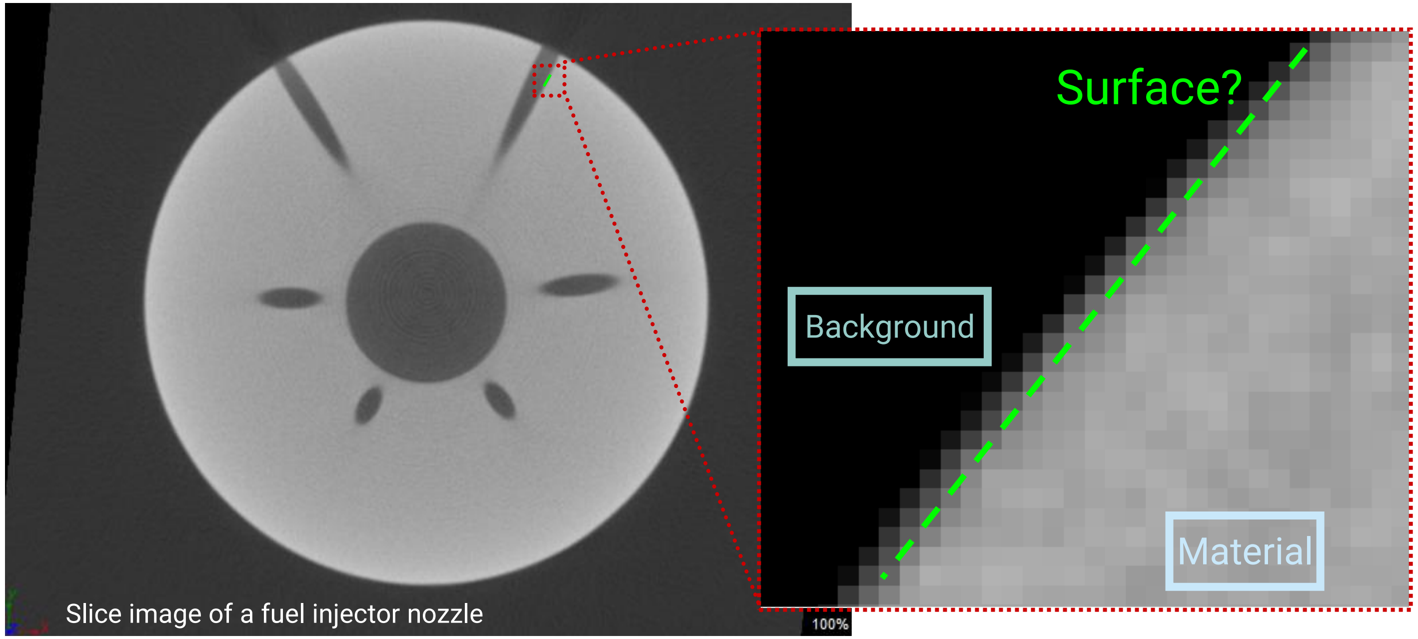


Voxels



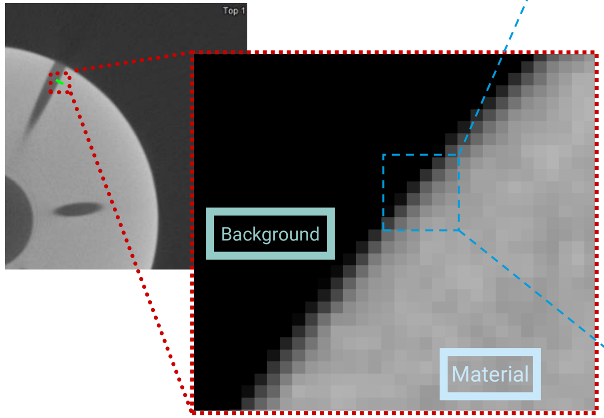
Grey Values

Why does the "surface look so blurred"?

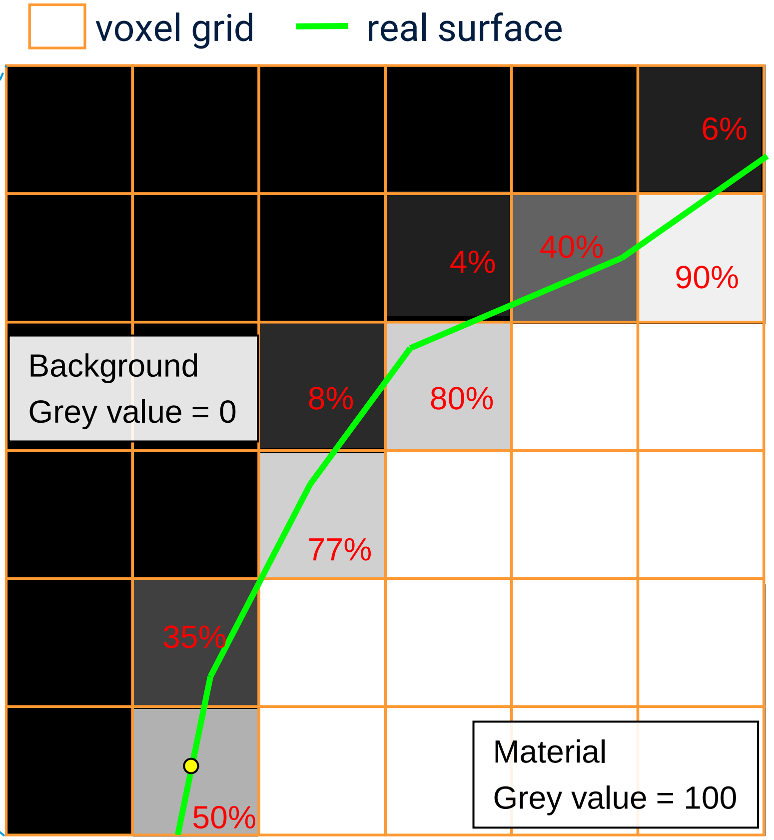


Why does the “surface look so blurred”?

Answer: Because of the **Partial Volume Effect**.
Voxels overlapping partially background and material receive an intermediate grey value according to the percentage of material overlap.

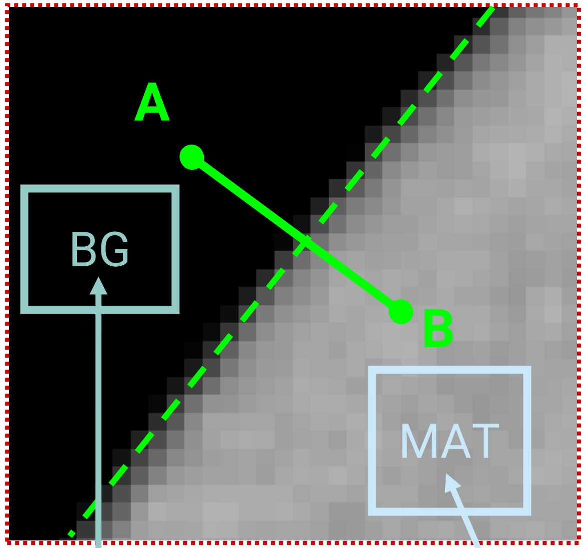


Simplified Example



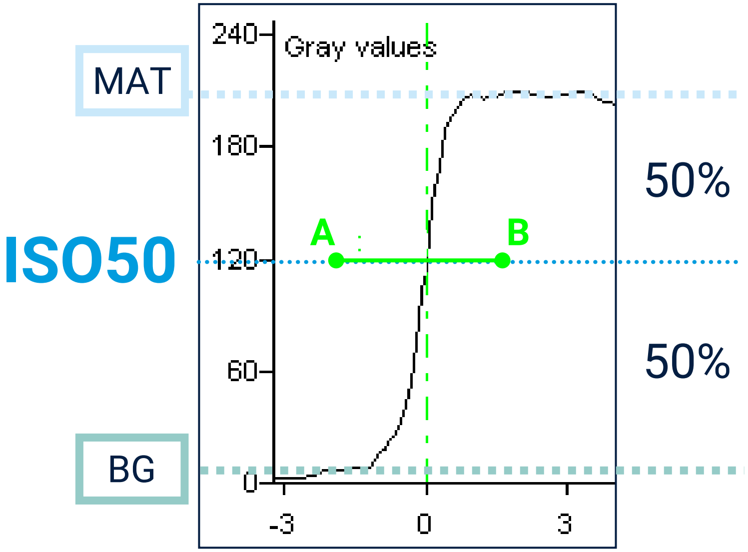
Finally, what is an ISO-50 surface?

- In theory: The object's exact surface is described by a **grey value threshold → so called ISO50 threshold**
  - ISO50=(average material grey value + average background grey value)/2



Calculate average grey value in background area

Calculate average grey value in material area

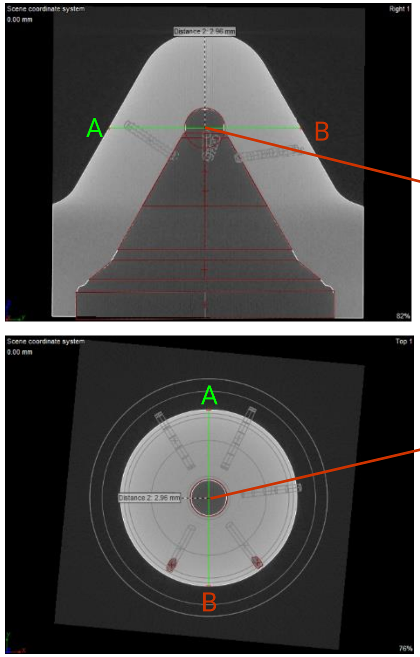


Grey value profile along line A-B

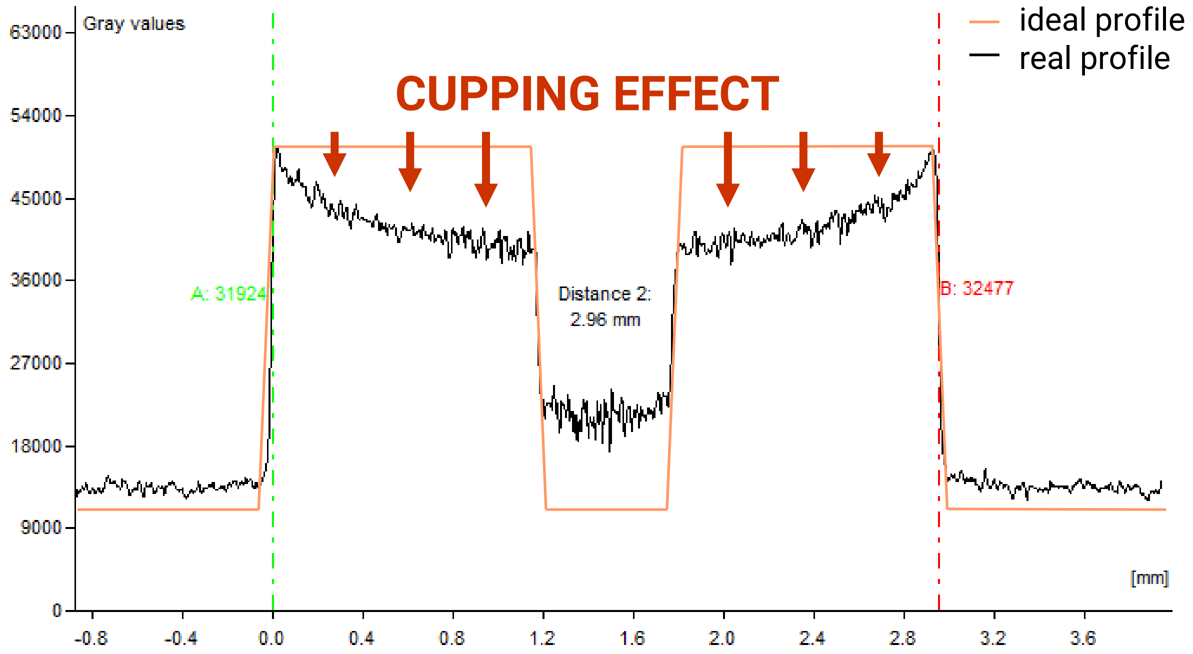
Would you use ISO-50 for CT-based metrology?

Real data unfortunately contains artifacts

- Beam hardening / Cupping: Nozzle material grey value become imaged darker radial to the inside



Slice images of a fuel injector nozzle



Grey value profile along line A-B

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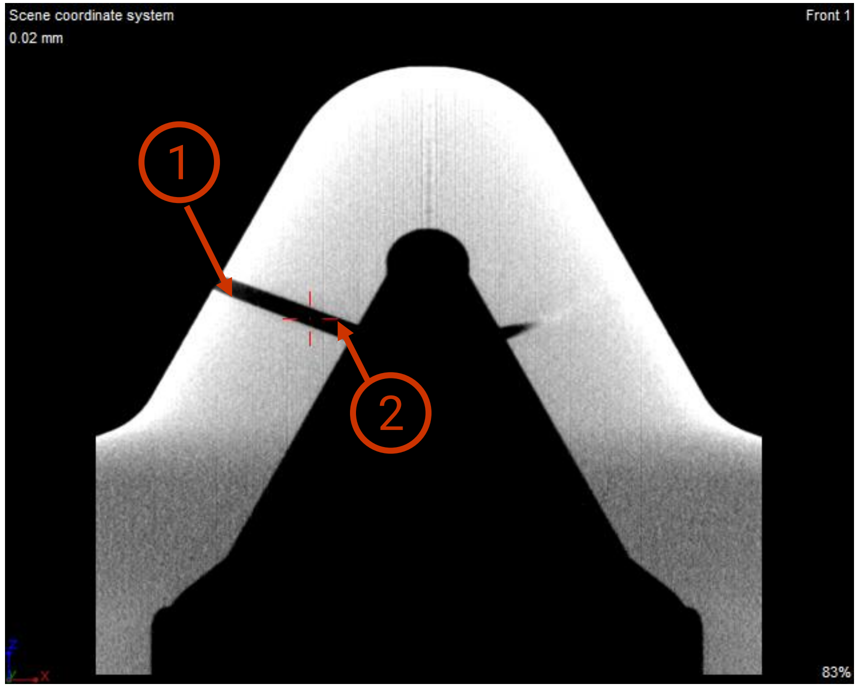
- A ISO50 threshold applied globally will typically cause geometry errors on “real data” since the local surface threshold at position ① differs from the one at position ②, e.g. due to imaging artifacts

- Fuel nozzle example: locally measured ISO50 threshold at:

① = 38900

② = 32700



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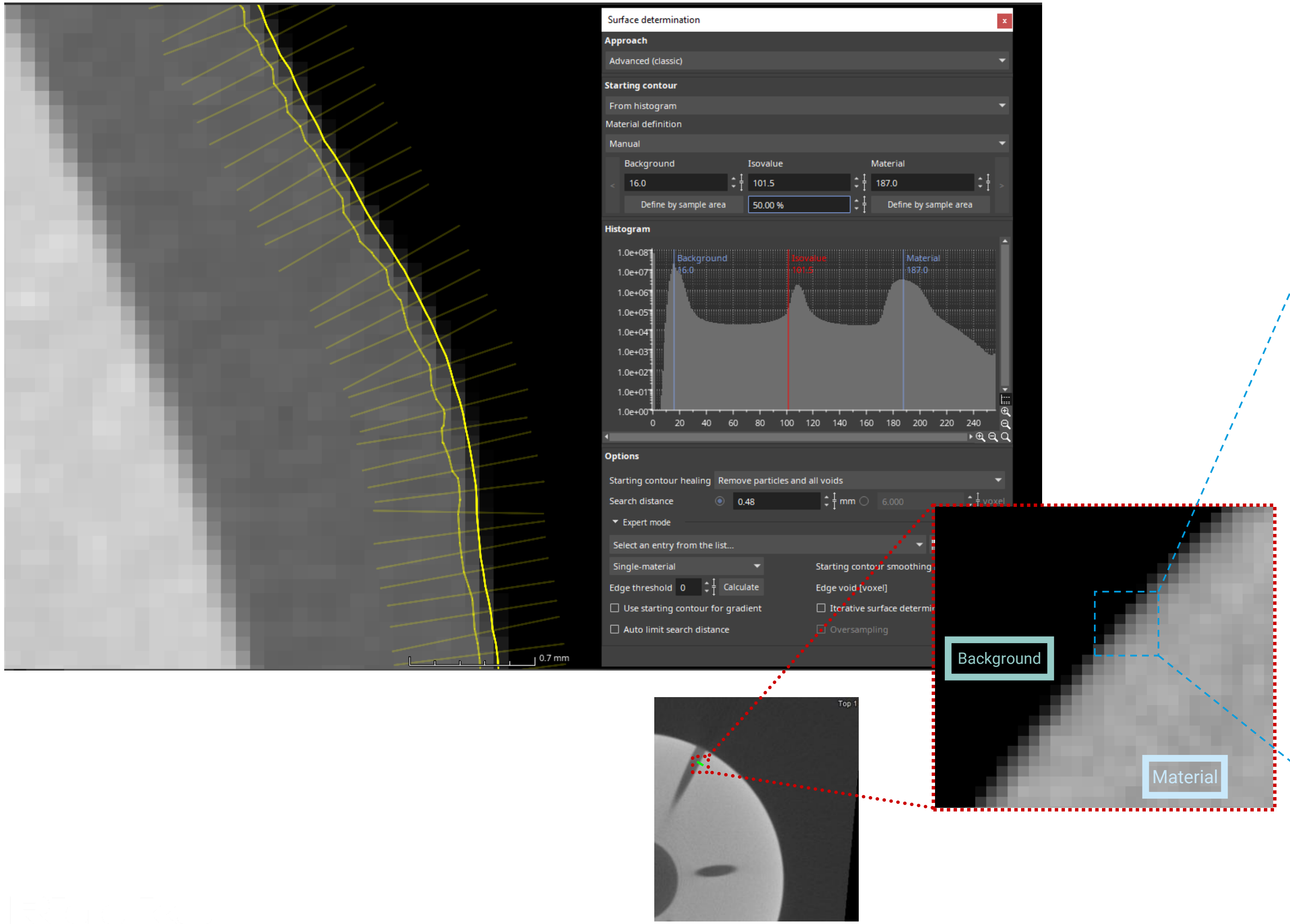
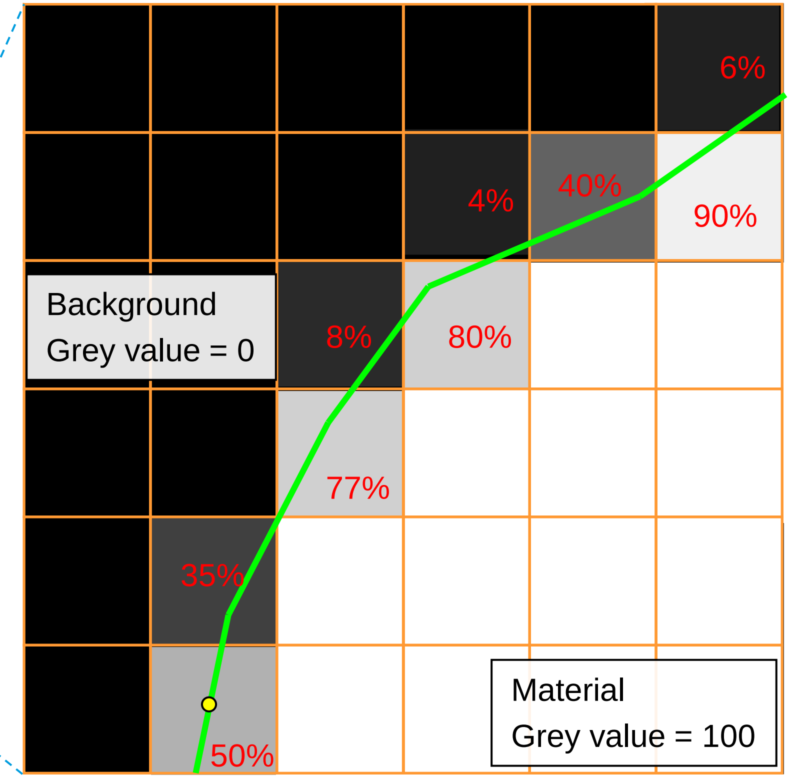
Local adaptive surface determination for sub-voxel accuracy



Simplified Example

voxel grid — real surface



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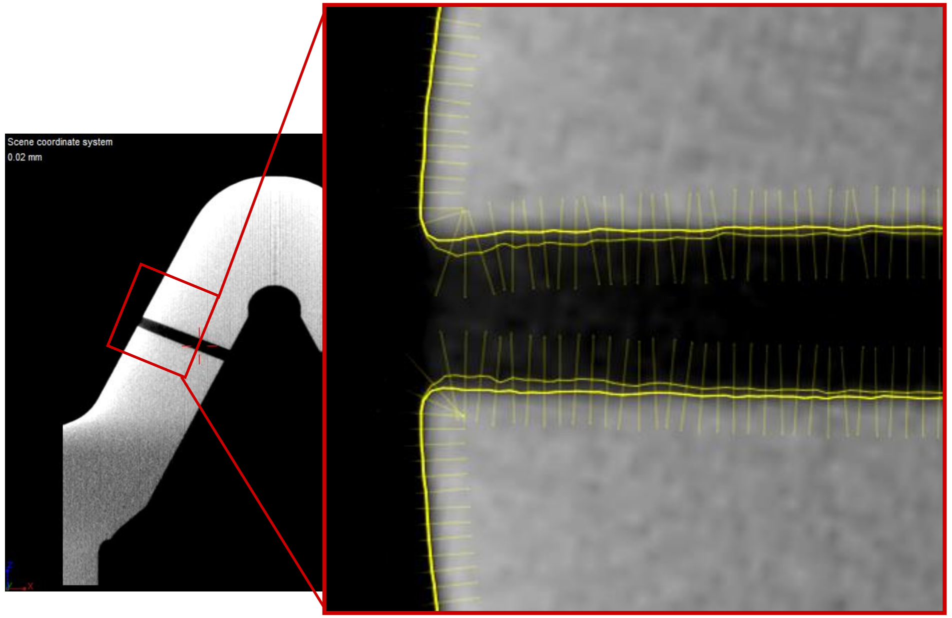
Perform a local adaptive surface determination

- Local adaptive edge detection algorithm to minimize measurement uncertainty (sub-voxel)
- All geometry related tools take full advantage of this feature to reduce measurement uncertainty

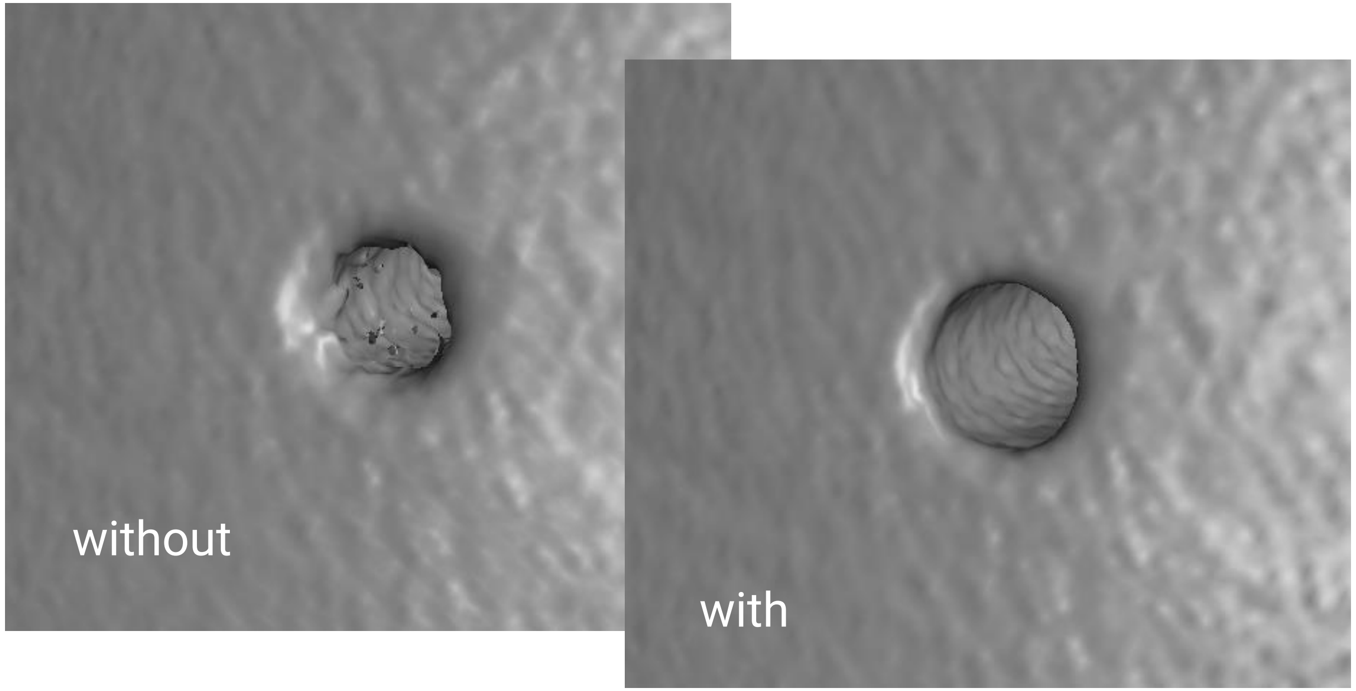


Thin yellow line = ISO50 surface

Thick yellow line = adaptive surface.

ISO-50 vs. Local Adaptive Surface Determination

Visually: Injector borehole with and without local adaptive surface determination



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What difference a precise surface determination makes?

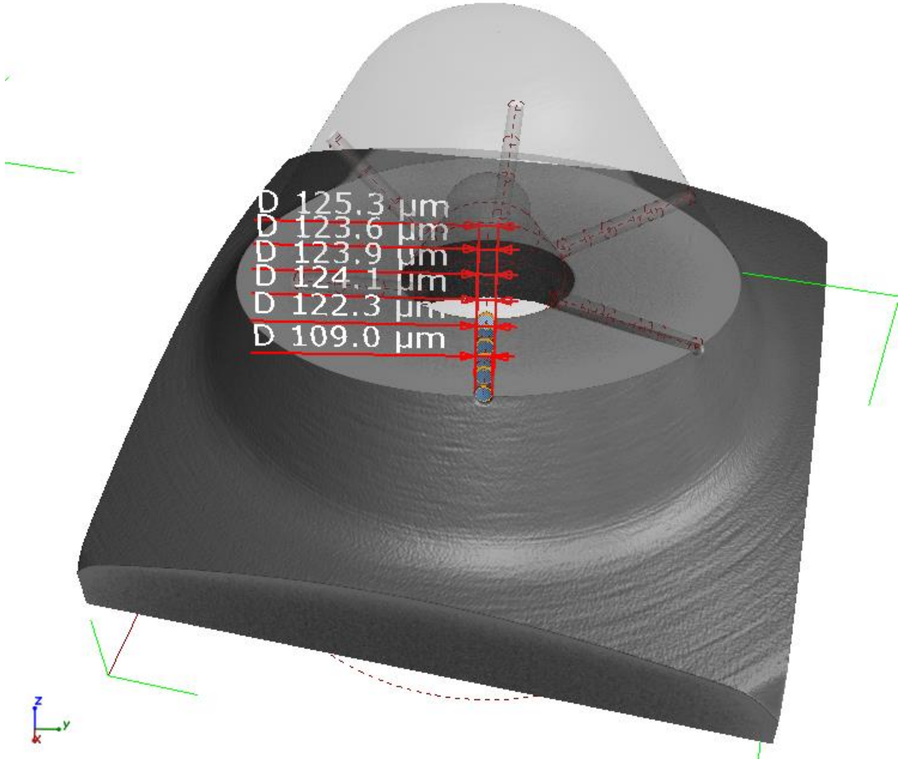
- Results on a nozzle injector borehole with Scan/Voxel resolution 8 µm:
CT is able to reproduce classical measurements
  - ➢ Measurement uncertainty >= 5 µm by using a global ISO50 surface threshold
  - ➢ Measurement uncertainty <= 1 µm by using local adaptive surface determination

Data and Results from:

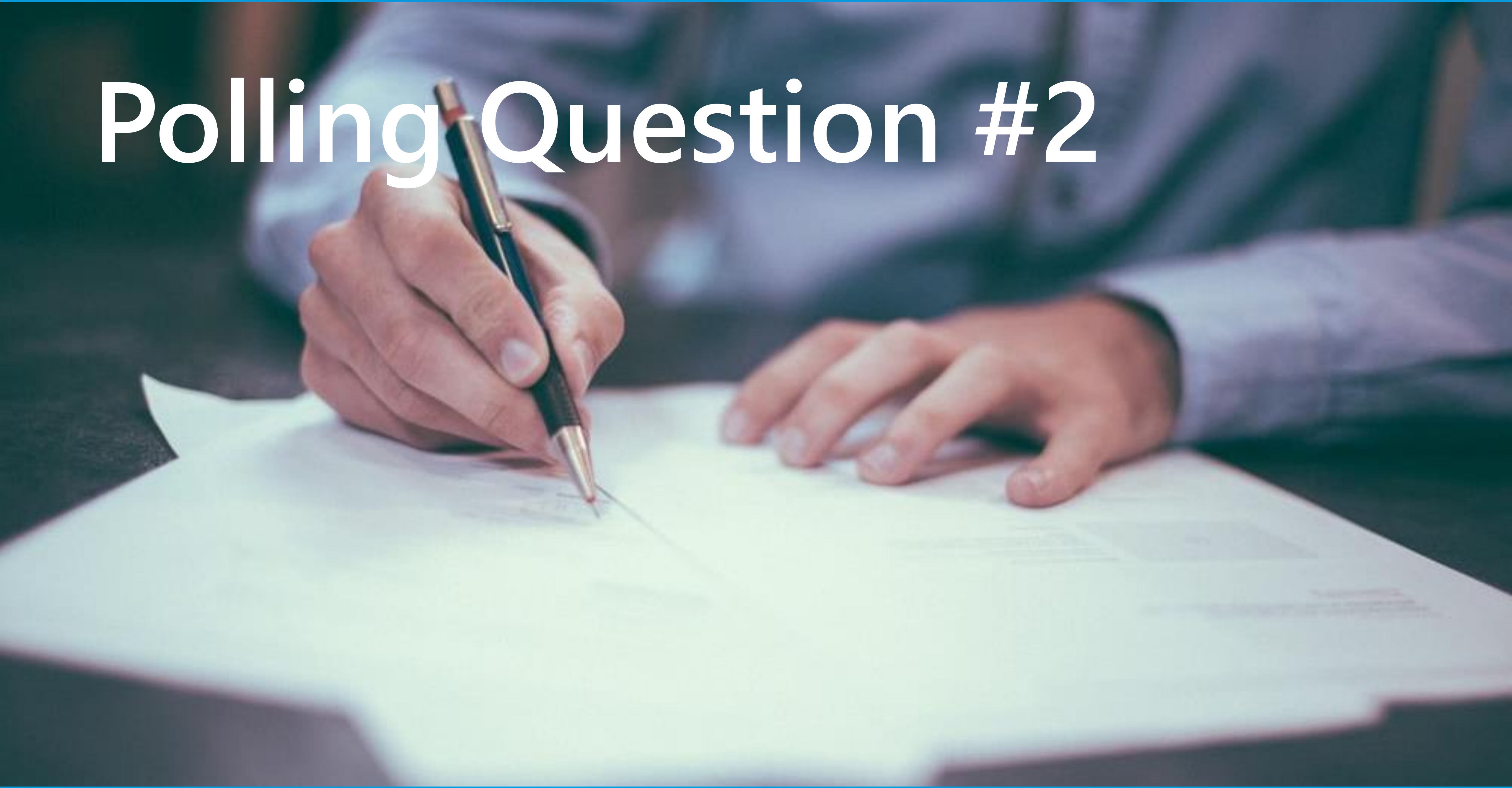
Formprod research project in 2003

& PhD Thesis, Dr. Heinz Steinbeiß,

UTG Munich



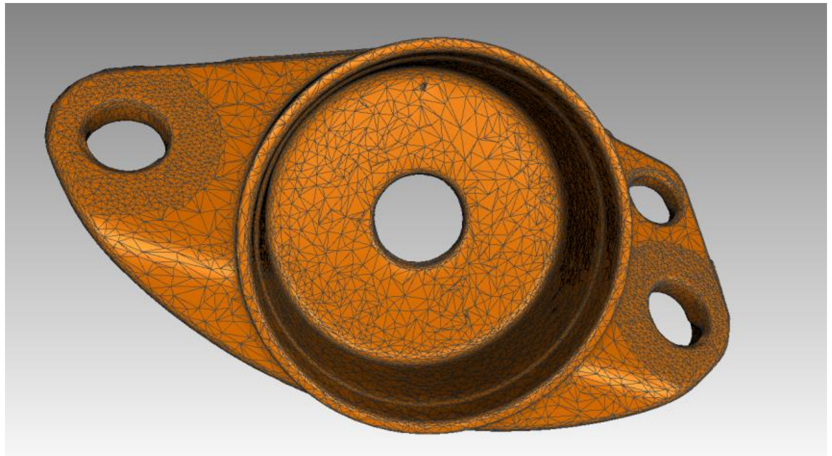
Polling Question #2



Why would I choose triangle mesh versus CAD for a given application?

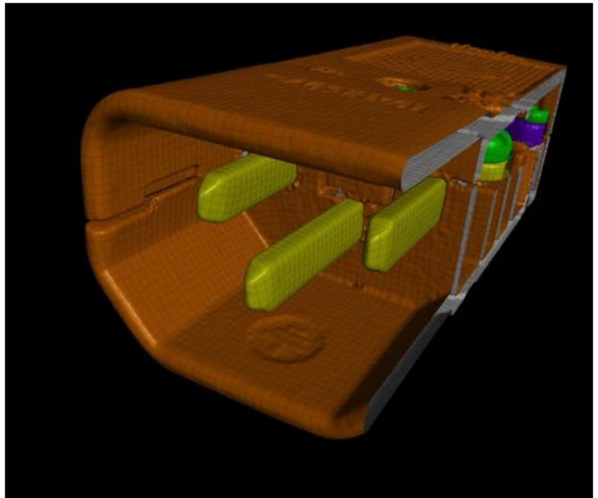
STL vs STEP

Triangle mesh : A surface mesh consists of **a set of polygonal faces, often triangles, that, taken together, form a surface covering of the object**. The advantage of a surface mesh is that it is fast to generate and works very well for visualization. However, difficult to achieve perfect curves.



CAD : Computer Aided Design, sometimes referred as 3D modeling, **allows engineers and designers to build realistic computer models of parts and assemblies for complex simulations and digital manufacturing.** CAD is smooth, noise-free, and easily editable.

- Parametric Model - offer a process where the dimensions and properties of a design are controlled by parameters or variables rather than fixed values
- NURB - pattern of 4-sided patches over the model that follows the edges and main features of the model



Create CAD models of both single components and several assembled parts.

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Why Reverse Engineering: Because it is often better to have a CAD model

- CAD is the master (inspection!)
  - CAD is the true reference
- CAD can be milled (with strategies)
  - Milling strategies only apply on CAD. Mesh CAM is slow
- CAD can be changed
  - Dimensional editing rather than organic morphing
- CAD can be parametric
  - Easy to change and update
- CAD has perfect theoretical geometry (radii, edge)
  - Meshes never have perfect analytical shapes
- CAD software understands CAD better than mesh
  - CAD engineer wants to see scanned shape in his SW

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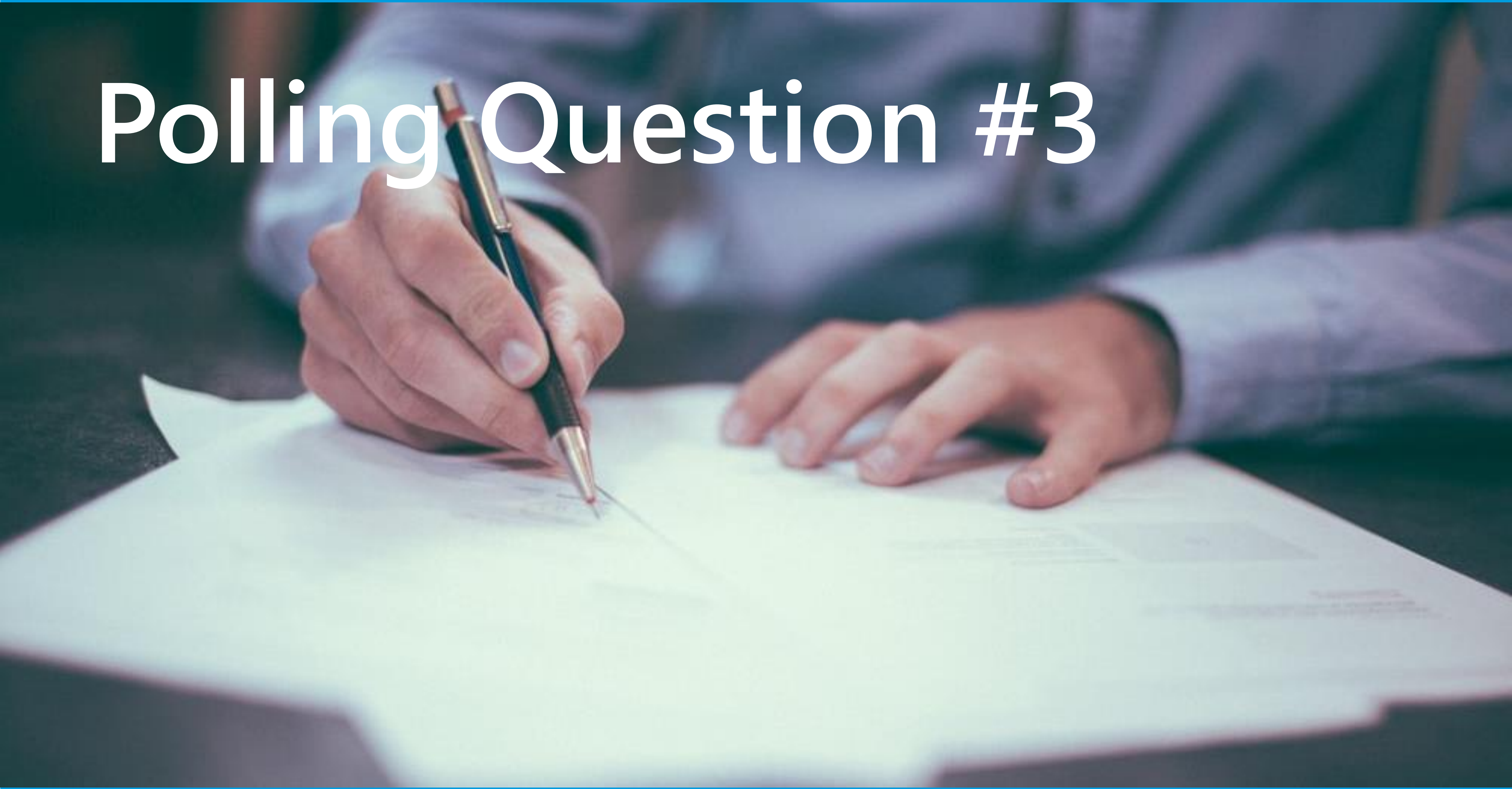
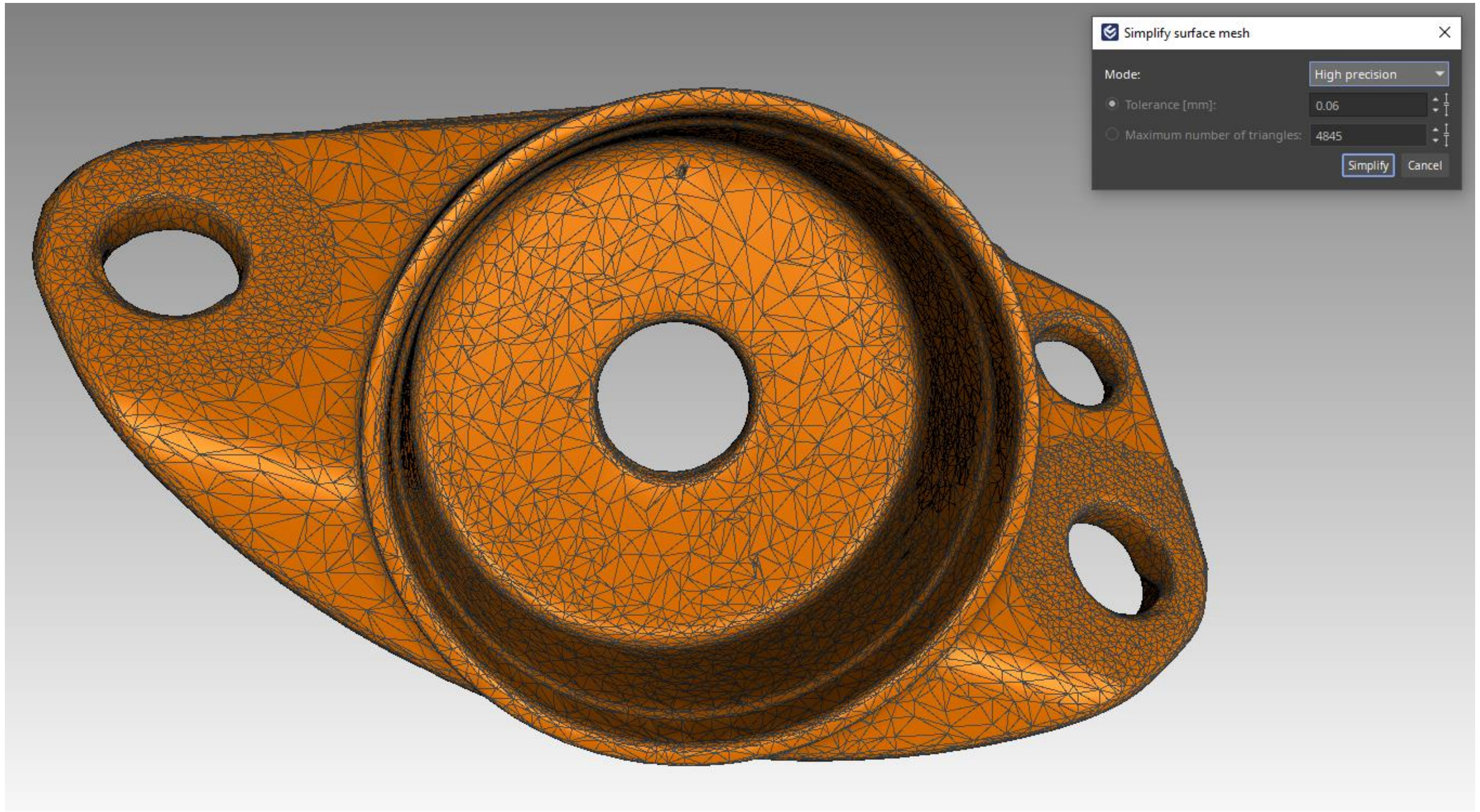
Polling Question #3



How should I optimize and export the surface detection results?

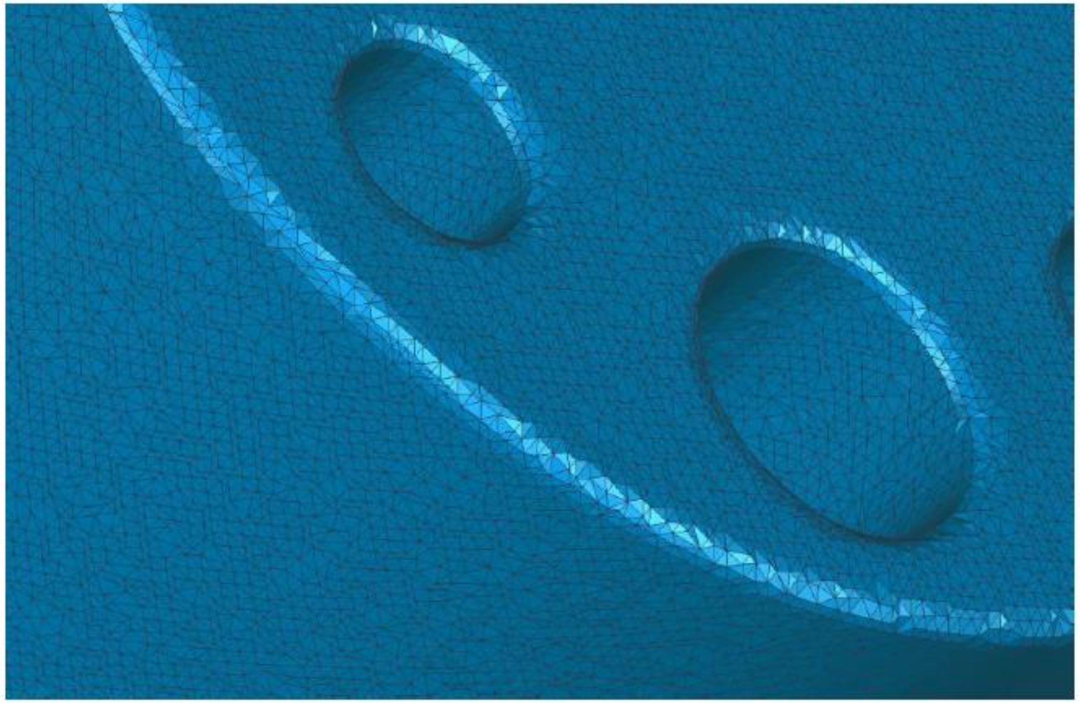
Simplify triangle mesh pending your application

- High Simplification
- High Precision



Ray vs Grid – Triangle mesh

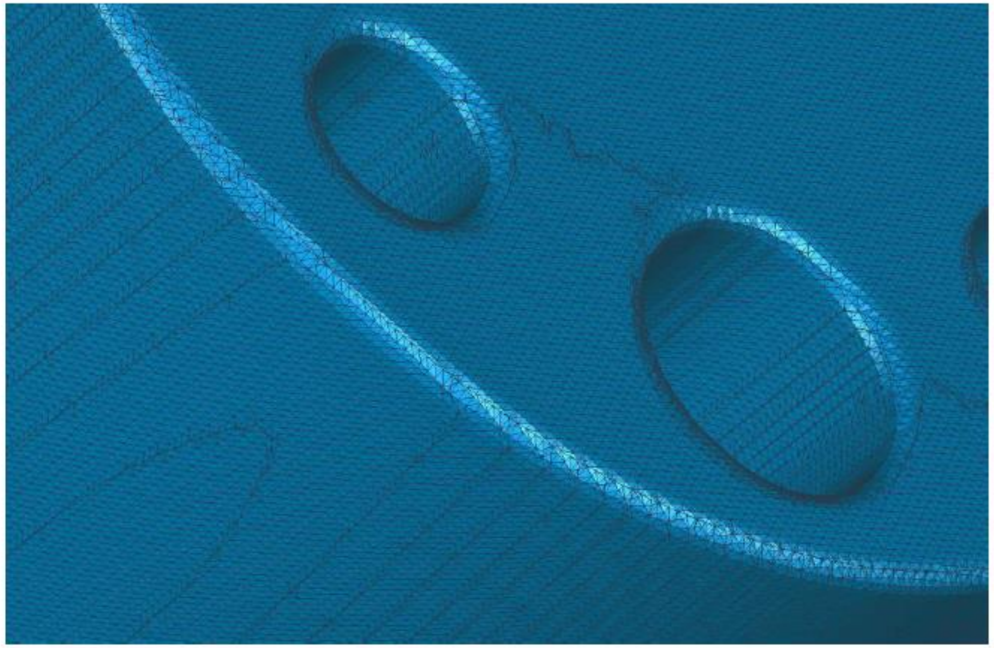
- Historic: Ray based polygonisation
  - Good for simplification (polygon count reduction), but:
  - Slow
  - Potential of imperfections in the mesh



Ray vs Grid – Triangle mesh

> Grid based polygonisation
  - Great mesh quality
  - Good for export to 3D printing
  - Faster calculation, but:
  - Larger file size
  - Simplify after creation

- Ray-based - very fast
- Ray-based - fast
- Ray-based - fast with simplification
- Ray-based - normal
- Ray-based - normal with simplification
- Ray-based - precise
- Ray-based - precise with simplification
- Grid-based - precise and watertight



Non-Manifold Edges	0
Self-Intersections	0
Highly Creased Edges	0
Spikes	14
Small Components	0
Small Tunnels	0
Small Holes	0

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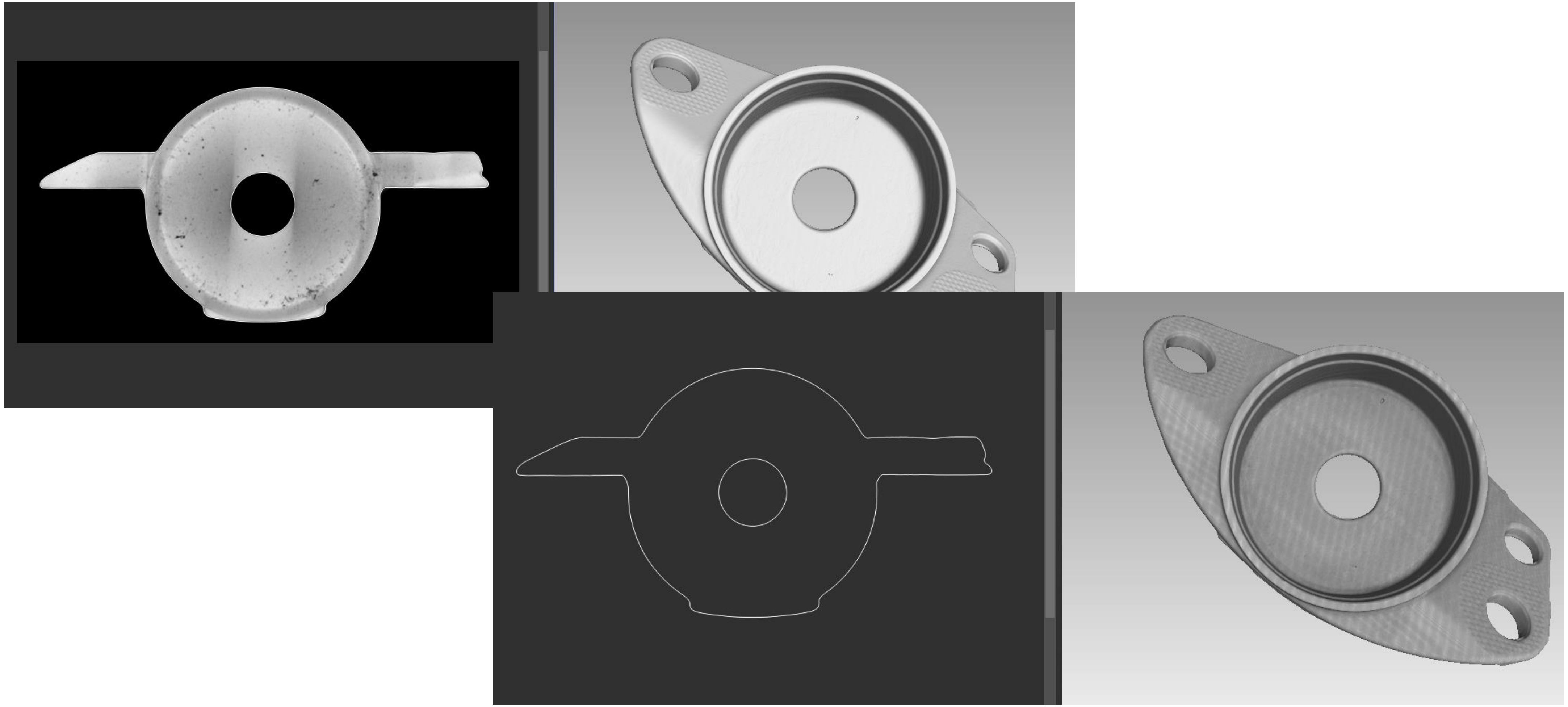
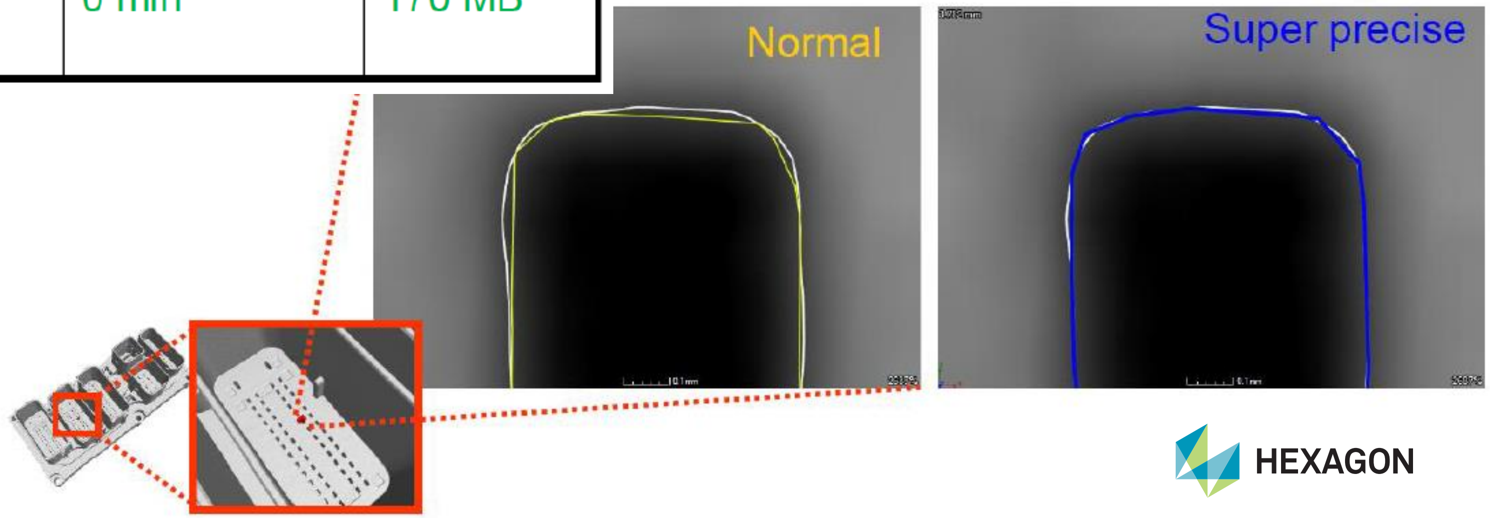
Unload the voxel material information



VOXEL vs. STL

STL Data Extraction Mode	Voxel size/ Sampling Distance	# Triangles	Time needed for STL extraction	Data set size
Normal	0.5	~2,2 million	1:45 min	109 MB
Super Precise	1	~11 million	8:20 min	568 MB
Oversampled	2	~29 million	>25 min	1,4 GB
Voxel Data Surface	X	X	0 min	170 MB



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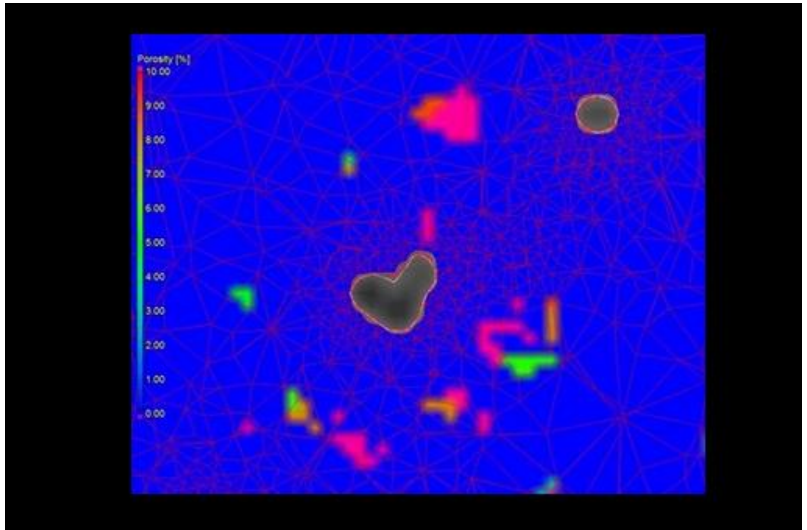
Lightning Round

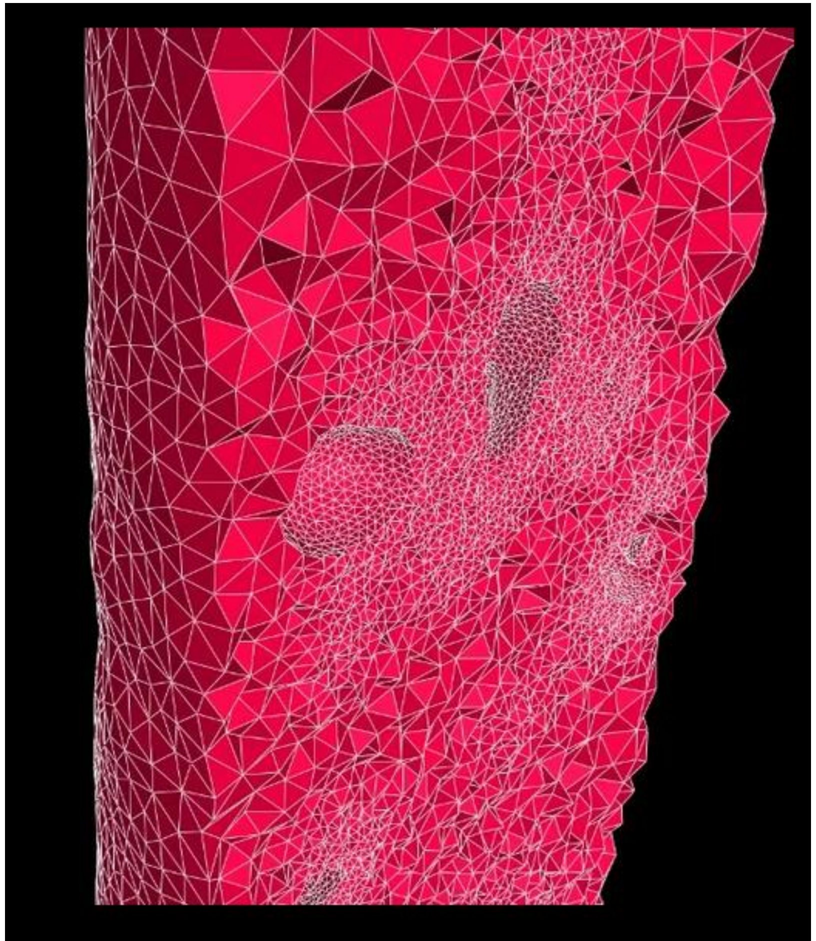
How do I export volume data?
Where is it used?

Volume Mesh

Generation of Tetrahedral Meshes (TETS) : the volume of the data is made up of many pyramids



Macropores are geometrically represented by the volume mesh; microporosity is mapped onto the cells of the volume mesh and color coded.



You can locally refine meshes in specified regions.

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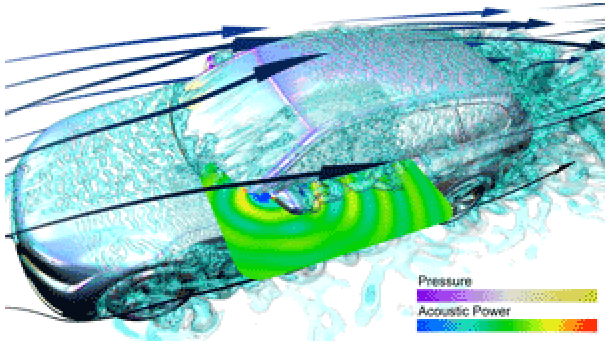
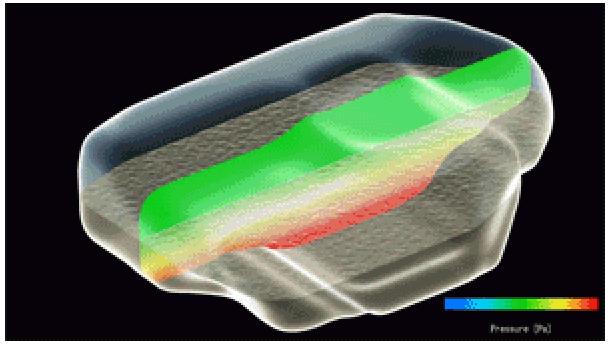
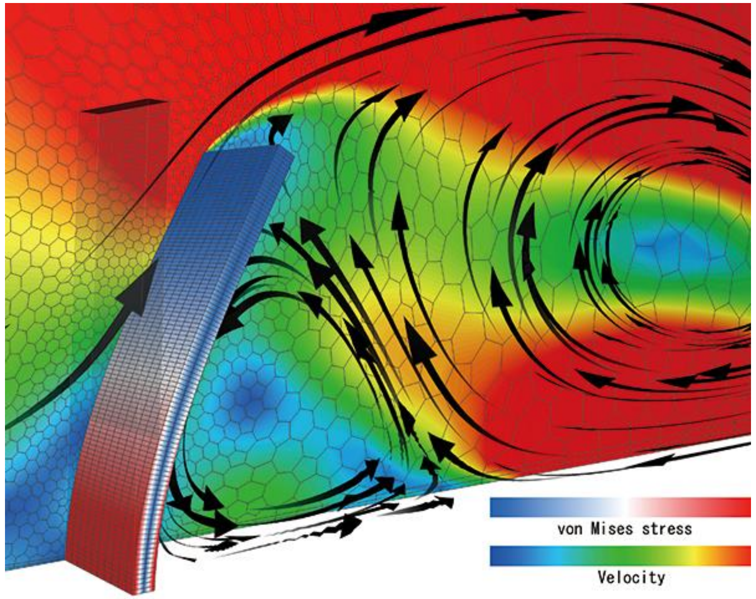
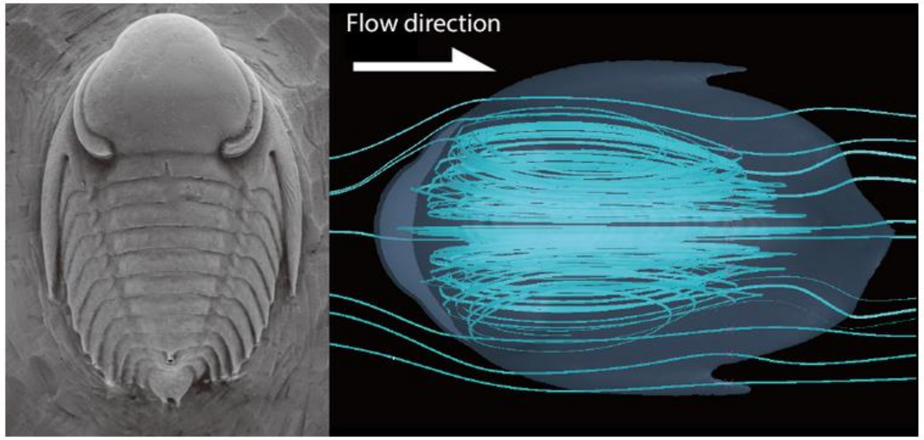
Finite Element Analysis (FEA)

Volume meshes are widely used for mechanical, fluid, thermal, electrical, and other simulations









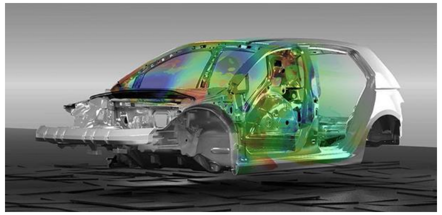
Tell me more about Hexagon MI and the VOLUME GRAPHICS software:

Metrology Hardware :

- Laser scanners
- Structured light
- Coordinate measurement machines
- Micrometers, calipers, and gauges

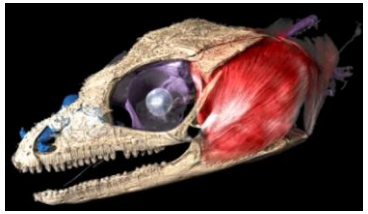
Software solutions:

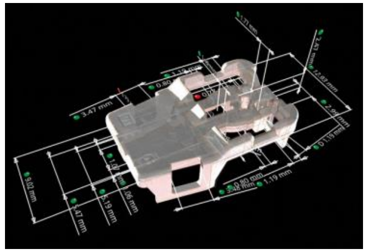
- Design/Reverse Engineering
- Metrology
- Finite Element Analysis (FEA)
- Manufacturing project management

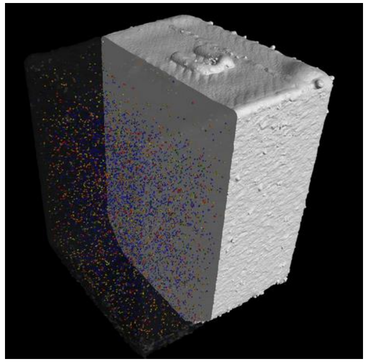


Volume **G**raphics:

- Visualization/Segmentation
- Automation
- Geometry
  - Coordinate Measurement
  - Nominal/Actual
  - Wall Thickness
  - Reverse Engineering
  - Manufacturing Geometry Correction
  - CAD Import with PMI
- Material
  - Porosity/Inclusion
  - Fiber/Composite
  - Foam/Powder
  - Digital Volume Correlation
  - Battery
- FEA
  - Volume Meshing
  - Structural Mechanical Simulation
  - Transport Phenomena







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https://hexagon.com/products/product-groups/manufacturing-intelligence

NEXT ON ASK THE EXPERT

Virtual Tomography – Optimizing Data Acquisition Parameters Without a CT Scanner

With Dr. Awen Autret

Wednesday, September 13, at 1 PM CDT

