

X-ray Computed Tomography as a Reverse Engineering Tool

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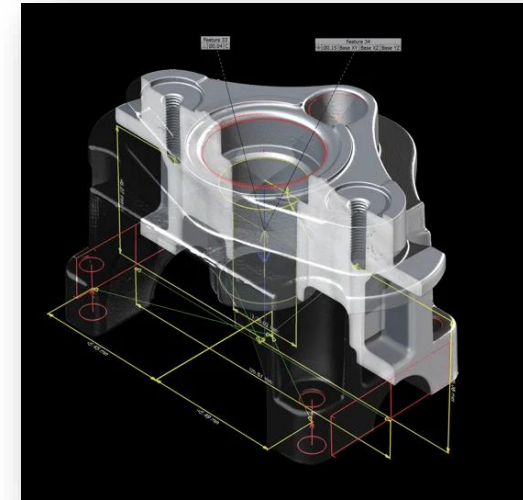
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Agenda

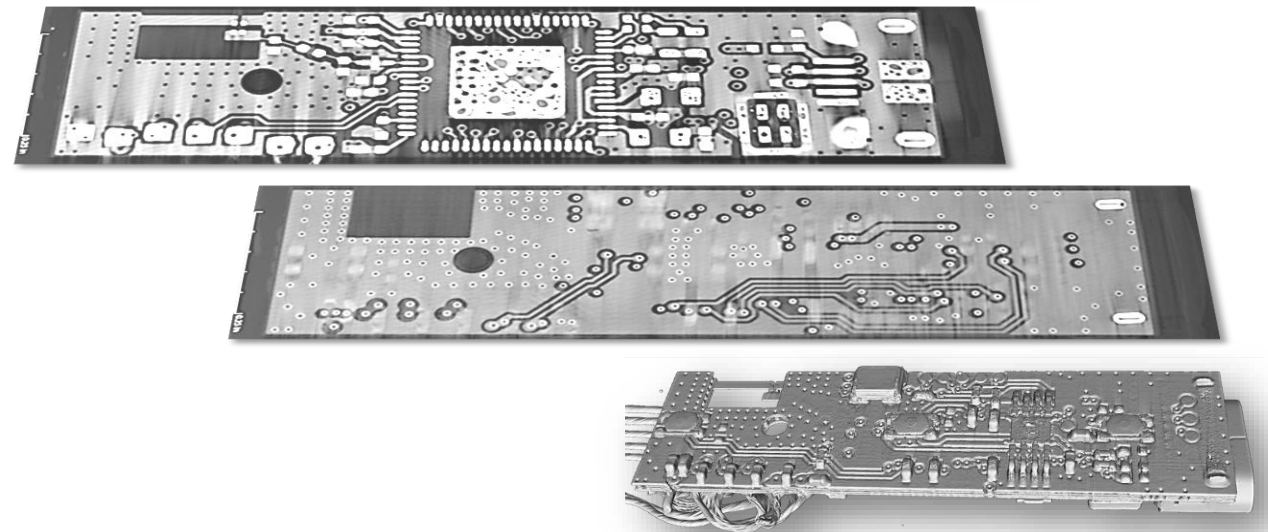
- What is reverse engineering?
- What is industrial x-ray CT, and how does it work?
- What are some general applications of x-ray CT?
- How can x-ray CT be used in reverse engineering applications?
 - Dimensional inspection with CT
 - CT Analysis of Electronics and PCBs
- How can I make the most effective use of CT?
- How can I access CT hardware and services?
- Where can I find additional information?

What is reverse engineering?

- Recovery of a part's design, operation or design intent:
 - Geometry
 - Material Properties
 - Function
 - Failure analysis
 - Vulnerabilities
- Not always nefarious and even a necessity in many instances



Volume Graphics
VGStudio MAX

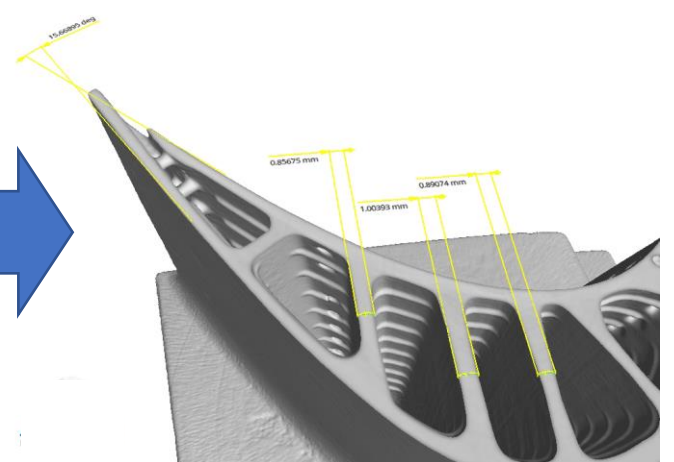


What is x-ray computed tomography?

- **X-ray Computed Tomography (CT)** is a non-destructive imaging method which results in cross-sectional and/or volumetric datasets, revealing a specimen's internal geometry, structure, and features.



Medical CAT Scan

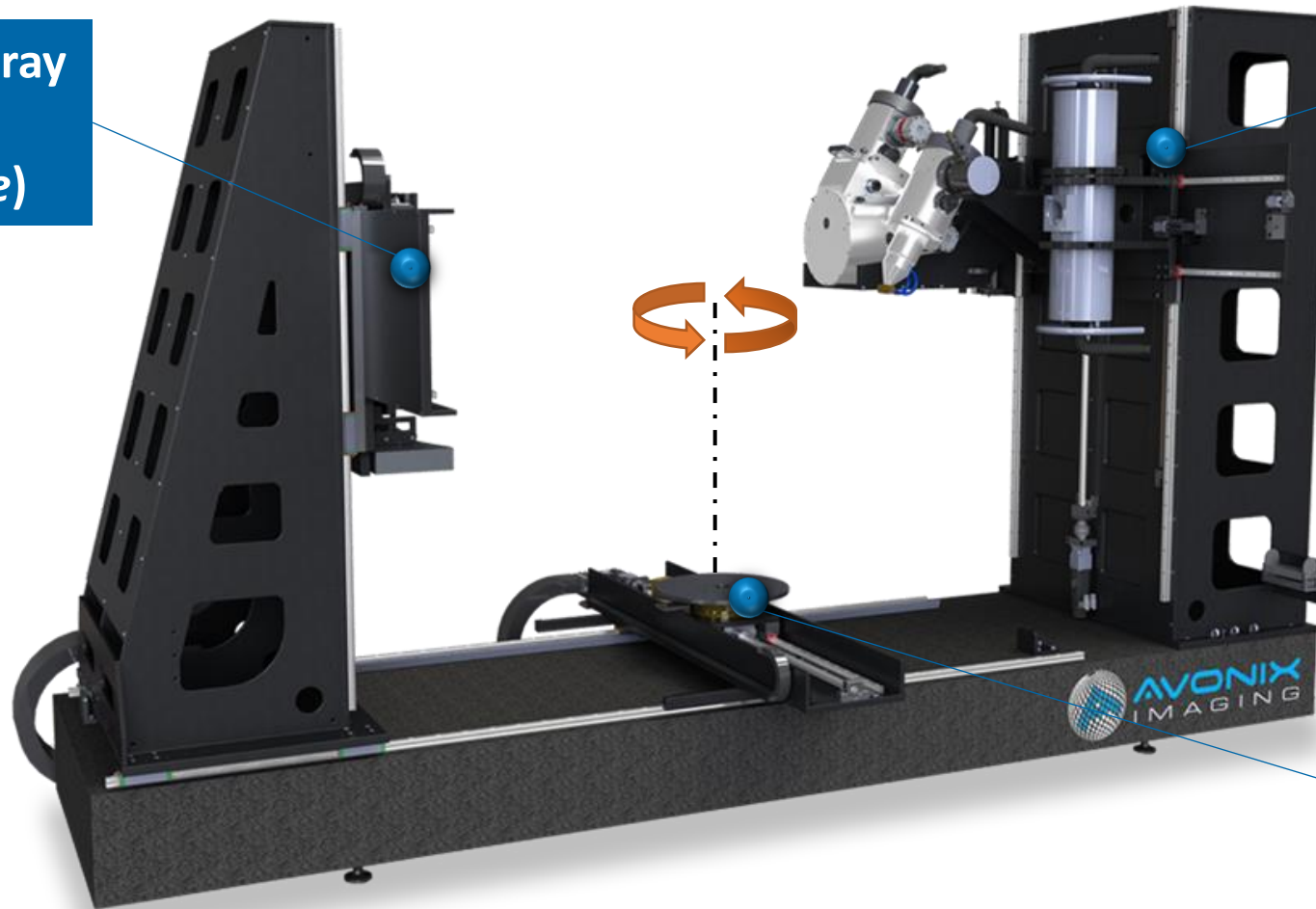


Industrial & Scientific Imaging

Industrial & Scientific CT Imaging

High-resolution x-ray imaging detectors
(~0.1mm pixel size)

Low-to-high energy x-ray sources
(20kV – 450kV)



Large-envelope CT scanning system

Control sample position and magnification
(Resolutions ~ 0.001mm)

CT Scanning Process



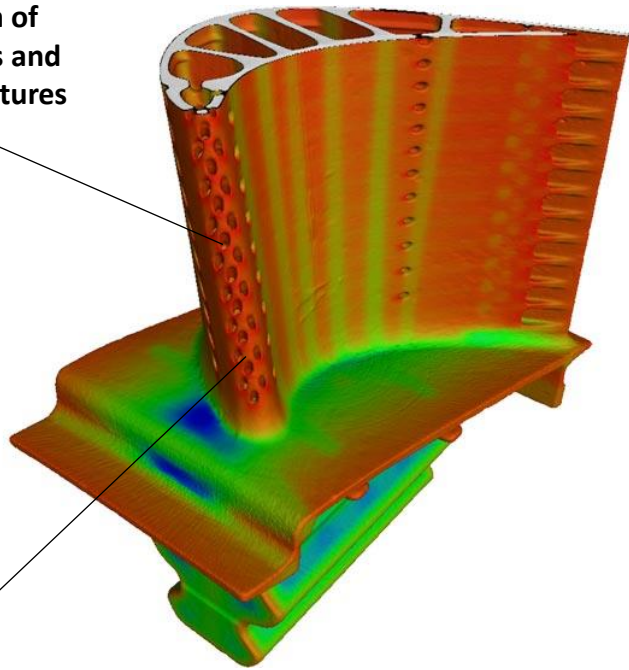
CT & Reverse Engineering?

- Quality Control
 - Part qualification
 - Modeling & simulation
- Part Obsolescence
 - Design recovery
 - Technical data packages
- Hardware Assurance
 - Design validation
 - Counterfeit mitigation

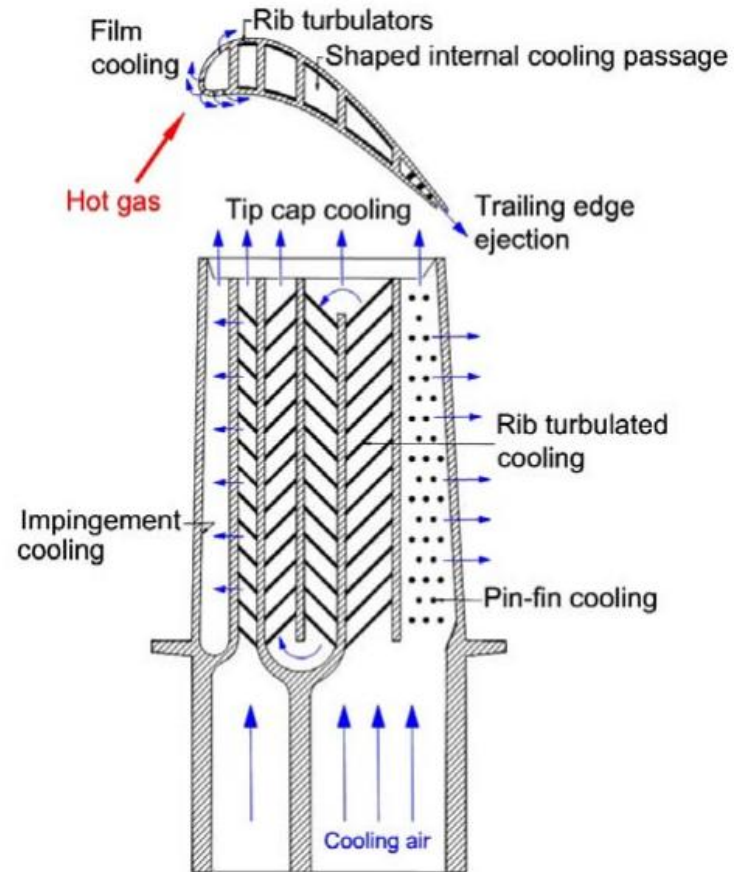
Part Qualification

Gas turbine blades

Verification of cooling holes and internal structures

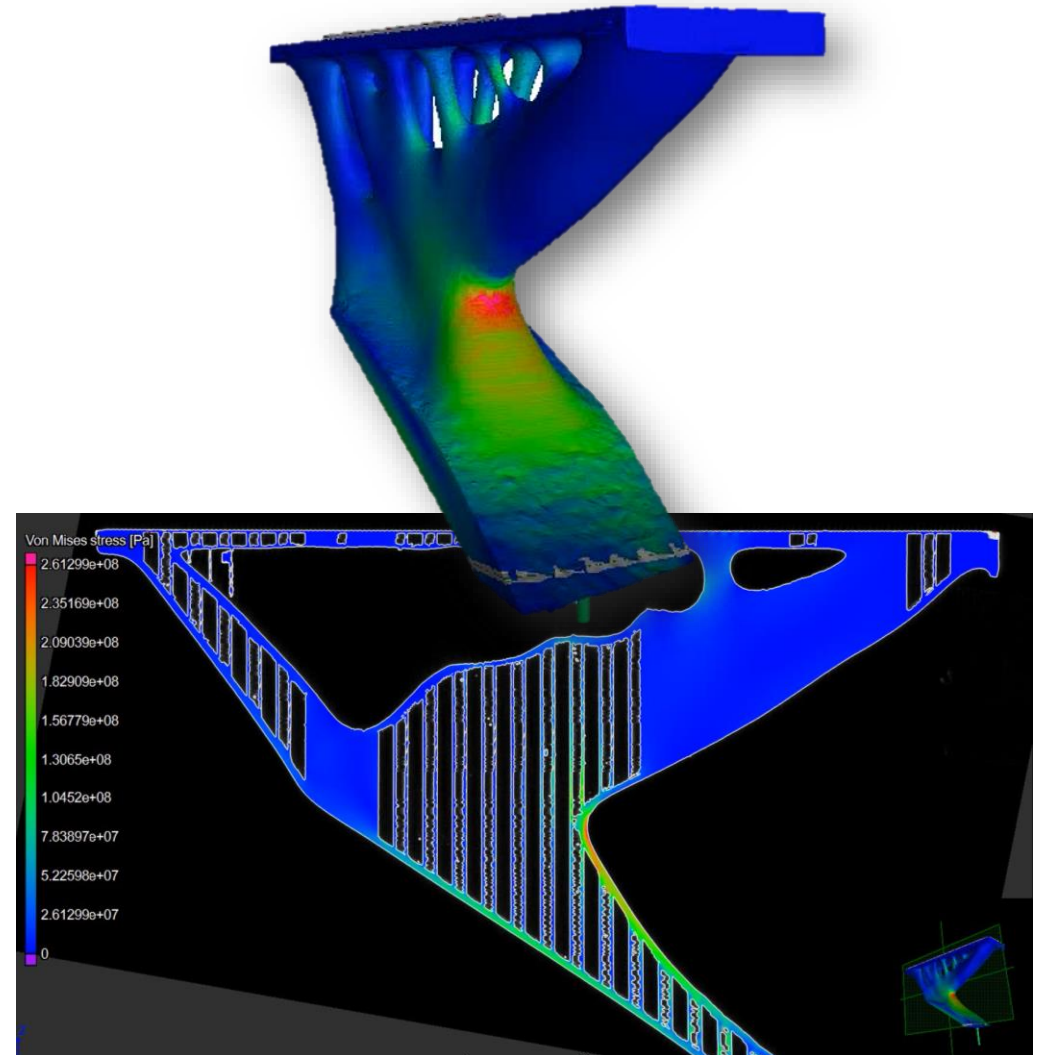


Wall thickness measurements

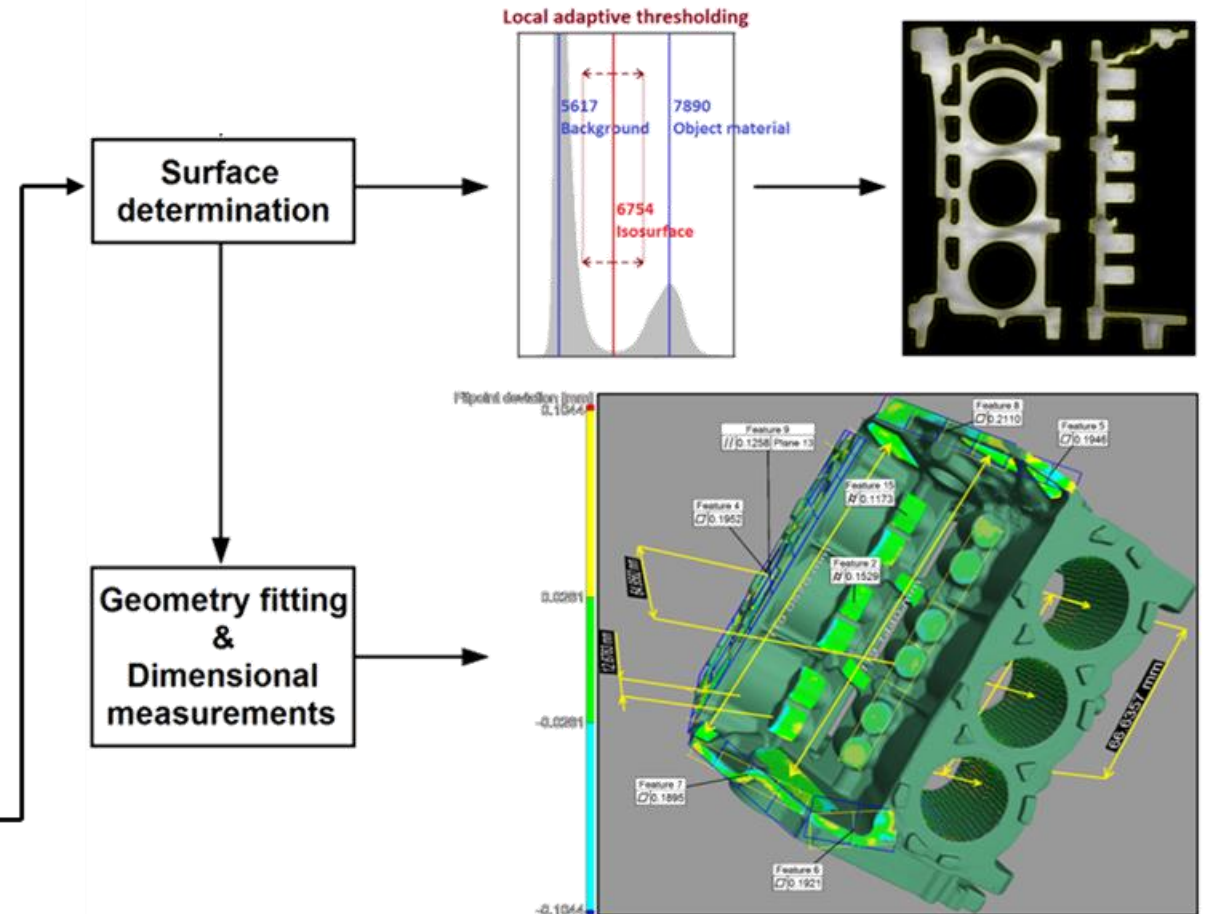
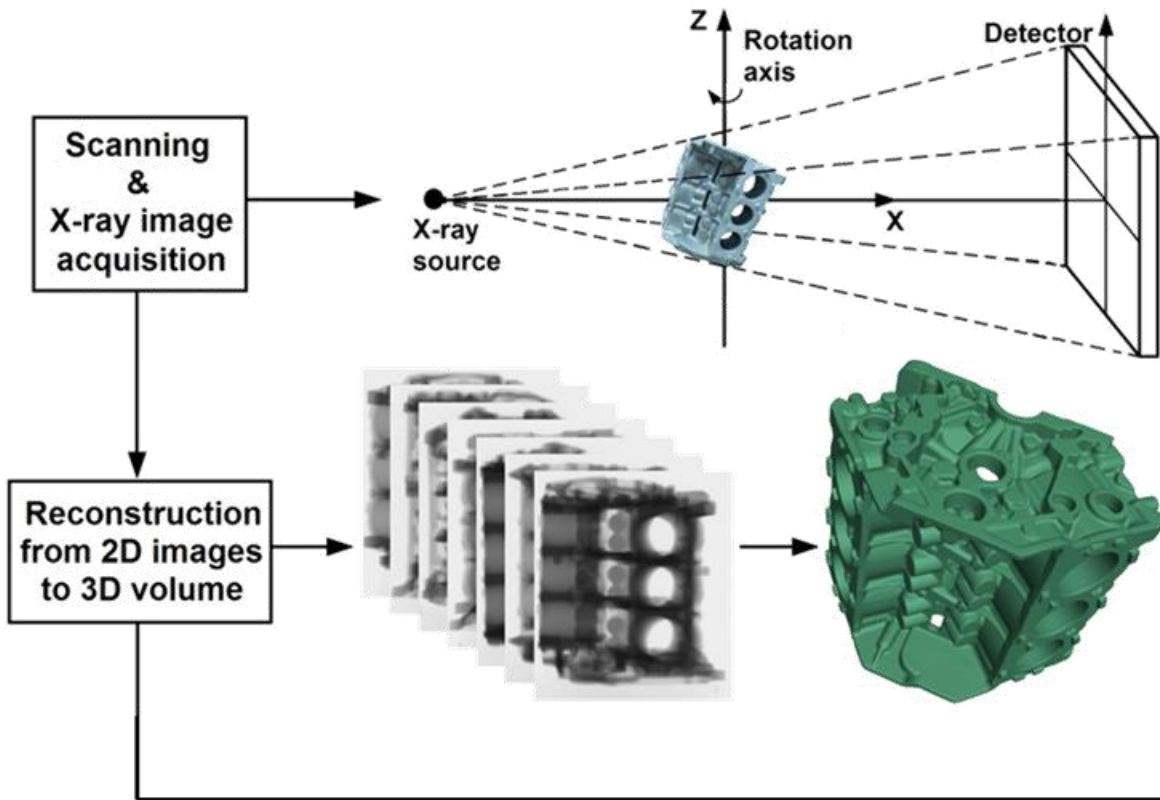


Modeling & Simulation

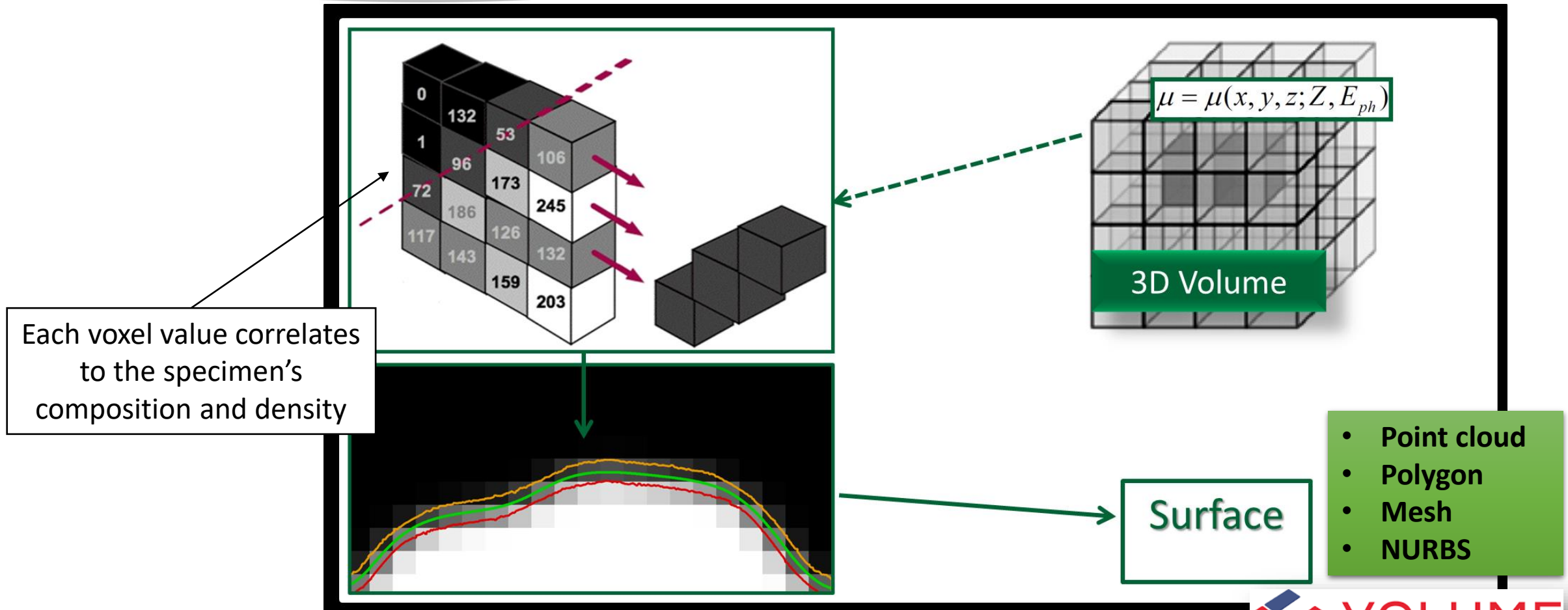
- In many cases, access to the as-built geometry is useful for computational analysis
 - Internal supports & lattices
 - Topology optimization
 - Internal defects
(not supposed to be there)



X-ray CT Data Workflow



Surface Extraction



CT Volume to Point Cloud DEMO

[Live/Recorded DEMO using VGStudio]

PCBs and Electronics

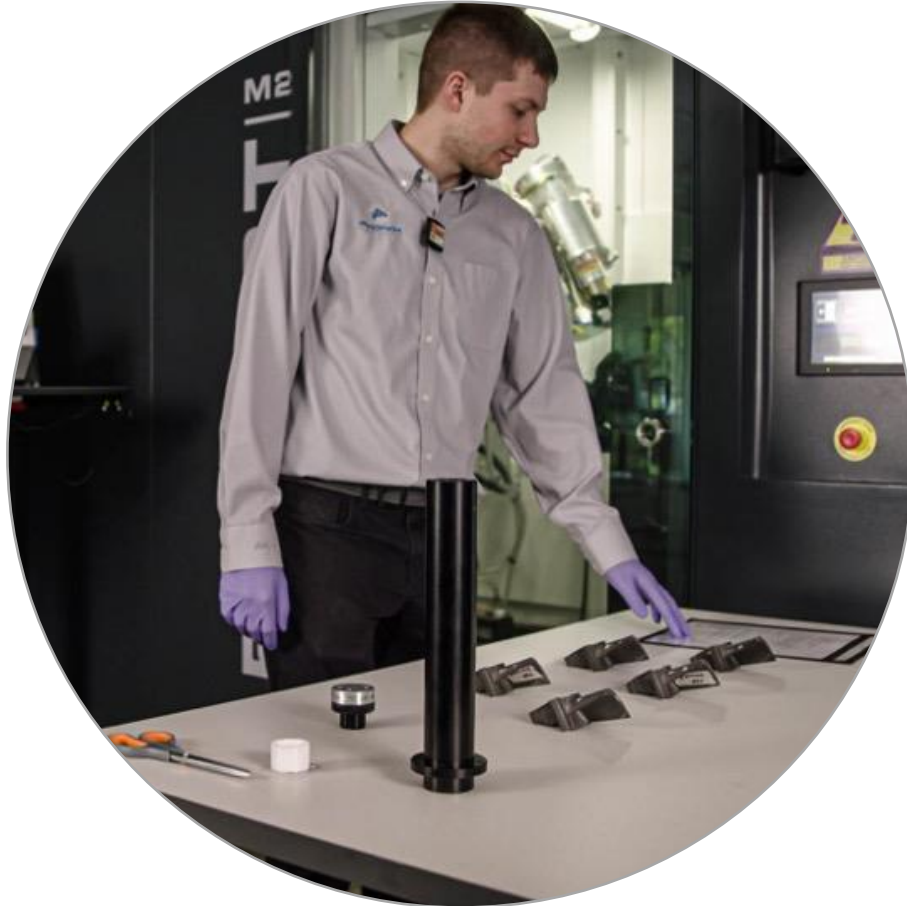
- PCBs can present many practical challenges in CT scanning:
 - Large samples requiring very high resolution
 - Mixed materials (high and low attenuation)
 - Dense array of embedded features

CT Analysis of PCBs and Electronics

[Live/Recorded DEMO using VGStudio]

“How can you access X-ray / CT Technology?”

Use Contract
Inspection Services



Acquire, Install, & Operate
a System at Your Facility



Additional References

- A-TEC: Avonix Technical Exchange, Minneapolis, MN
 - September 20-21, 2022
- IEEE PAINE, Huntsville, AL
- ASNT – American Society for Non-destructive Testing

Questions

- Questions