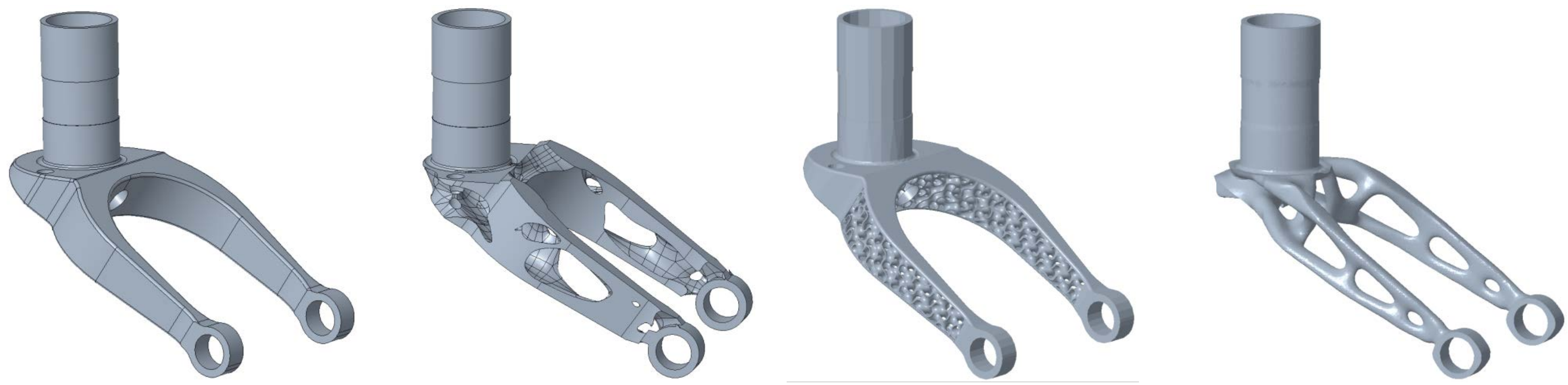
Generating the Digital Thread for Backlogged Parts that Lack TDP



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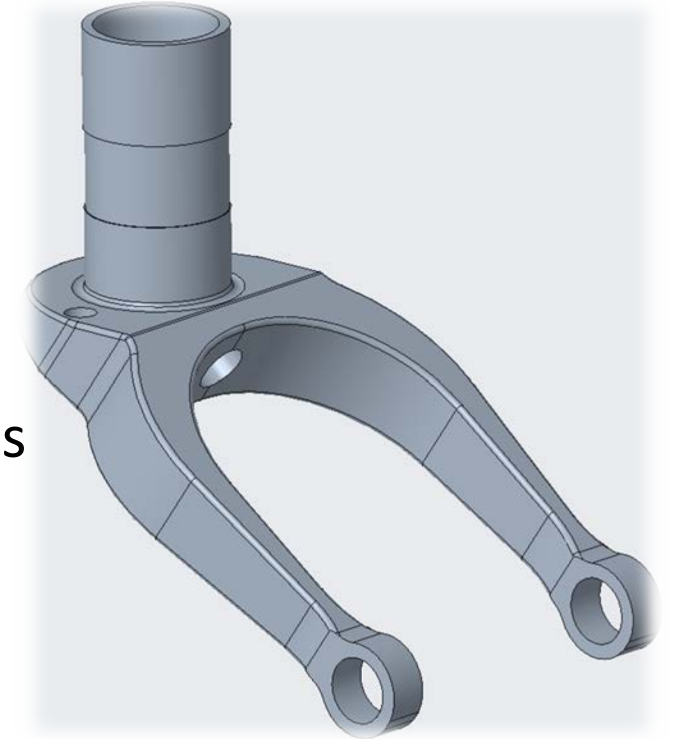
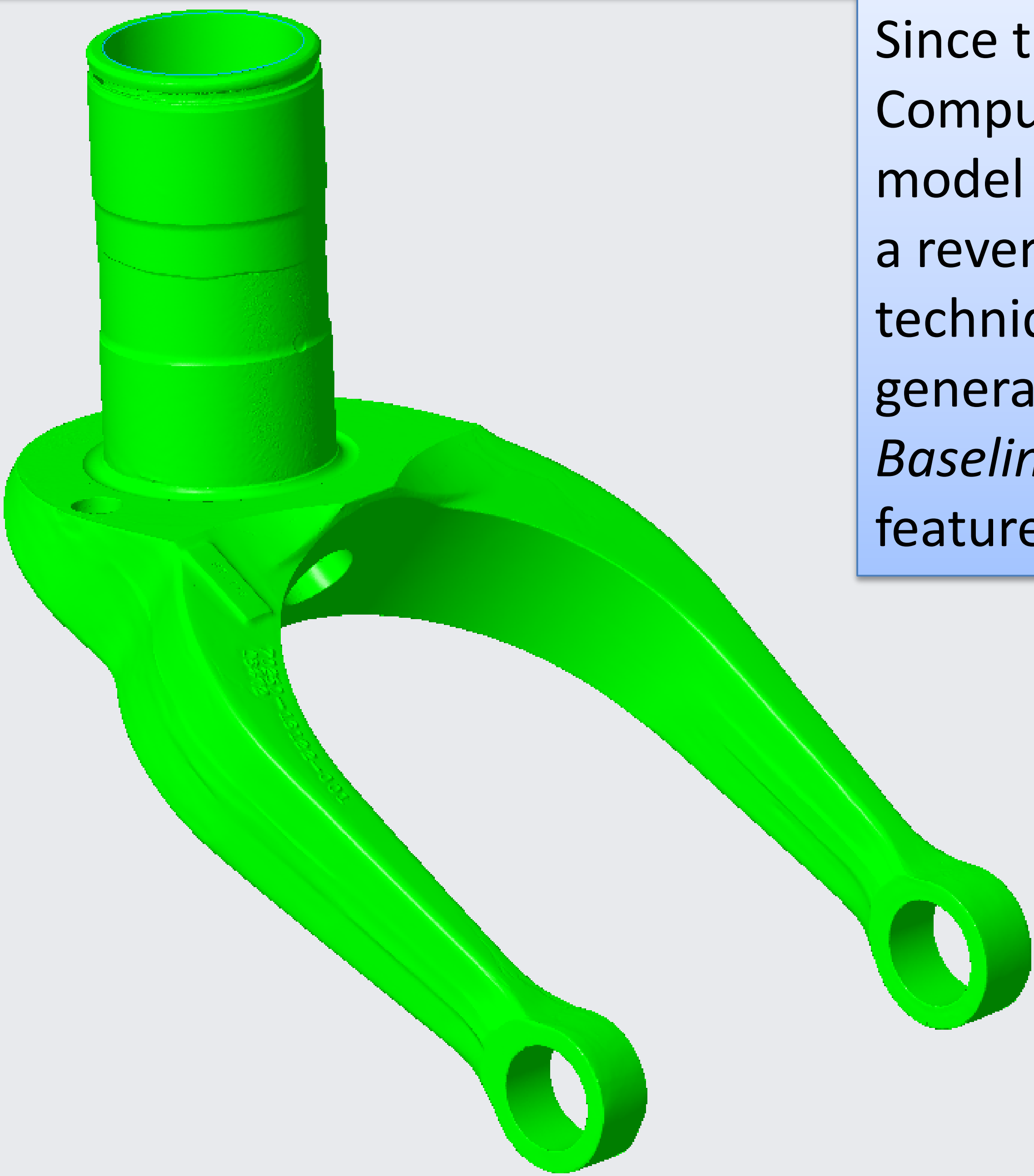
Generating the Digital Thread for Backlogged Parts that Lack TDP

- Sometimes *aerospace manufactures* of the defense industry go out of business or the parts are so old there are no TDP or performance requirements are not available
- This presentation will provide a methodology for a rapid response to organizations that need to:
  - Generate a Technical Data Package (TDP)
  - Introduce the part into the Digital Thread
  - Improve part's performance
  - Reduce part's weight
  - Explore Alternative Manufacturing Options
  - Manufacture fast backlogged spare parts
  - Reduce part's time to manufacturing

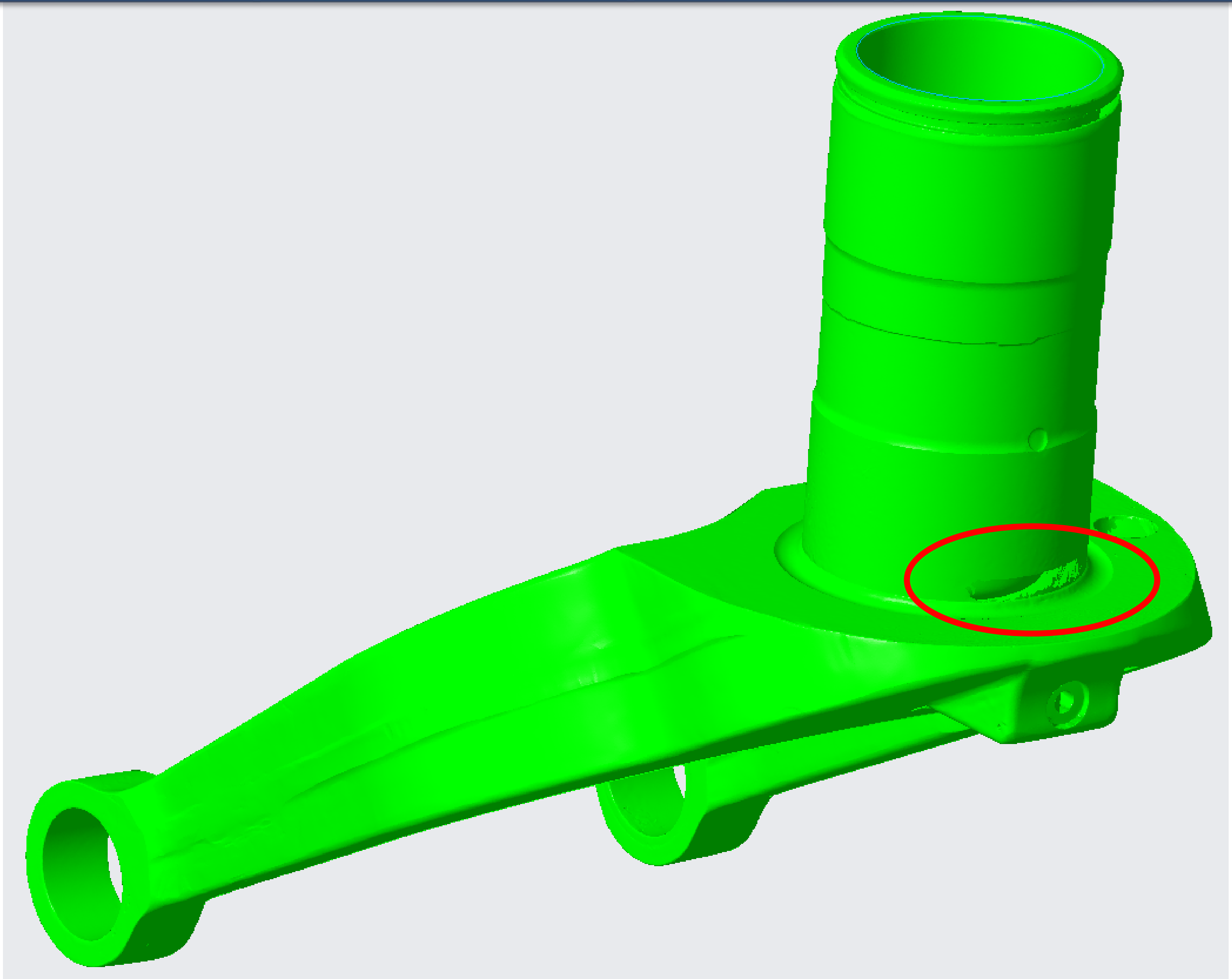


Scanned Data for Tail Wheel Yoke

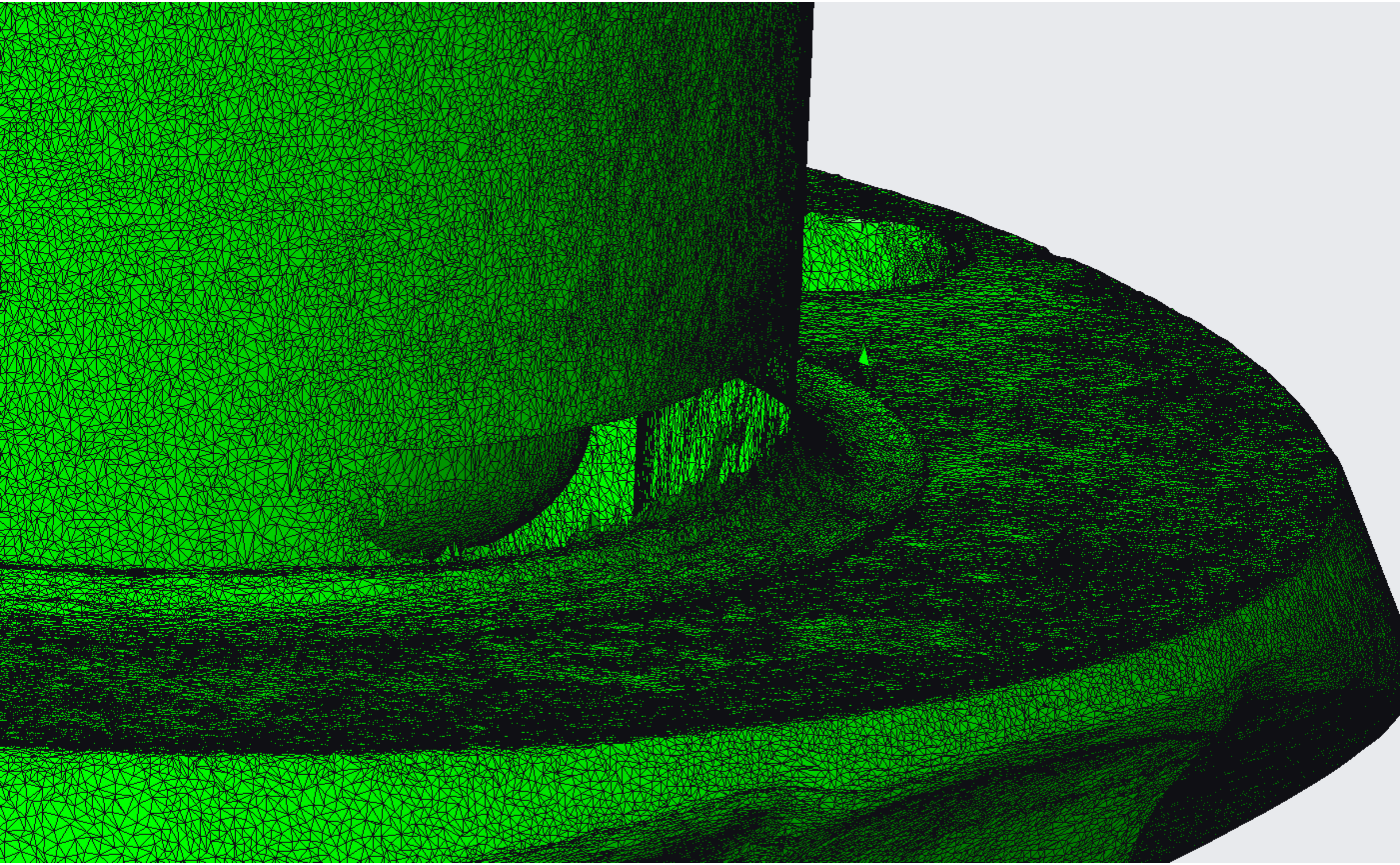


Since there is no access to Computer Aided Design (CAD) model data for these components, a reverse engineering (RE) technique need to be employed to generate the geometry of the *Baseline Geometry* in a parametric feature based CAD format.

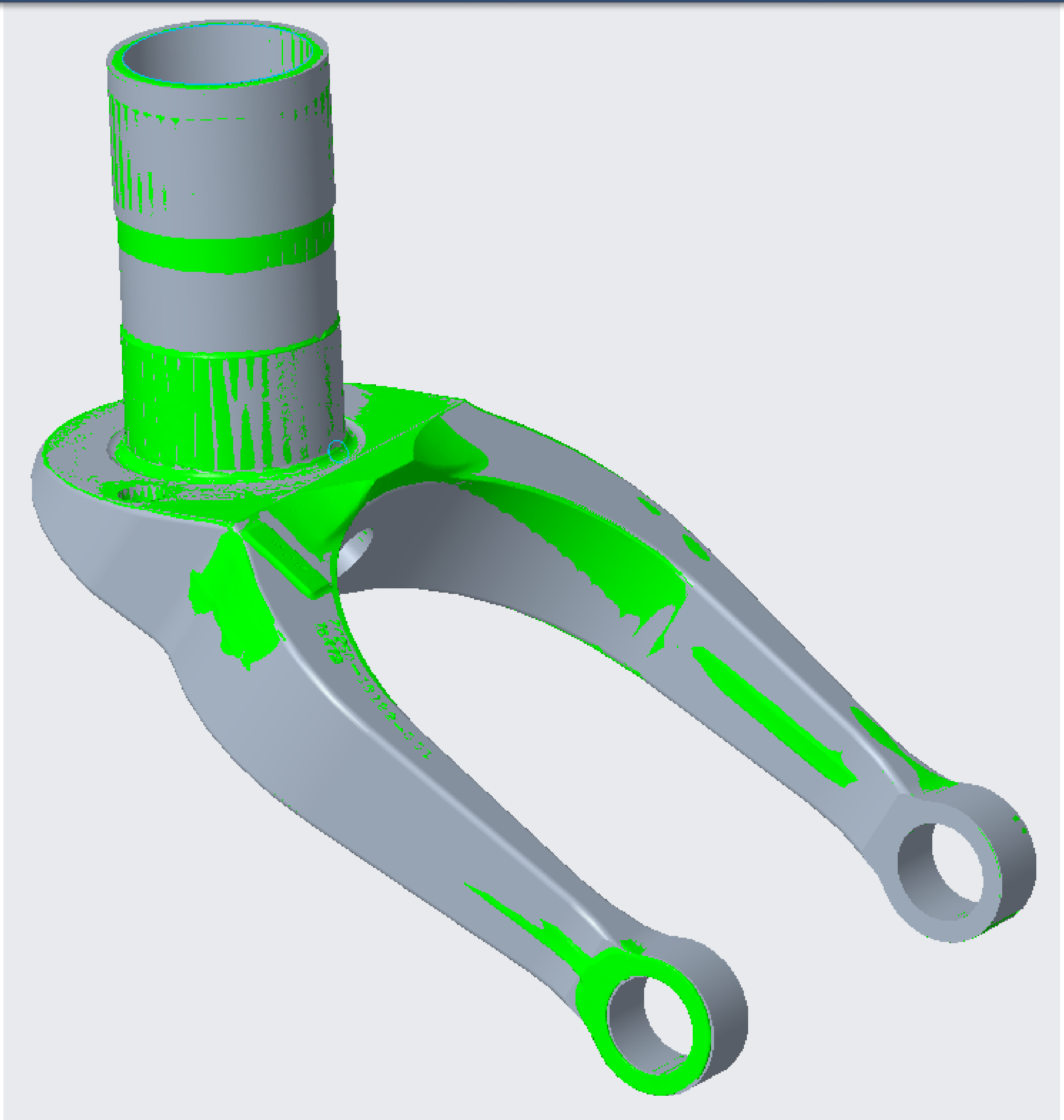
Scanned Data Tail Wheel Yoke



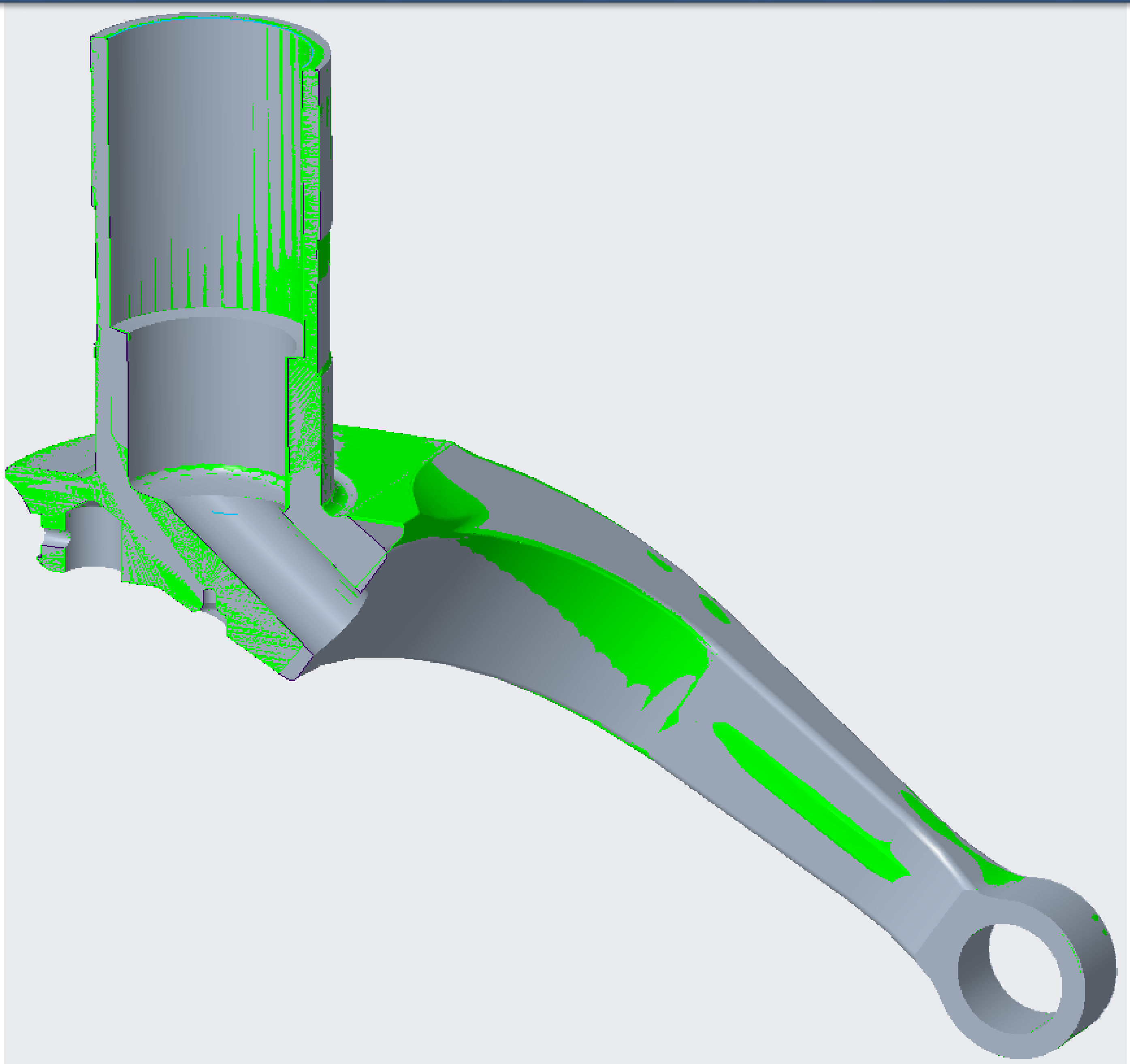
Scanned Data for Tail Wheel Yoke



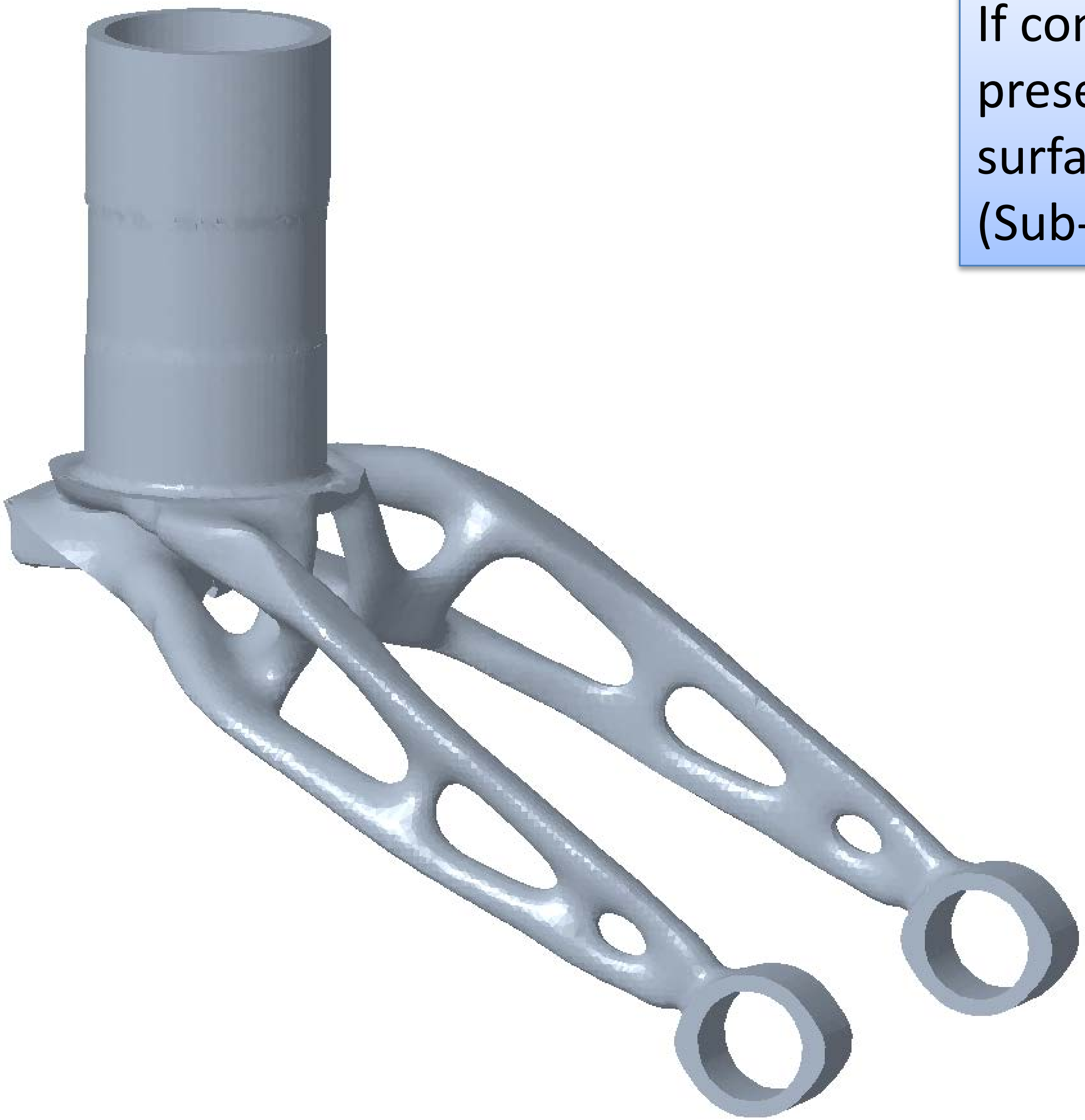
New Parametric CAD model & Scanned data



Section New Parametric CAD model & Scanned data

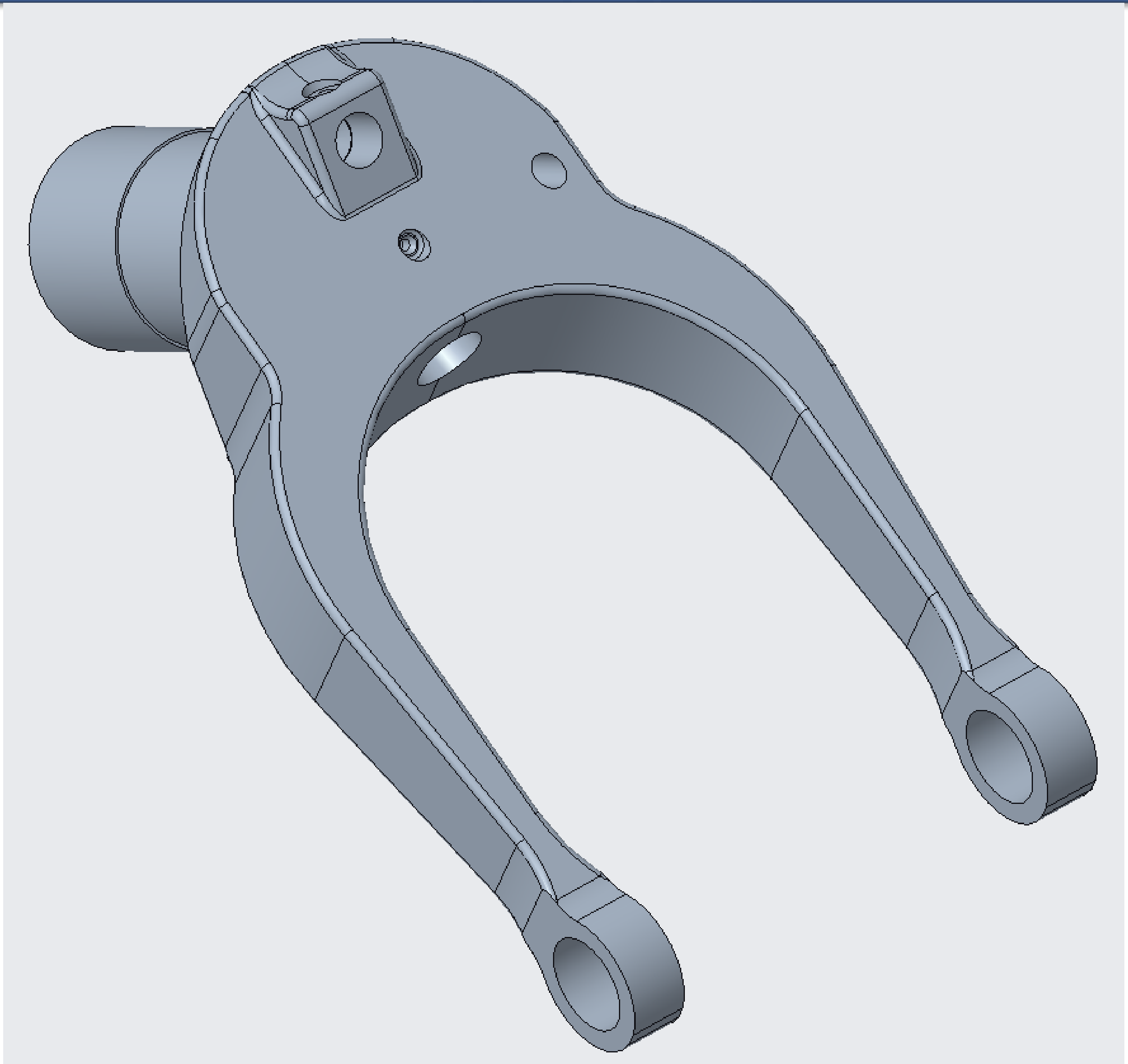


High Quality CAD Model (TDP)



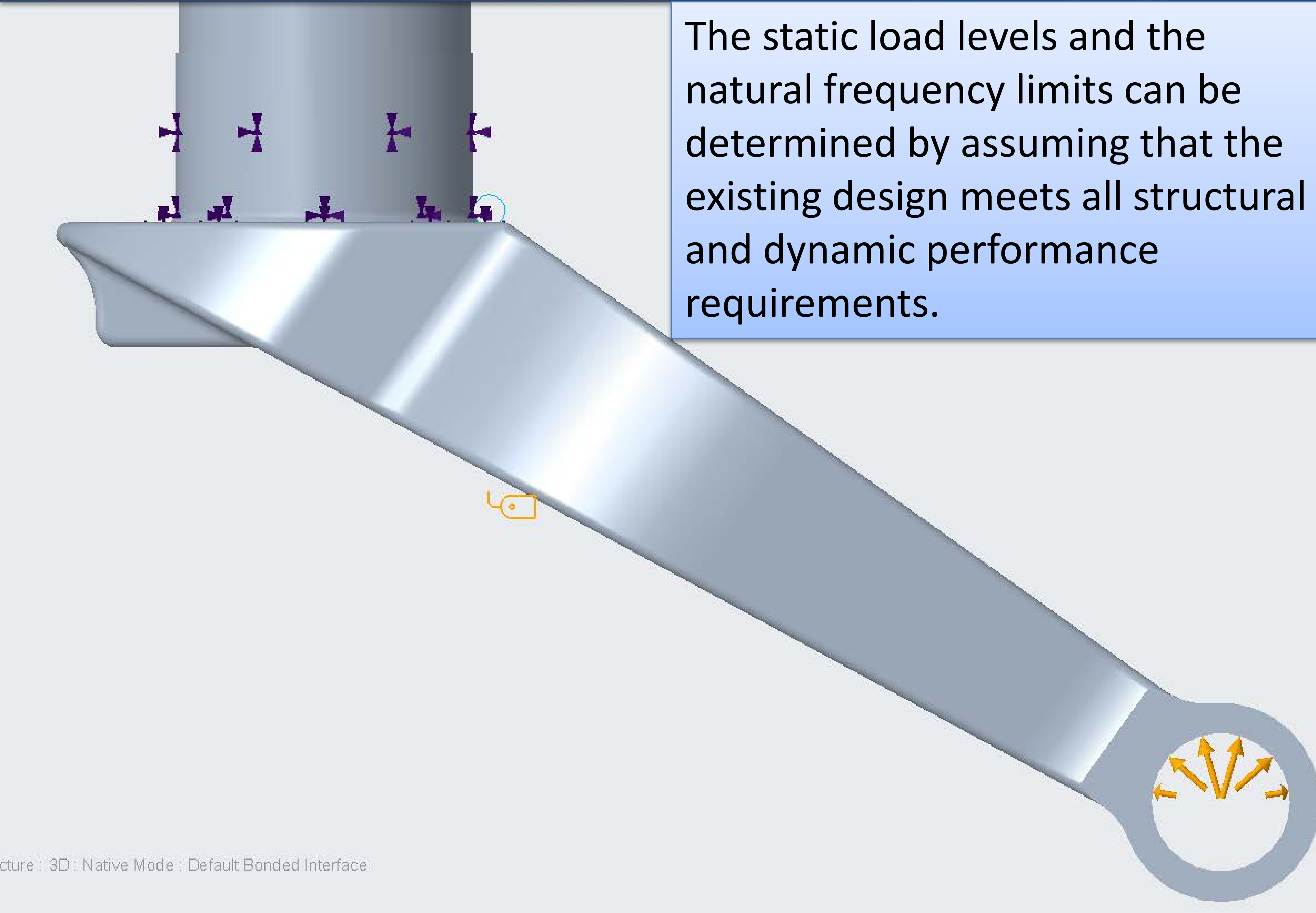
If complex surfaces are present a Sub-Divisional surface modeling technique (Sub-D) is deployed

High Quality CAD Model with PMI (TDP)

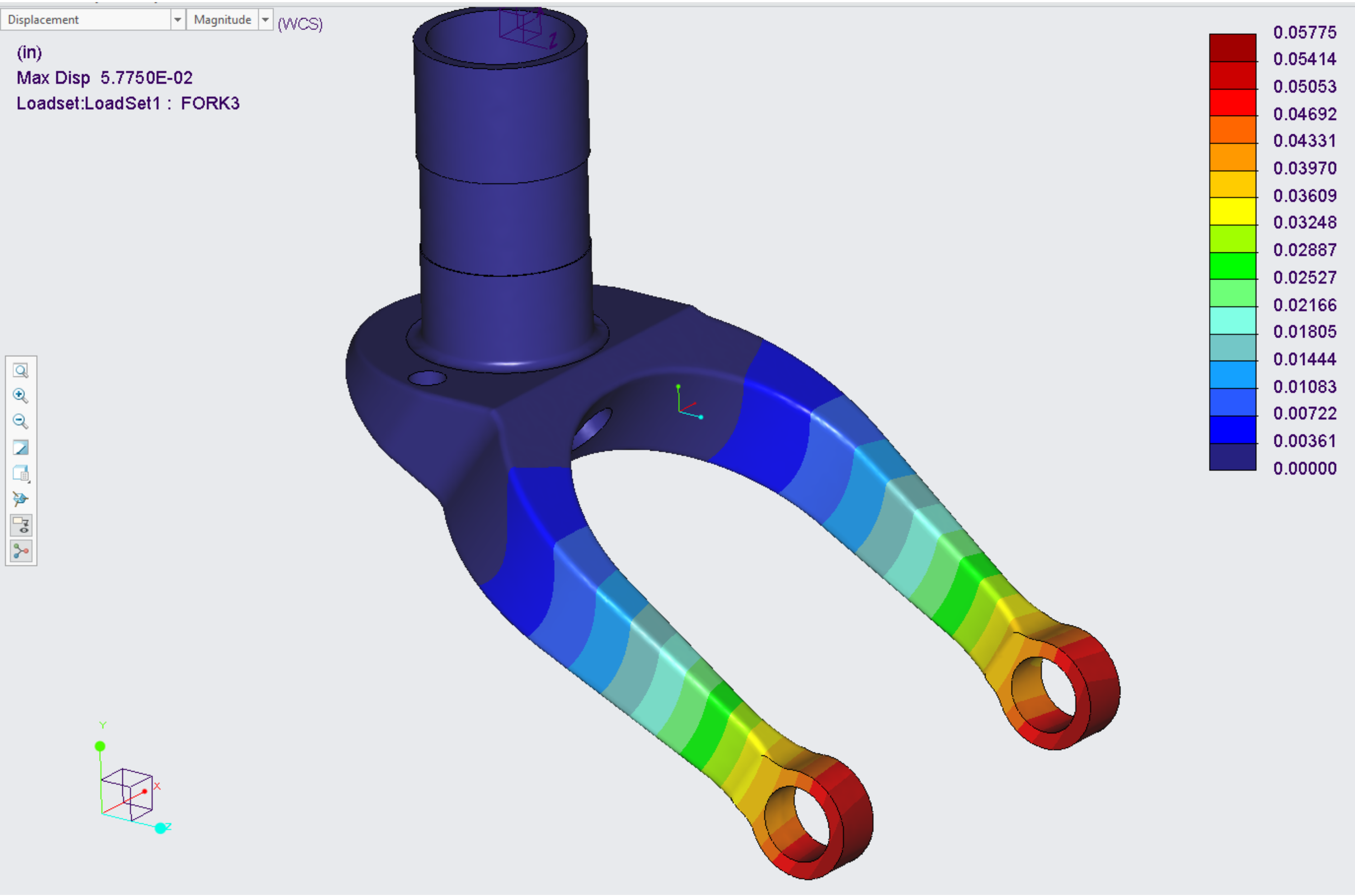


Supports and Loading Conditions

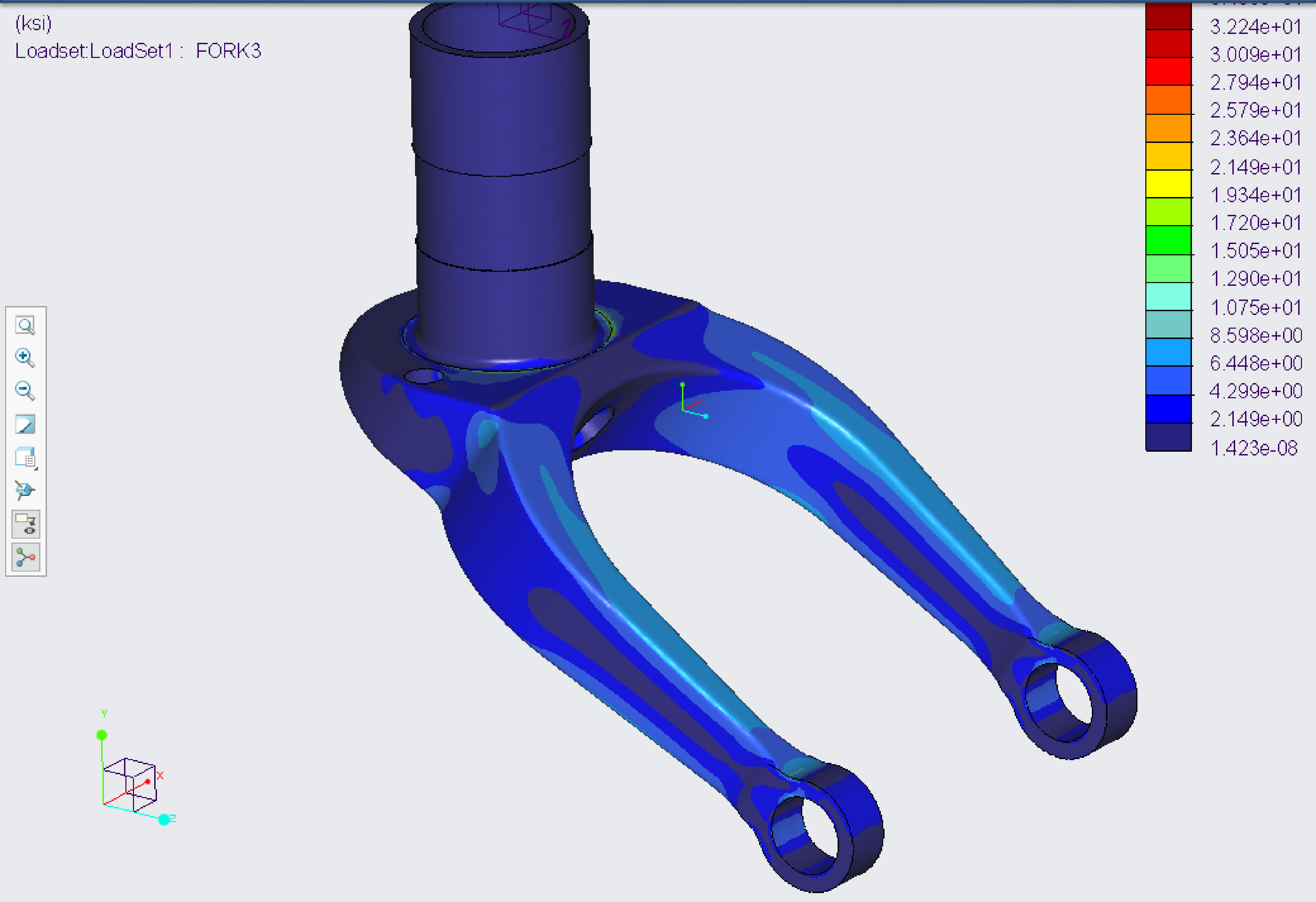
The static load levels and the natural frequency limits can be determined by assuming that the existing design meets all structural and dynamic performance requirements.



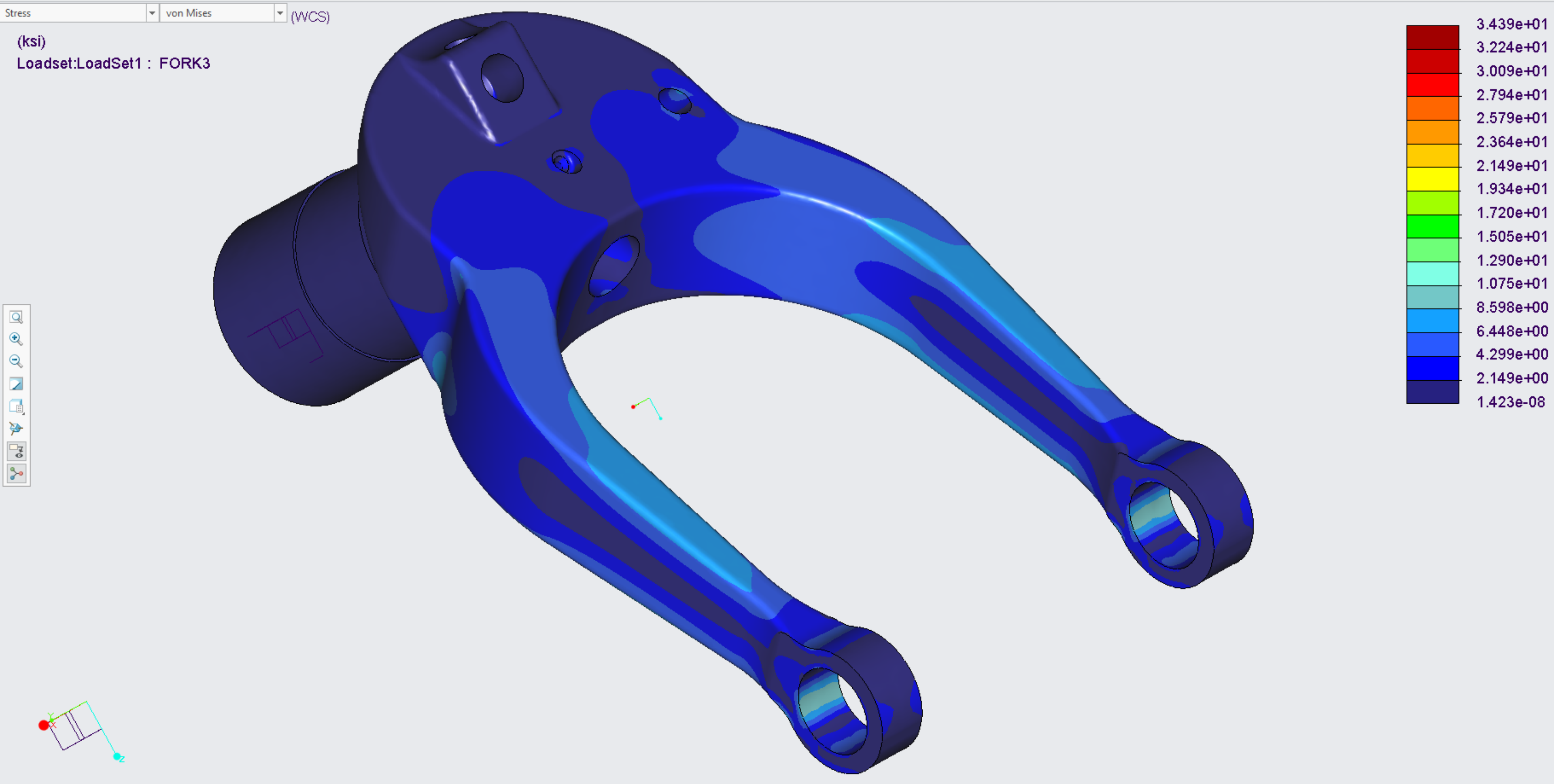
Displacement Distribution



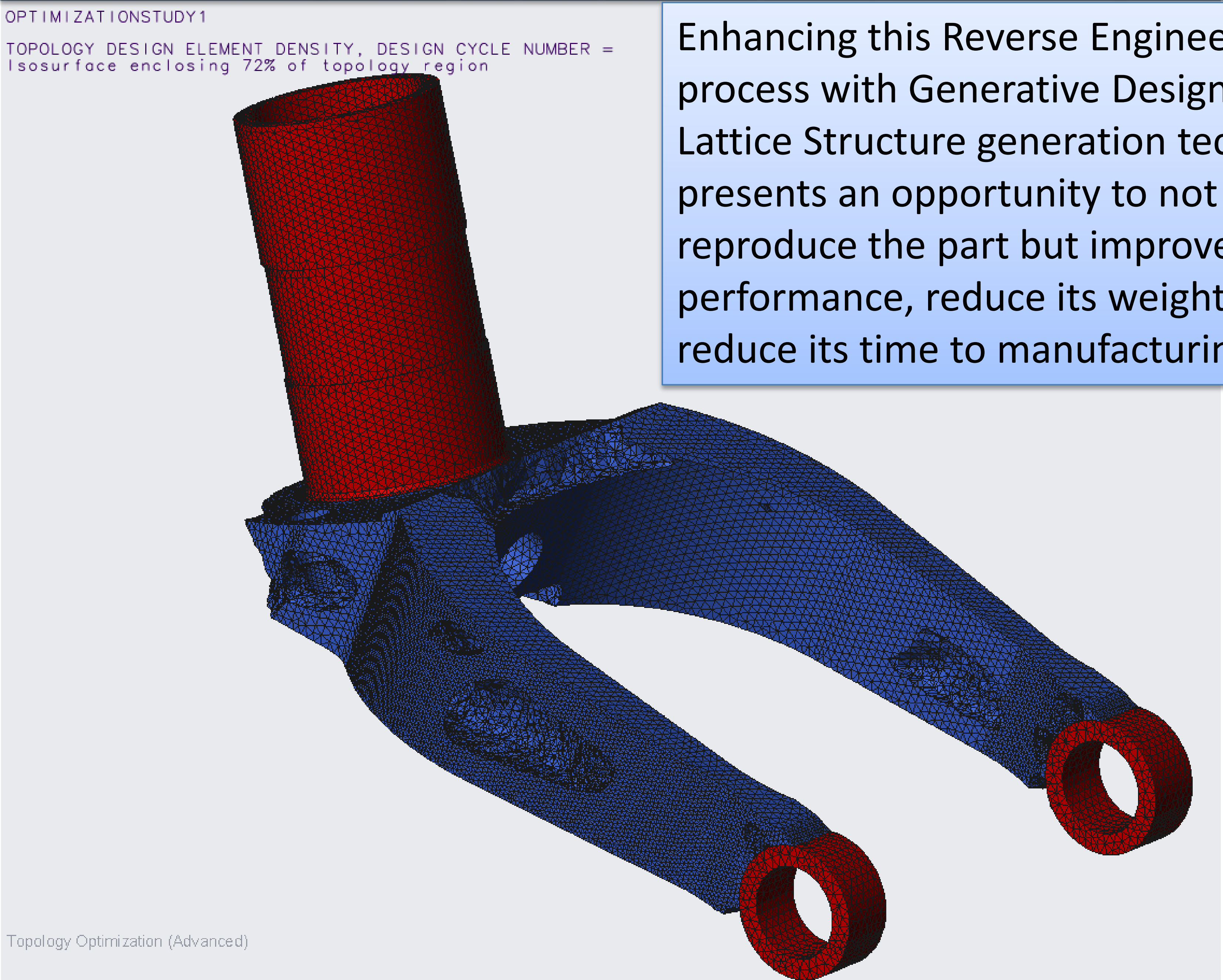
Stress Distribution



Stress Distribution

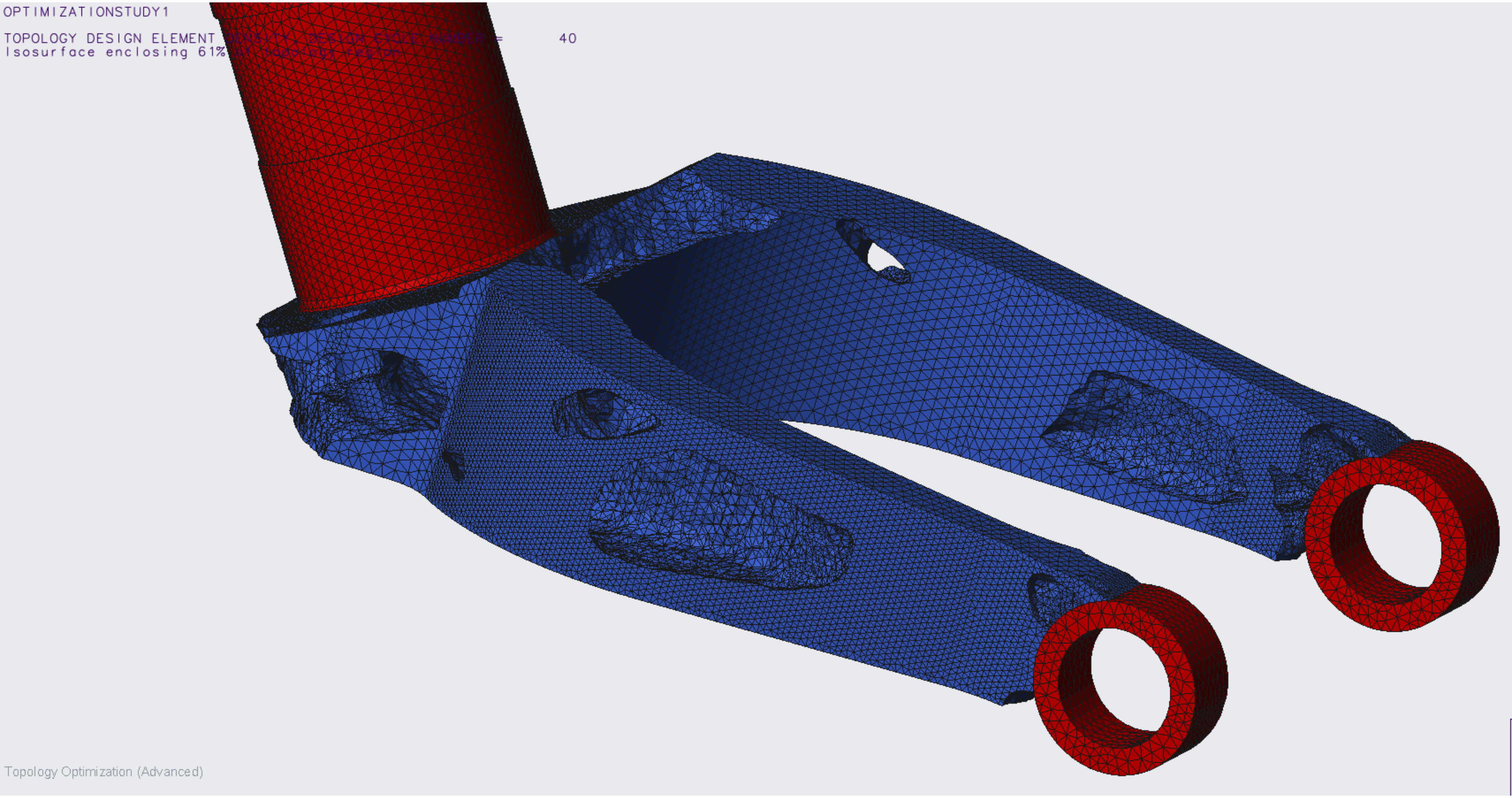


Design Domain and Keep out Regions

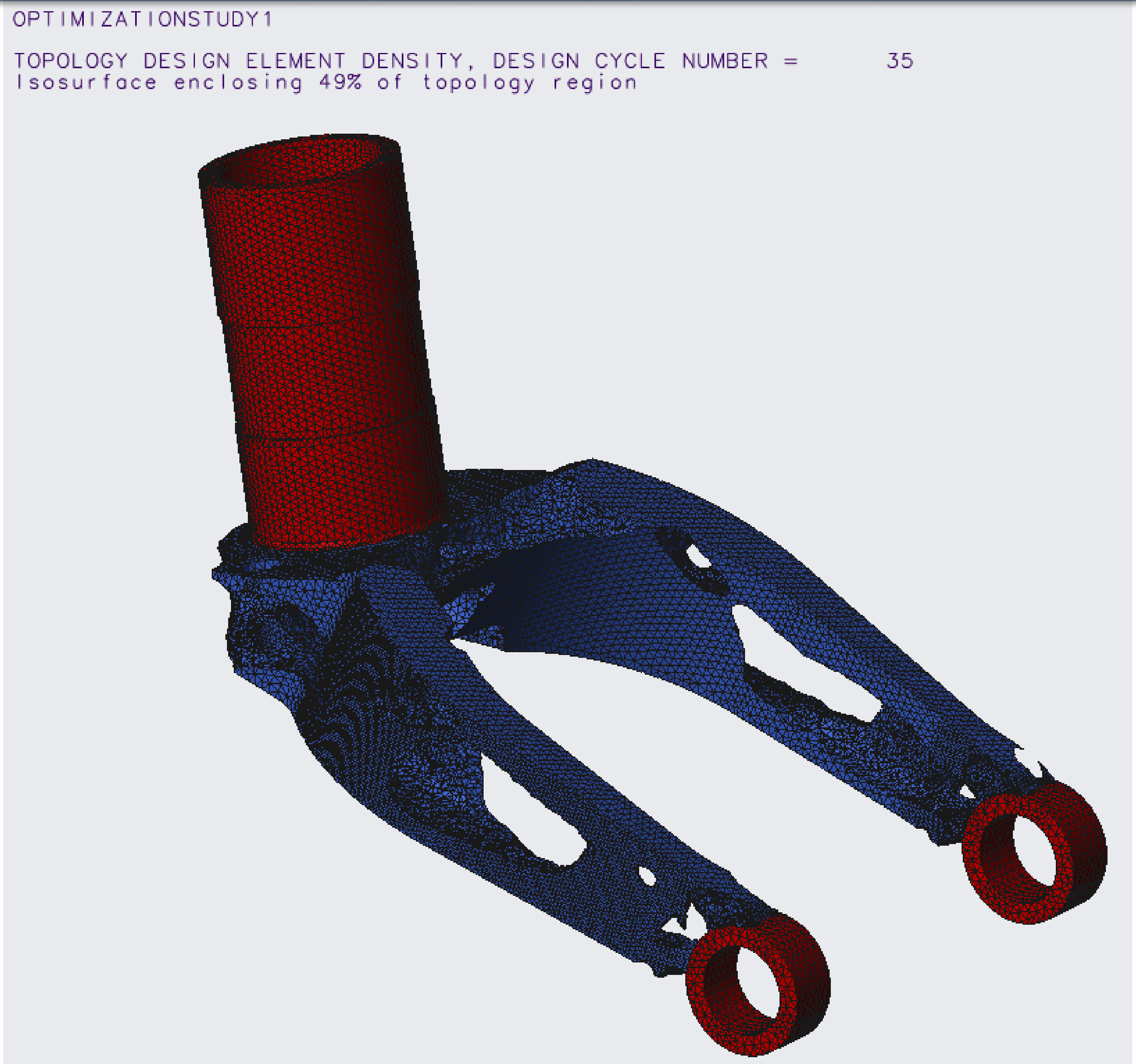


Enhancing this Reverse Engineering process with Generative Design and Lattice Structure generation techniques presents an opportunity to not only reproduce the part but improve its performance, reduce its weight and reduce its time to manufacturing

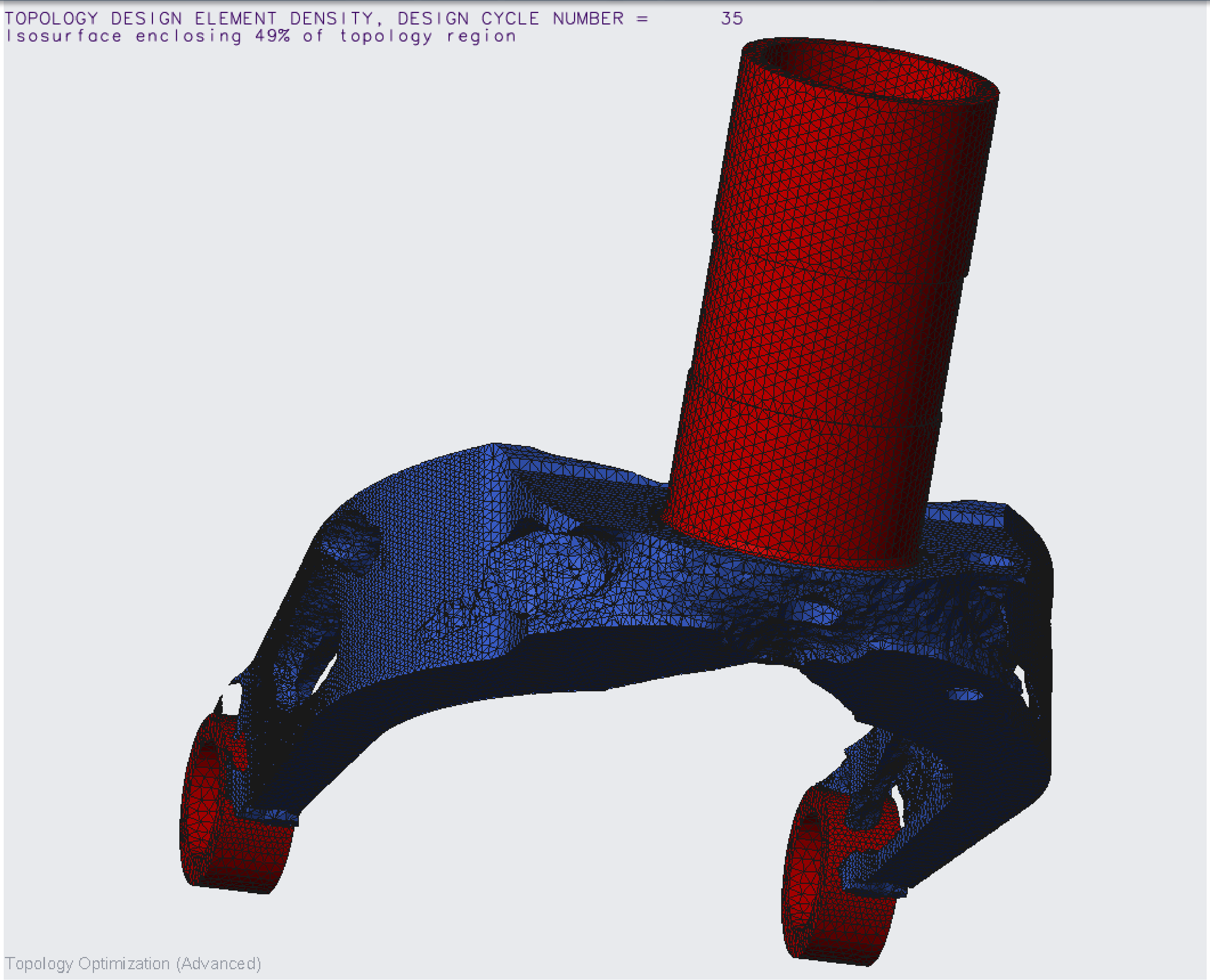
60 % of Original Weight



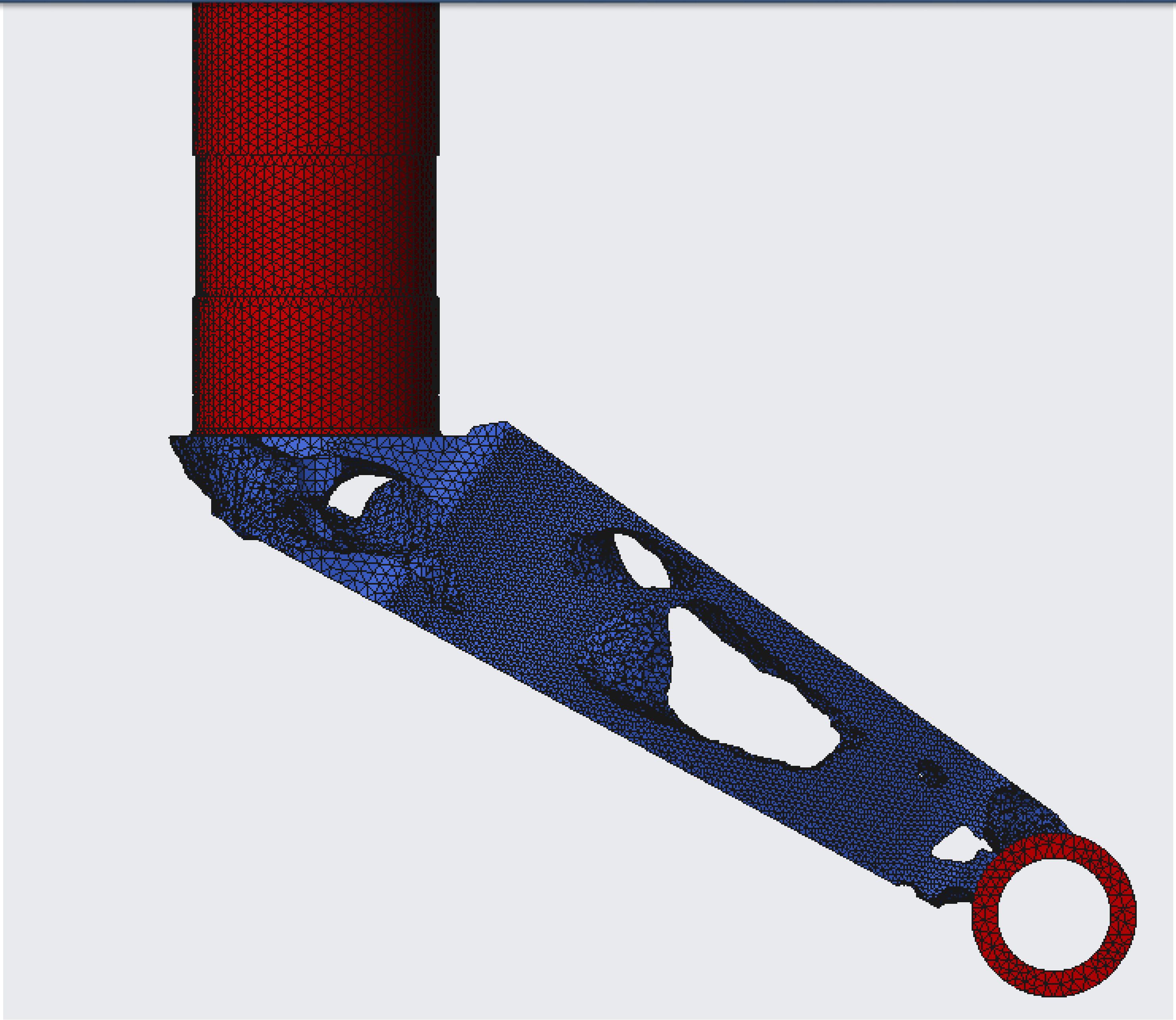
50 % of Original Weight



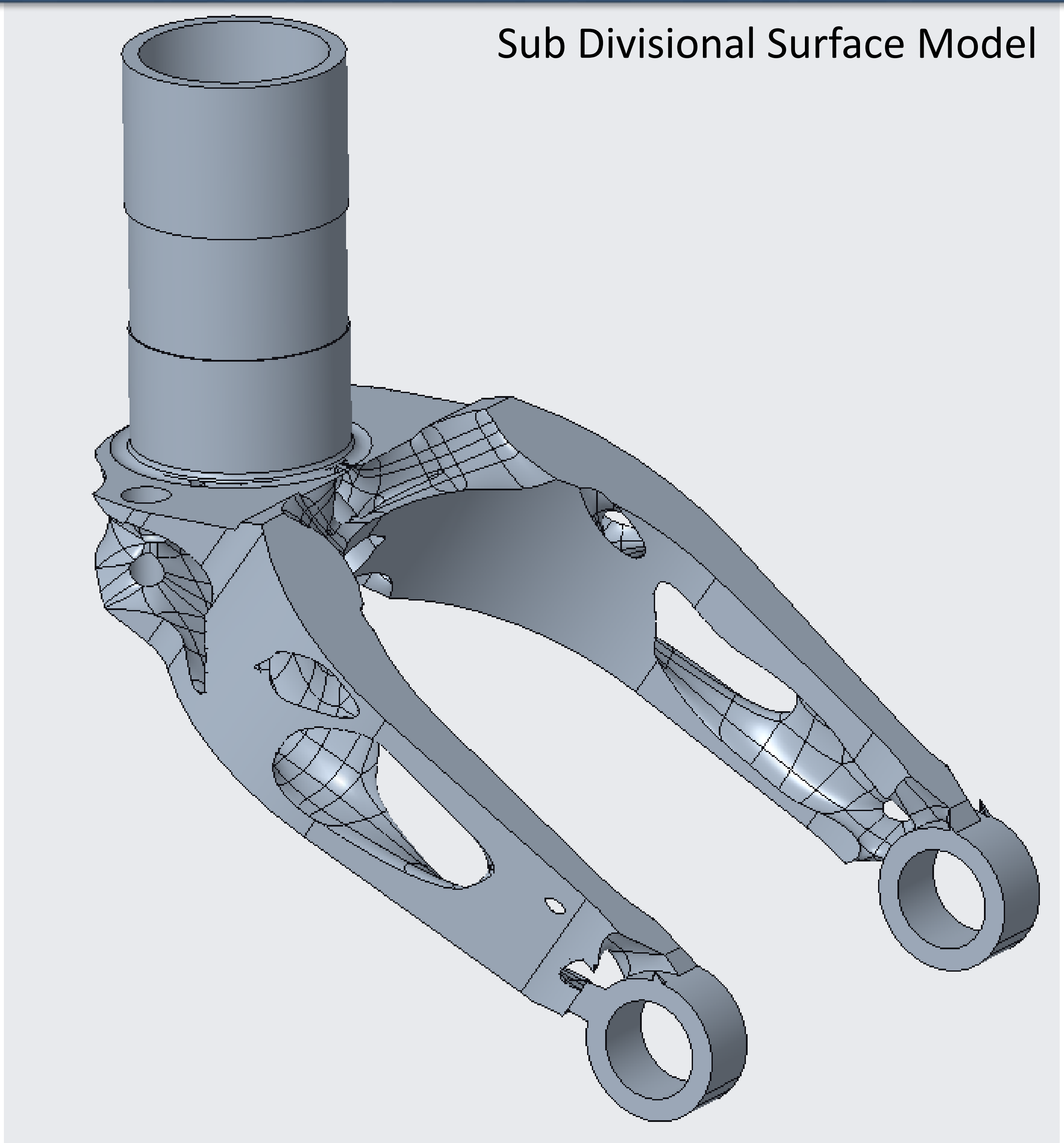
50 % of Original Weight



50 % of Original Weight

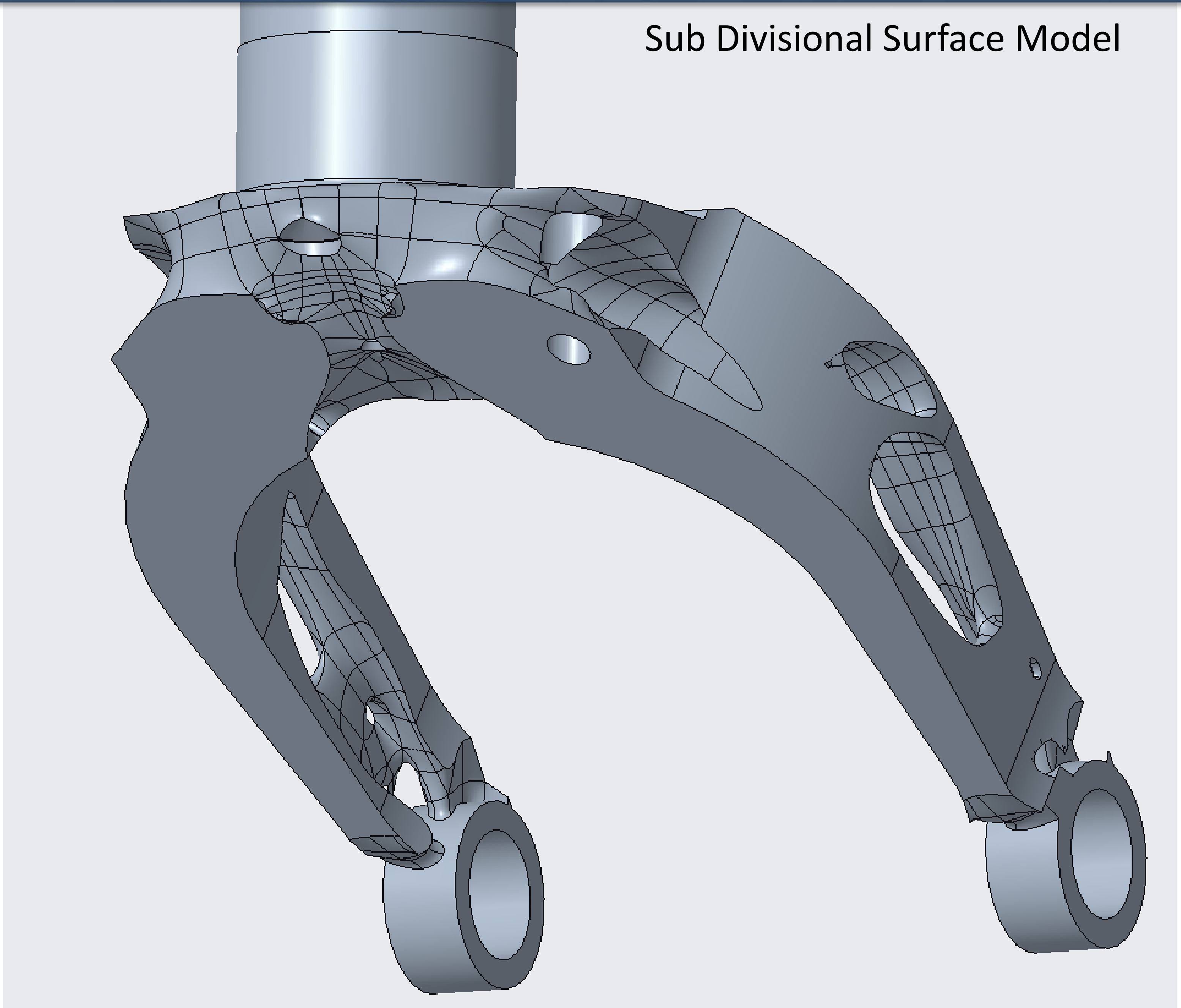


CAD Model of Optimized Geometry



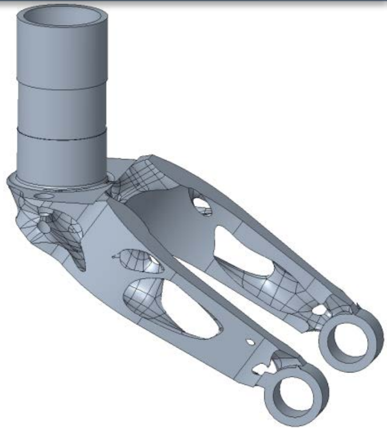
CAD Model of Optimized Geometry

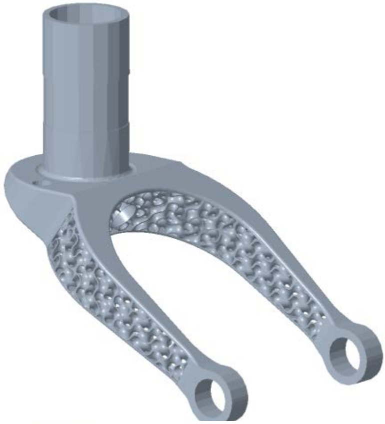
Sub Divisional Surface Model

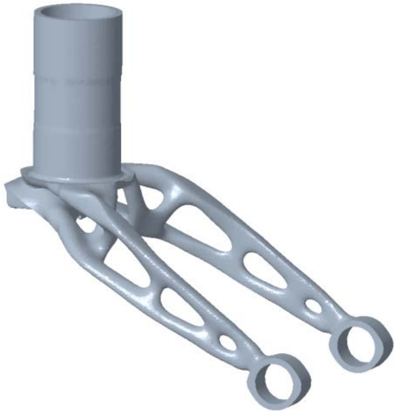


Reduce part's fabrication time with Additive Layer manufacturing

- Since the additive manufacturing (AM) industry continues to grow with new machines, faster processes and a large selection of materials there is a great opportunity to redesign these parts using *Lattice Structures* and *Generative Design Techniques*.
- Lattice structures such as Gyroid minimal surfaces are very effective for light weighting, energy absorption, dynamic damping, ballistic protection, etc.
- The combination of Sub-Divisional surface modeling, Topology Optimization, manufacturing constraints and Lattice Structure generation tools enable us to generate optimum designs.

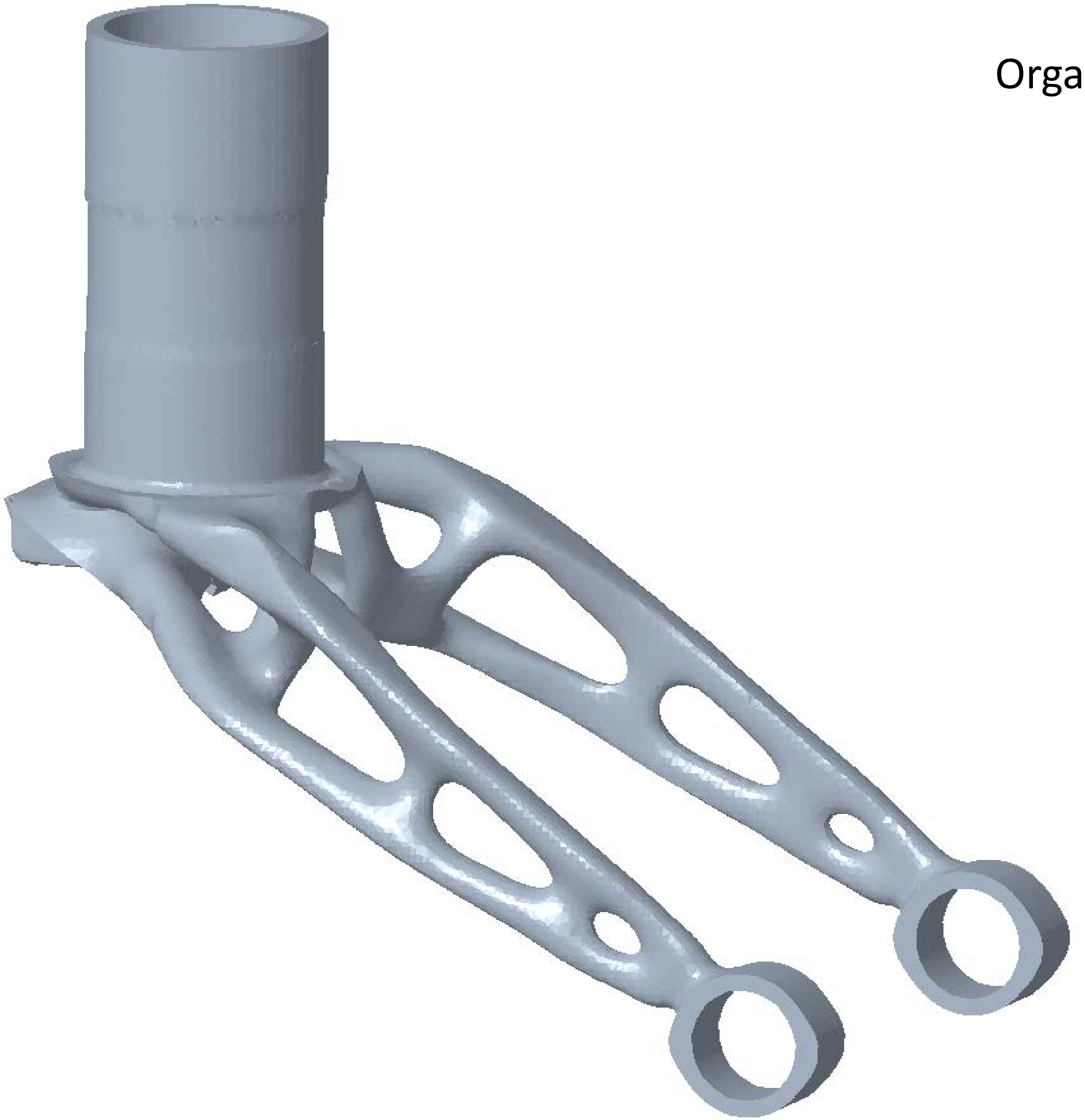




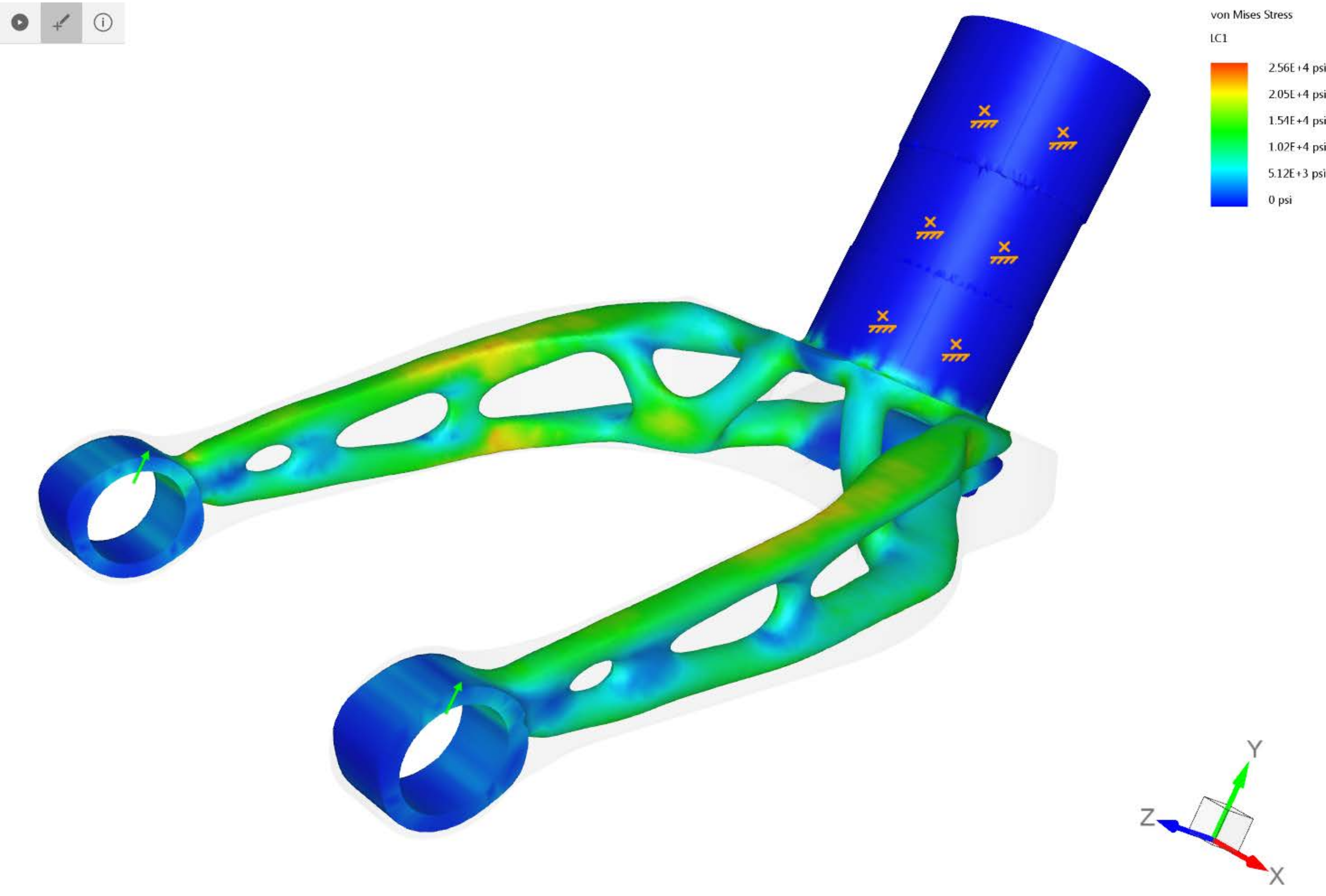


Optimized Geometry Design Option 2 for AM

Organic Geometry

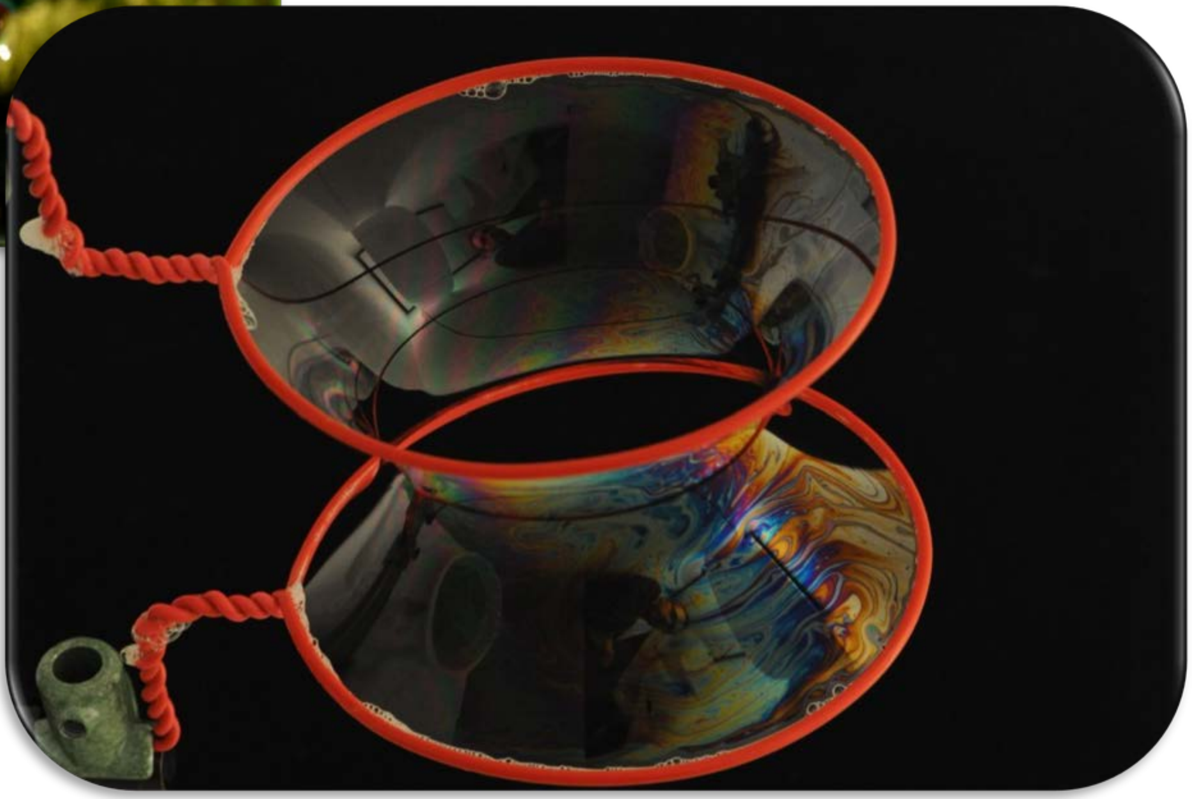


Design Option 2 Fully Stressed Geometry



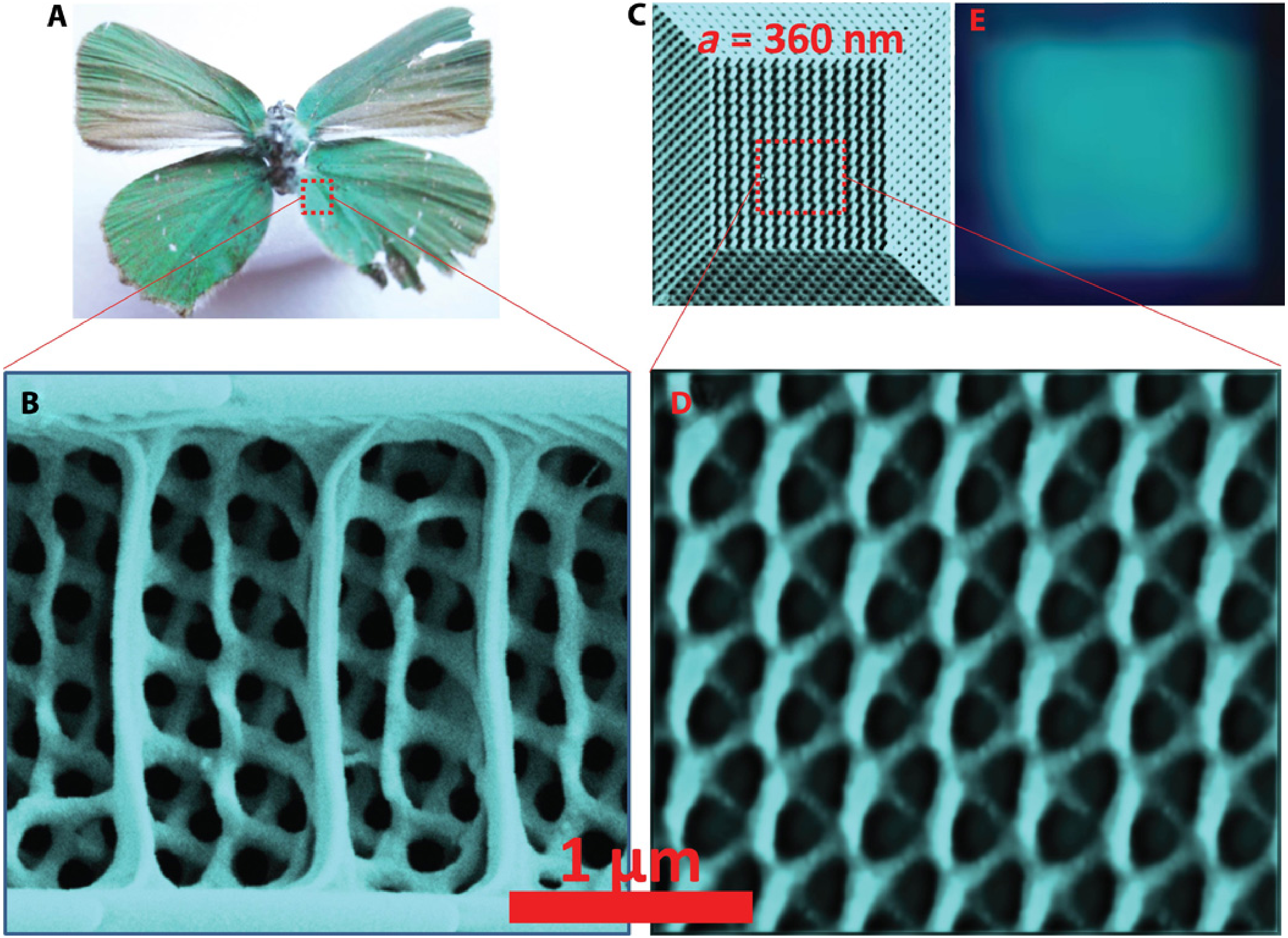
Minimal Surfaces

- Nature uses them for a long time
- Discovered by Mathematicians in the 1970s
- Introduced in ANSYS SC, CAD, AM preprocessors and Generative Design Systems the last couple of years



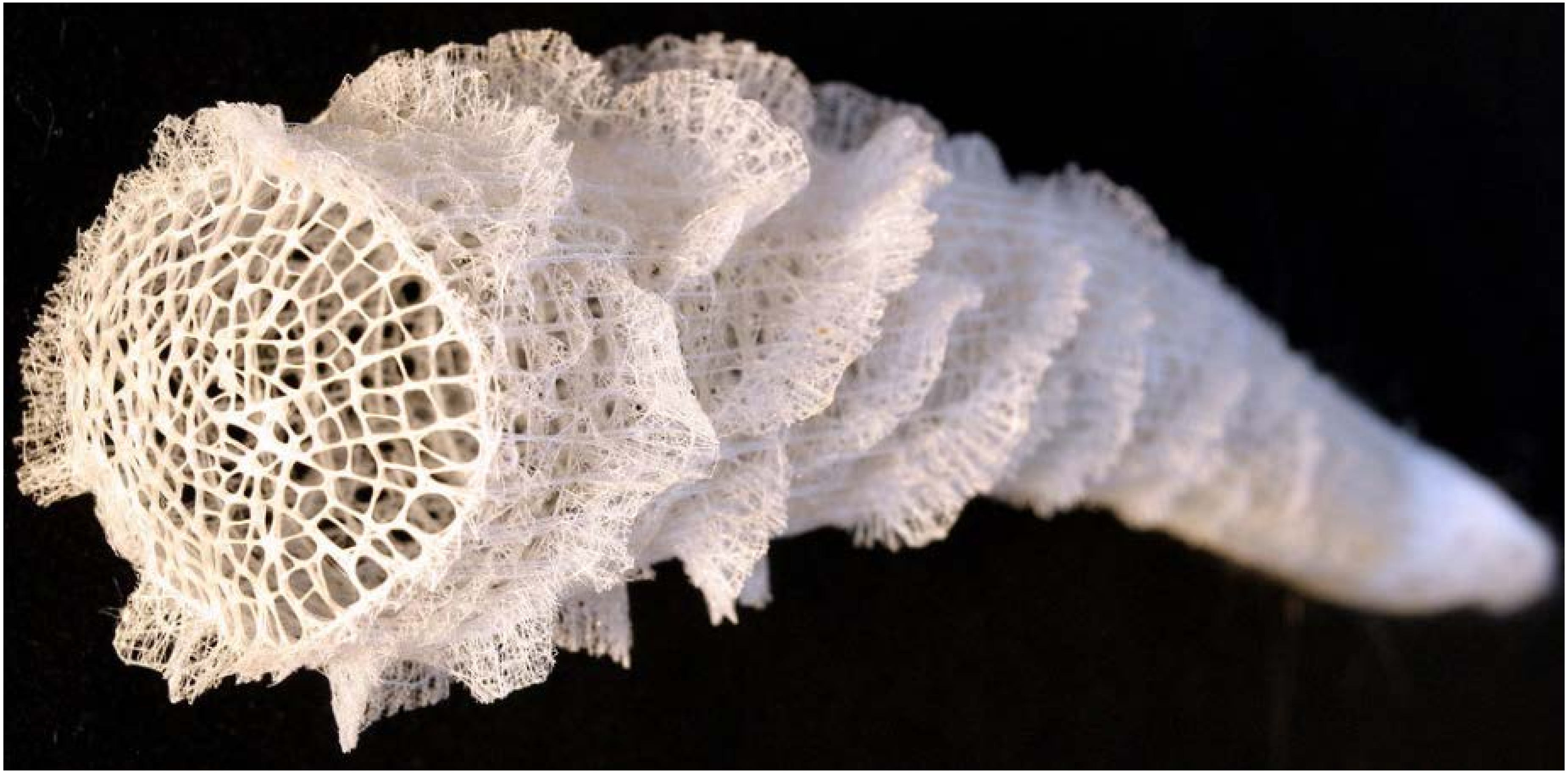
$$Area\_Funtional := \int_0^h 2\,\pi \cdot R(y)\,\mathrm{d}y$$

Biomimicry
Butterfly wings with Gyroid Topologies



Bio-inspired Lattice Generation

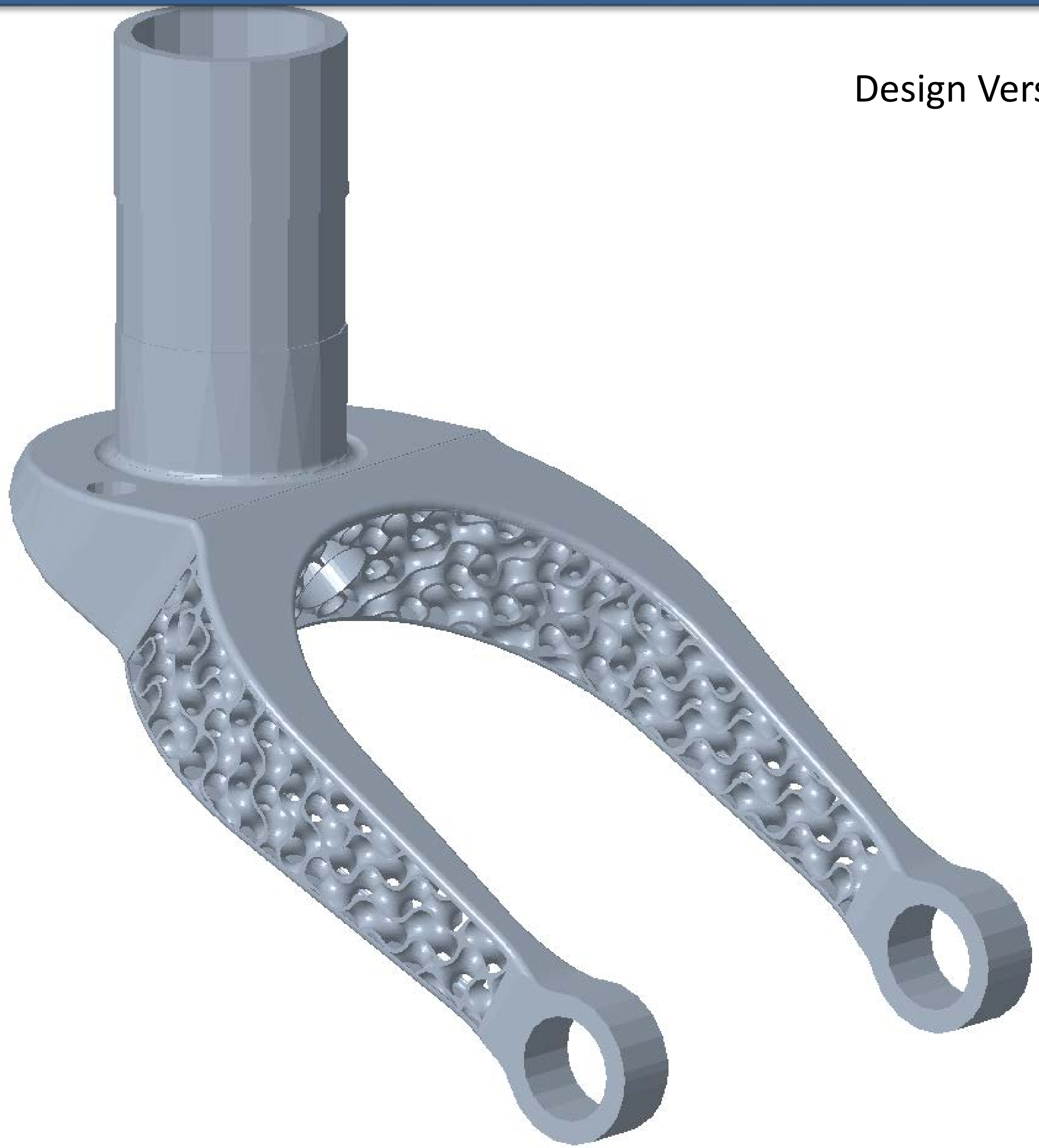
- Bio-inspired hexagonal and square honeycomb structures and lattice materials based on repeating unit cells composed of webs or trusses



Venus flower basket glass sponges Euplectella

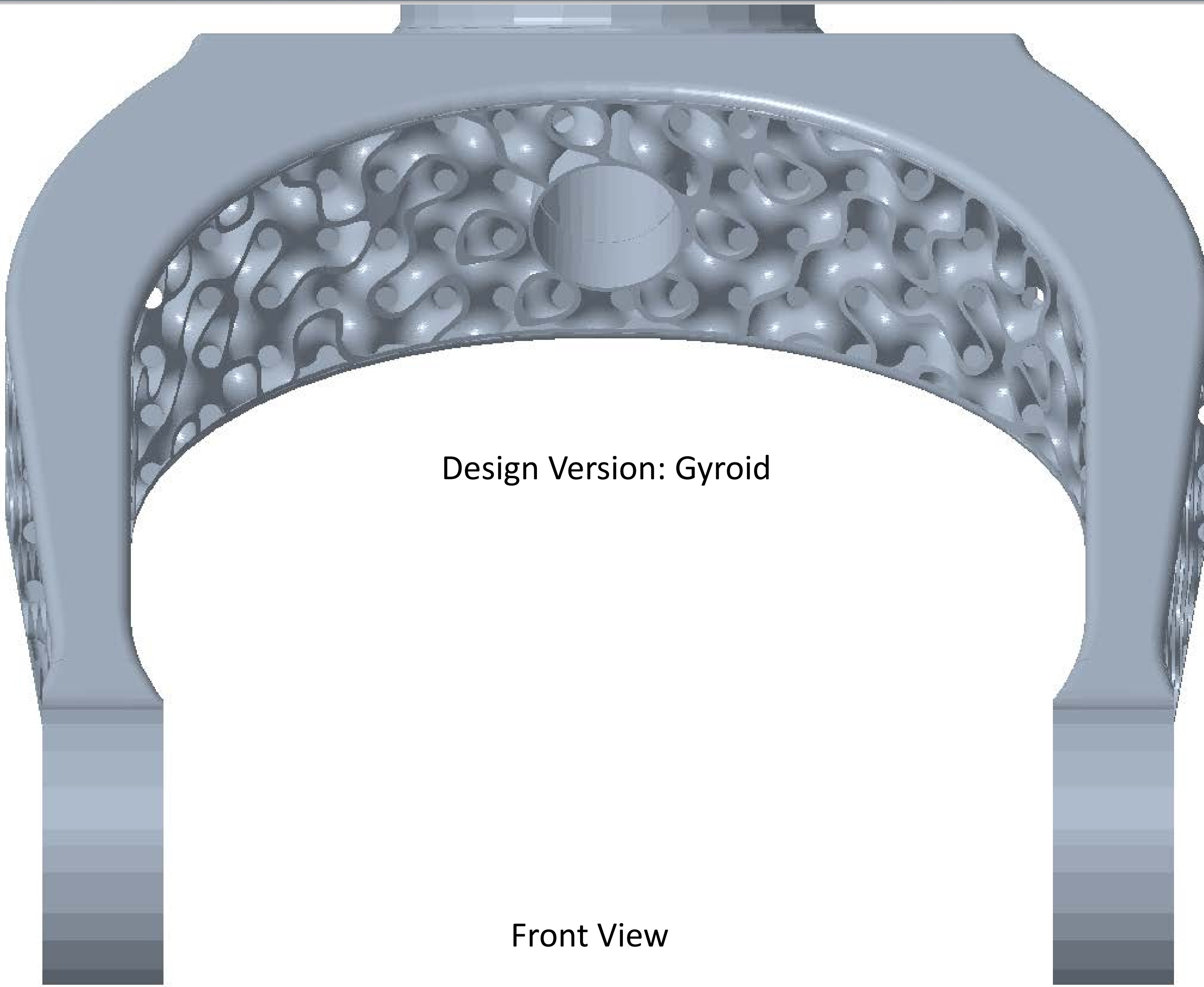
Design Option 3 with large Gyroid Lattice

Design Version: Gyroid



Isometric View

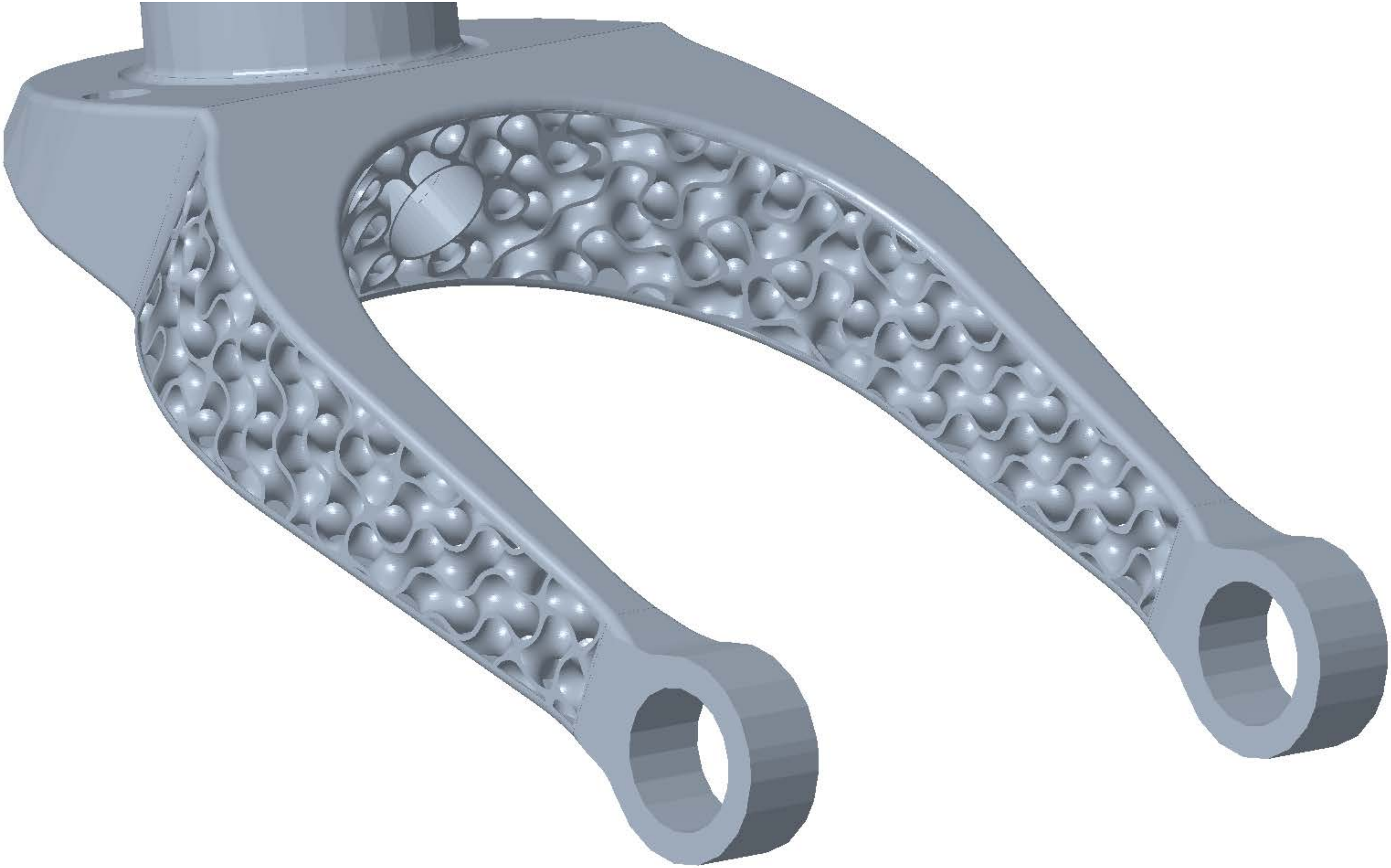
CAD Model with fine Gyroid Lattice



Design Version: Gyroid

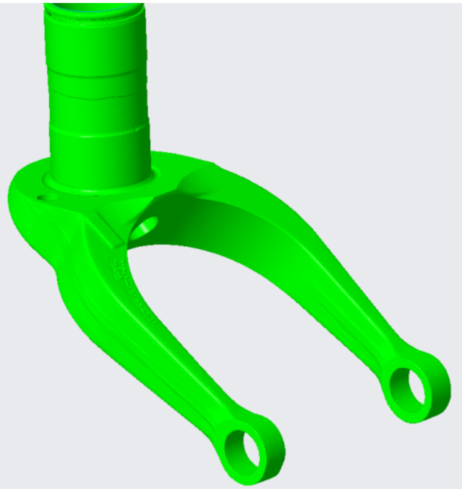
Front View

CAD Model with fine Gyroid Lattice

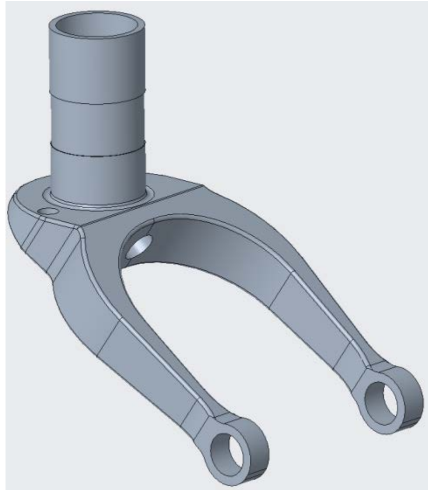


Detail View

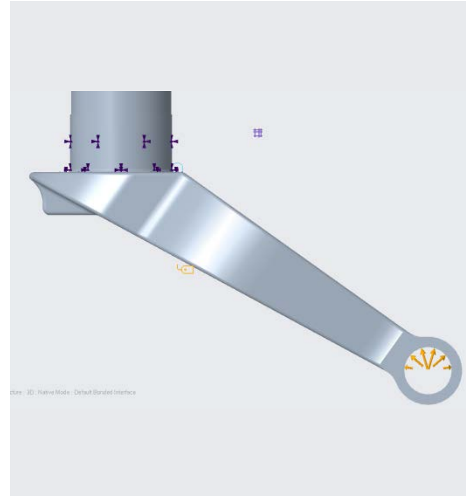
Summary Reverse Engineering Techniques that reduce weight and improve safety margins



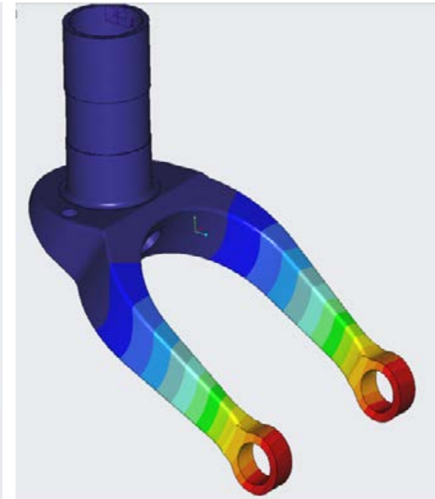
Facetted Scanned Part



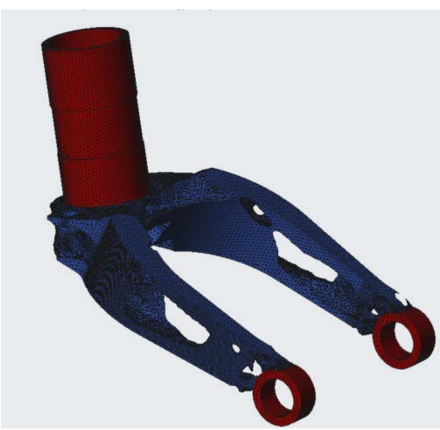
Parametric Solid Model



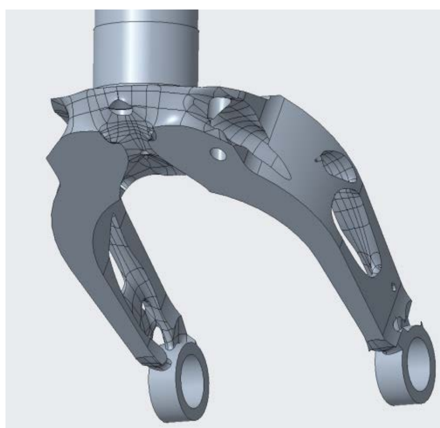
Load cases and Boundary conditions



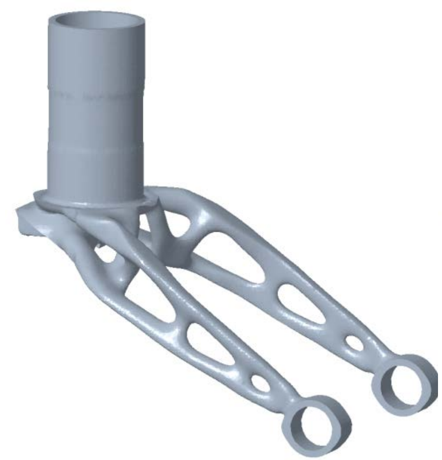
Finite Element Results for Load Estimation



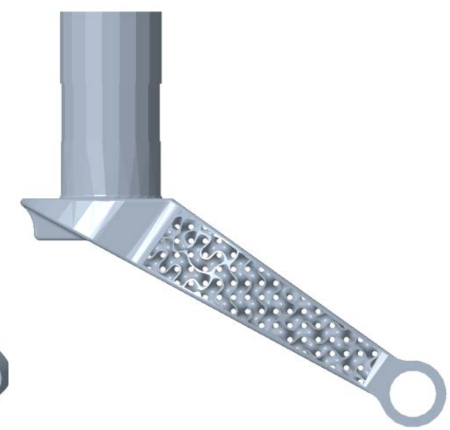
Generate optimum shape (stl part)



Generate MBD smooth surface model (Nurbs)



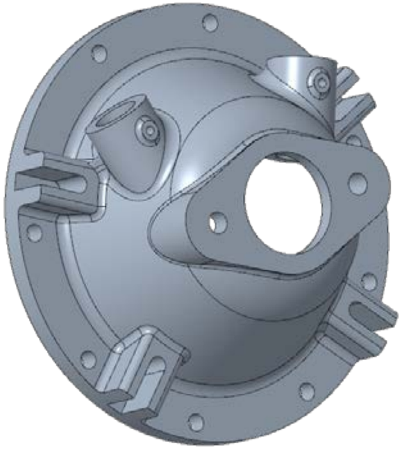
Alternative Design Option 2

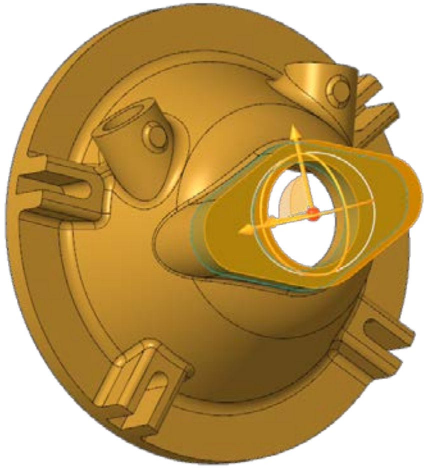


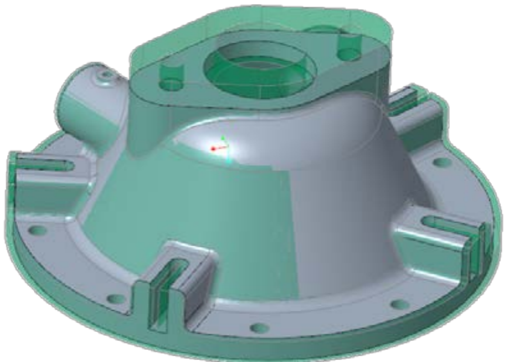
Alternative Design Option 3

Design Challenges to MBD Implementation

- Topology Optimization output is a faceted model (.stl)
- **Automatic CAD reconstruction**. This is not trivial (SC from ANSYS, Sub-D, PTC/Freestyle, Altair/Inspire, Dassault Systems 3DX, SANDIA, etc.)
- Why bother with **CAD/NURBS**?
  – Size optimization, morphing, post-processing
  – Design model, Stock model & CNC assembly
  – High quality mesh for validation step
  – In the age of MBD/MBE we need:
    - Accurate mass properties
    - Semantic GD&T
    - Automated Assembly Tolerance Analyses
    - Inspection/Verification & process definition for metrology (QIF)
    - Technical Data Package (TDP) for NASA & DOD projects

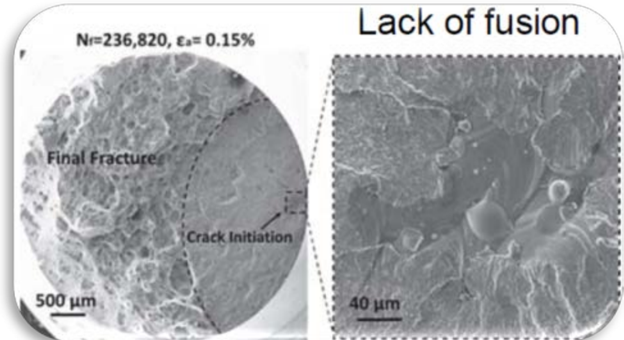




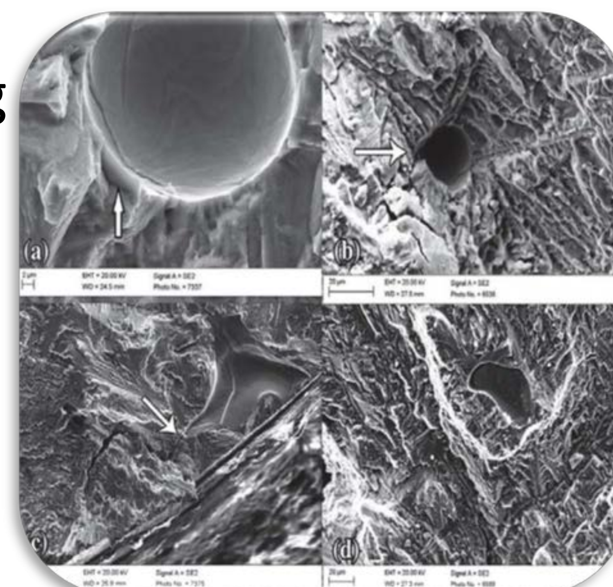


Design Challenges to AM Implementation

- Process regularly produces what would be considered **defects** in conventional processes porosity and lack of fusion. Possible root causes are:
  - Powder contamination
  - Unremoved powder
  - Rough finish on downward facing surfaces
  - Voids due to lack of fusion and distributed porosity
  - Process interruptions, spreader impacts on protruding solidified geometry



- Anisotropic & variable mechanical properties
- There are "AM design rules" that are different than conventional manufacturing design rules
- Design is not unconstrained by manufacturing There are AM limitations such as:
  - Min/Max Wall Thicknesses
  - Complexity
  - Wall Pitch, Fillet Radii
  - "Overhangs", "Ceilings"
  - Support Structures
  - Powder Removal



PMI Information for Additive Manufacturing

- Material Specification (Alloy composition, Powder diameter, Powder compaction, Service trace elements)
- Printer & Print Orientation
- Manufacturing process settings (Power, Speed, Layer thickness, hatch spacing, Spot size, Bed & Powder Temperature, etc.)
- Post Processing requirements
  - Strain Relief
  - Support Removal
  - Sanding / grit blasting
  - Painting / coating
  - Heat Treatment
  - Hot Isostatic Press (HIP) cycle
- Surface Finish
- Machined Features (Design & Stock Models)
- Inspection Dimensions
  - Datums
  - Inspection points for acceptable warping/distortion
  - Inspection Plan