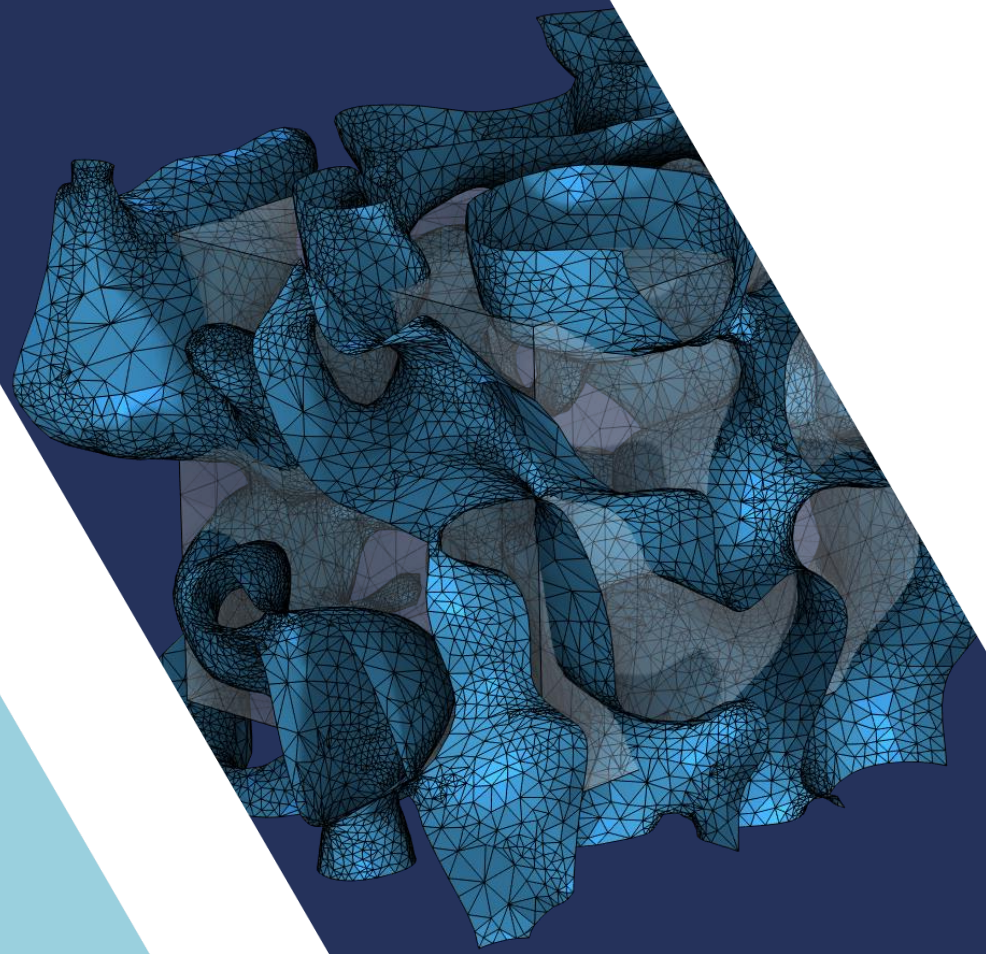

Import and Editing of Segmented Geometries in COMSOL Multiphysics

Matouš Lorenc
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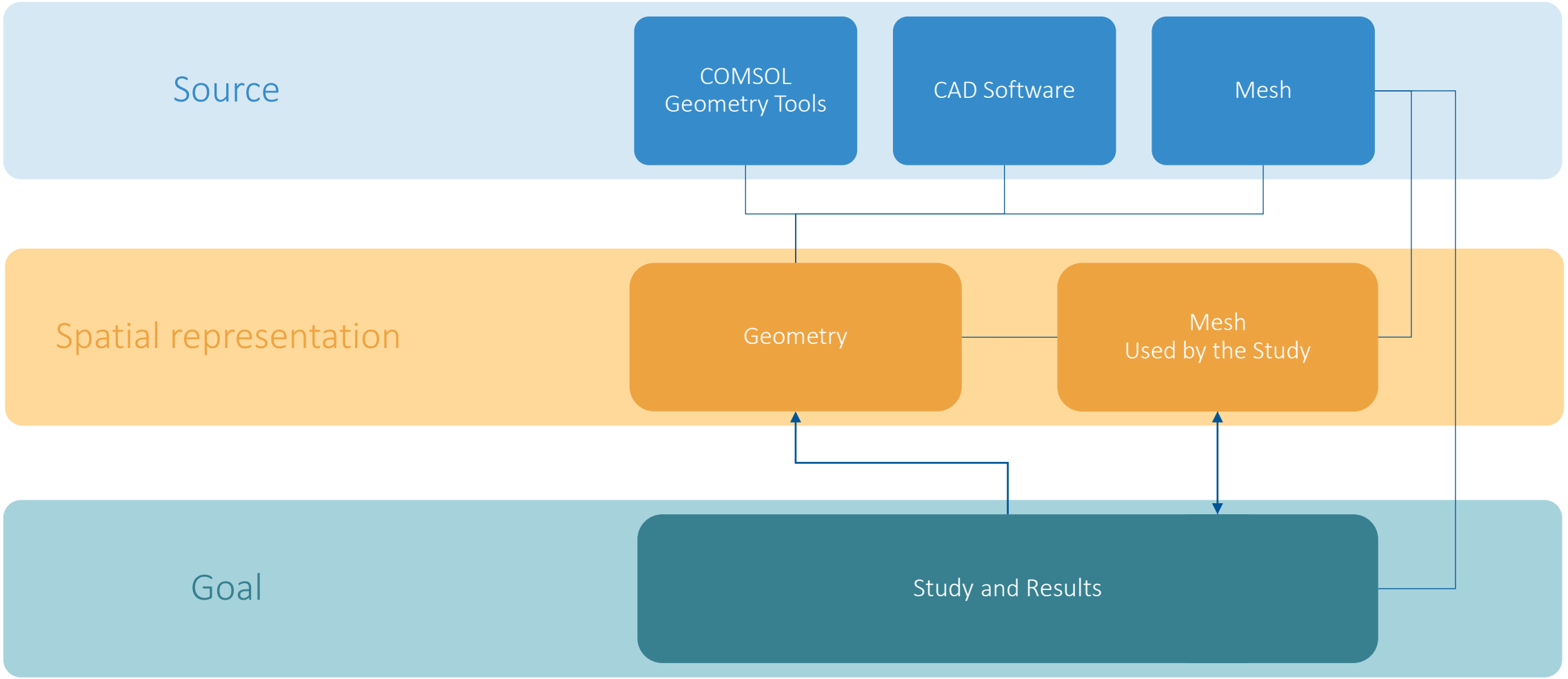
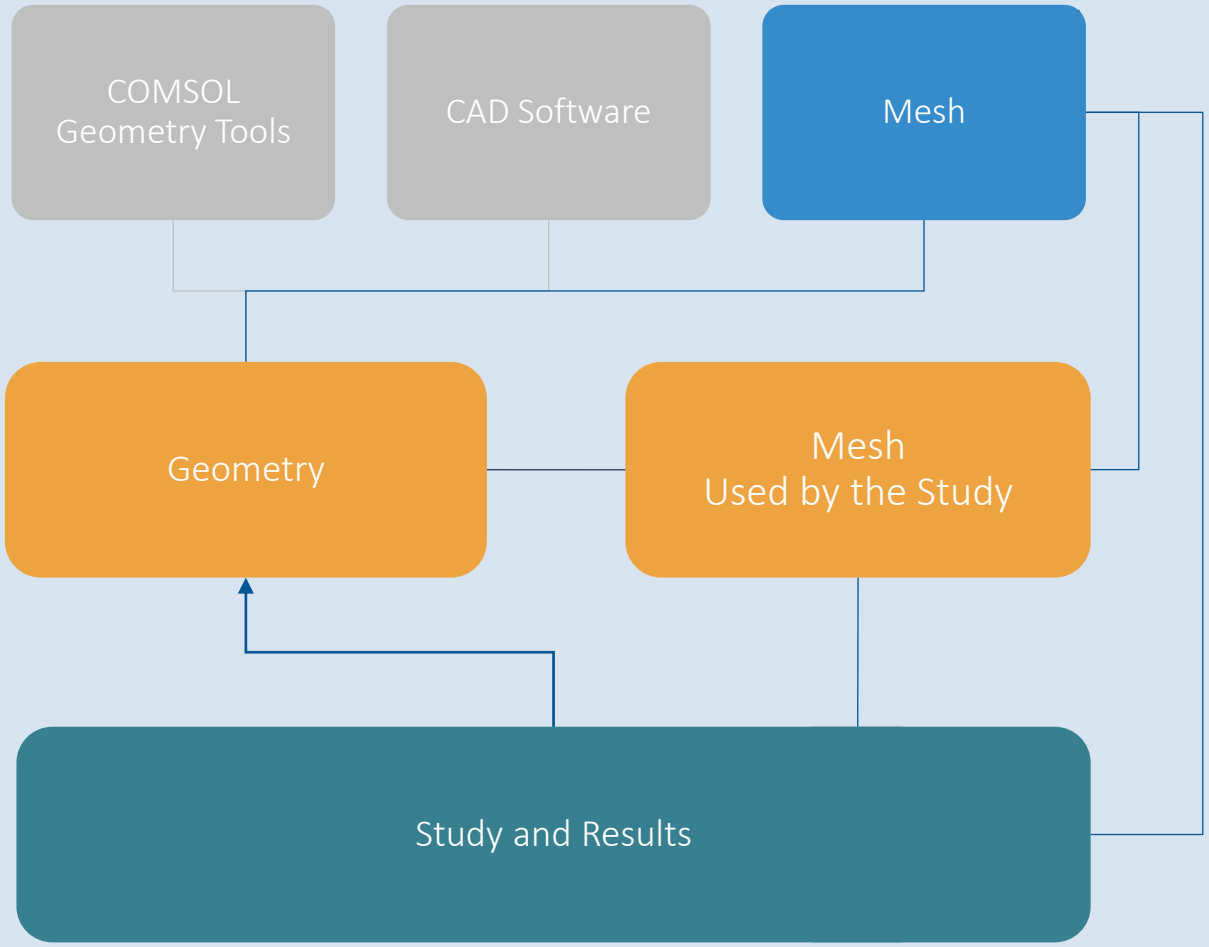
The Big Picture



Working With Meshes

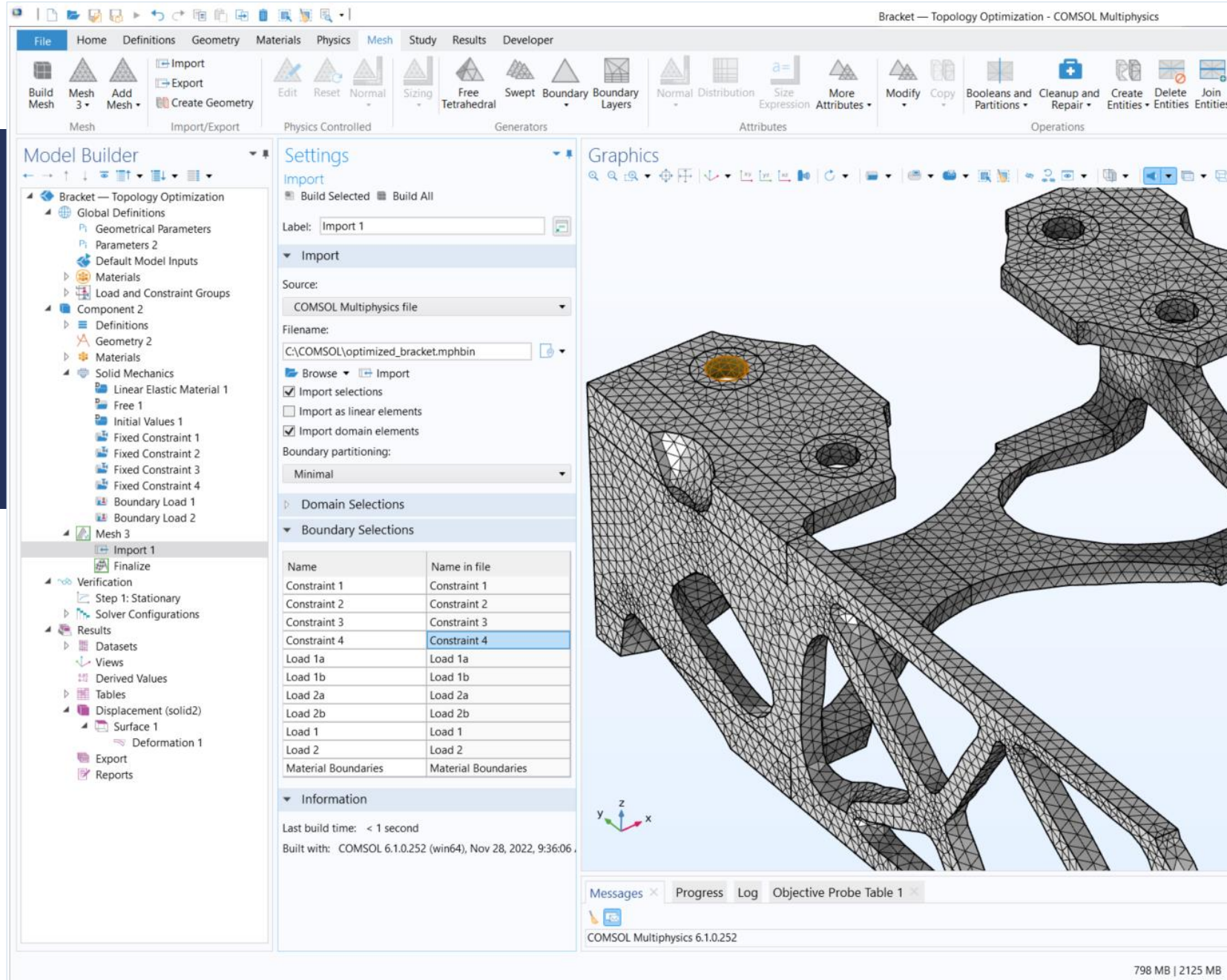
- Meshing Concepts
- Preparing the Geometry
- Meshing the Geometry
- Generating Meshes
- Mesh During Solving
- Editing Meshes

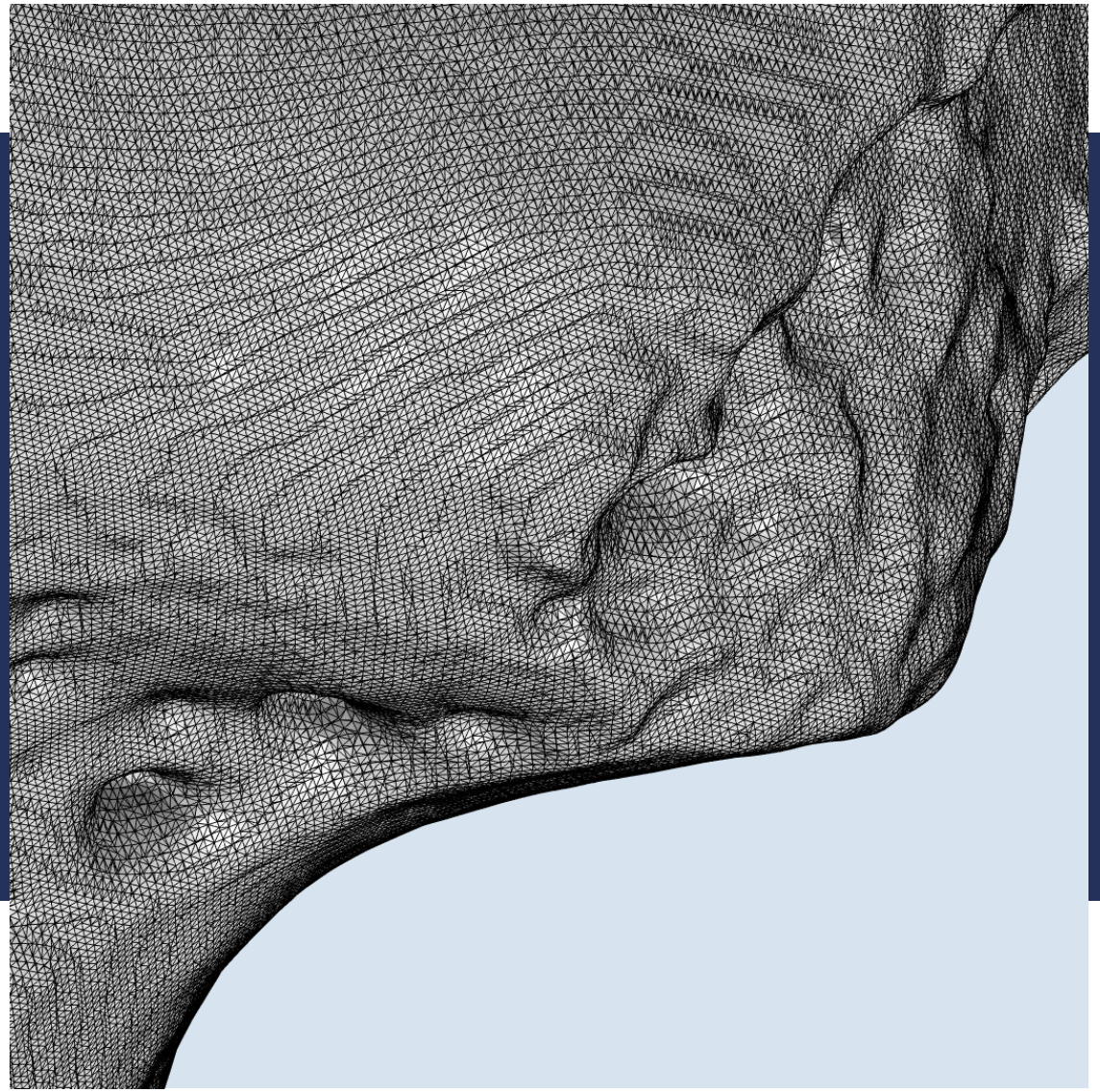


The COMSOL® Mesh Format

The native file format supports grouping elements into selections and gives full control over how the elements form domains and boundaries.

For more information, see the COMSOL Multiphysics Mesh Import and Export Guide.





STL, PLY, and 3MF Import

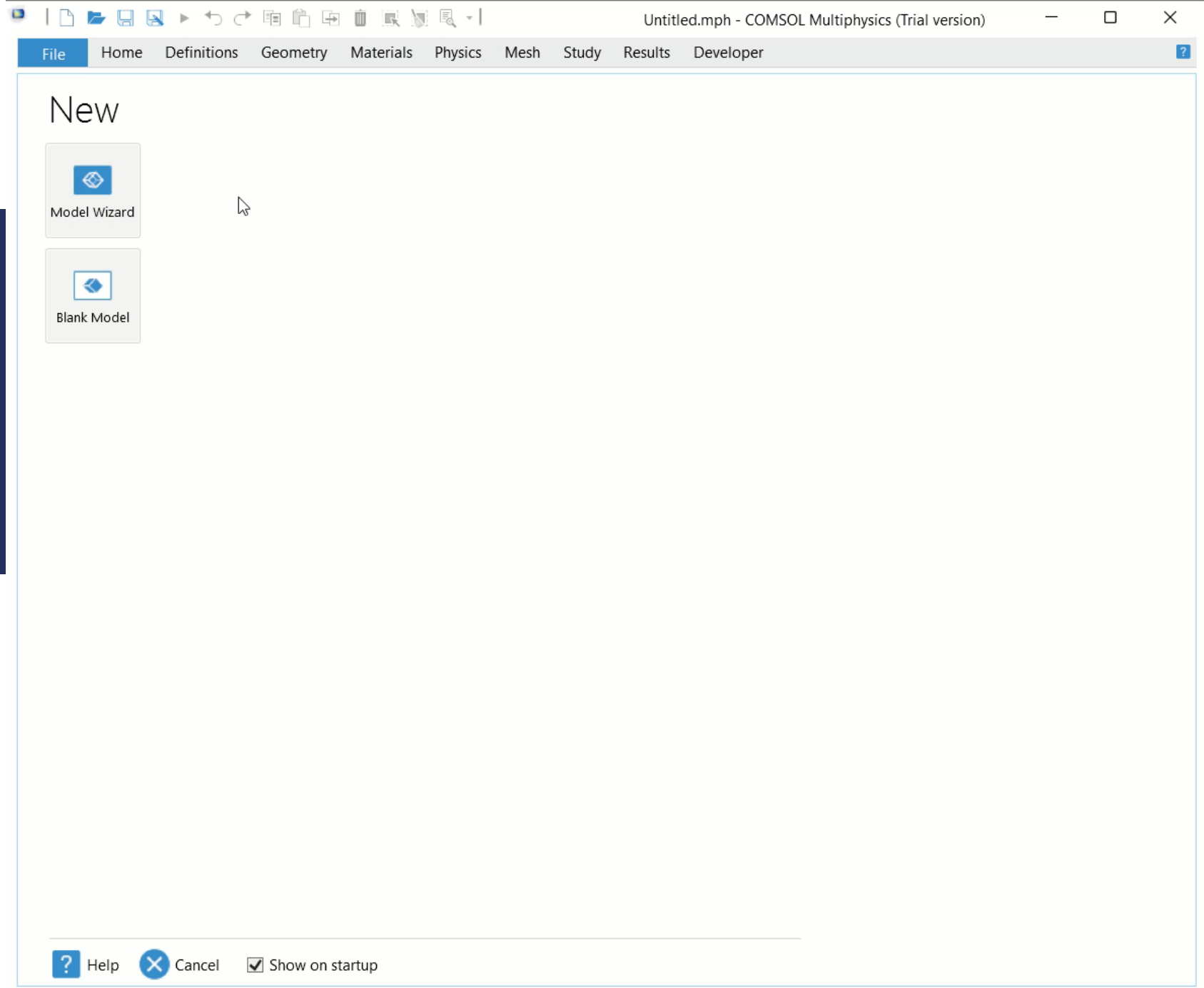
Import surface meshes of scanned data to use for simulations. The triangles in the file define a linear mesh, but the software will automatically curve the elements when needed.

DEMO: Lungs Import

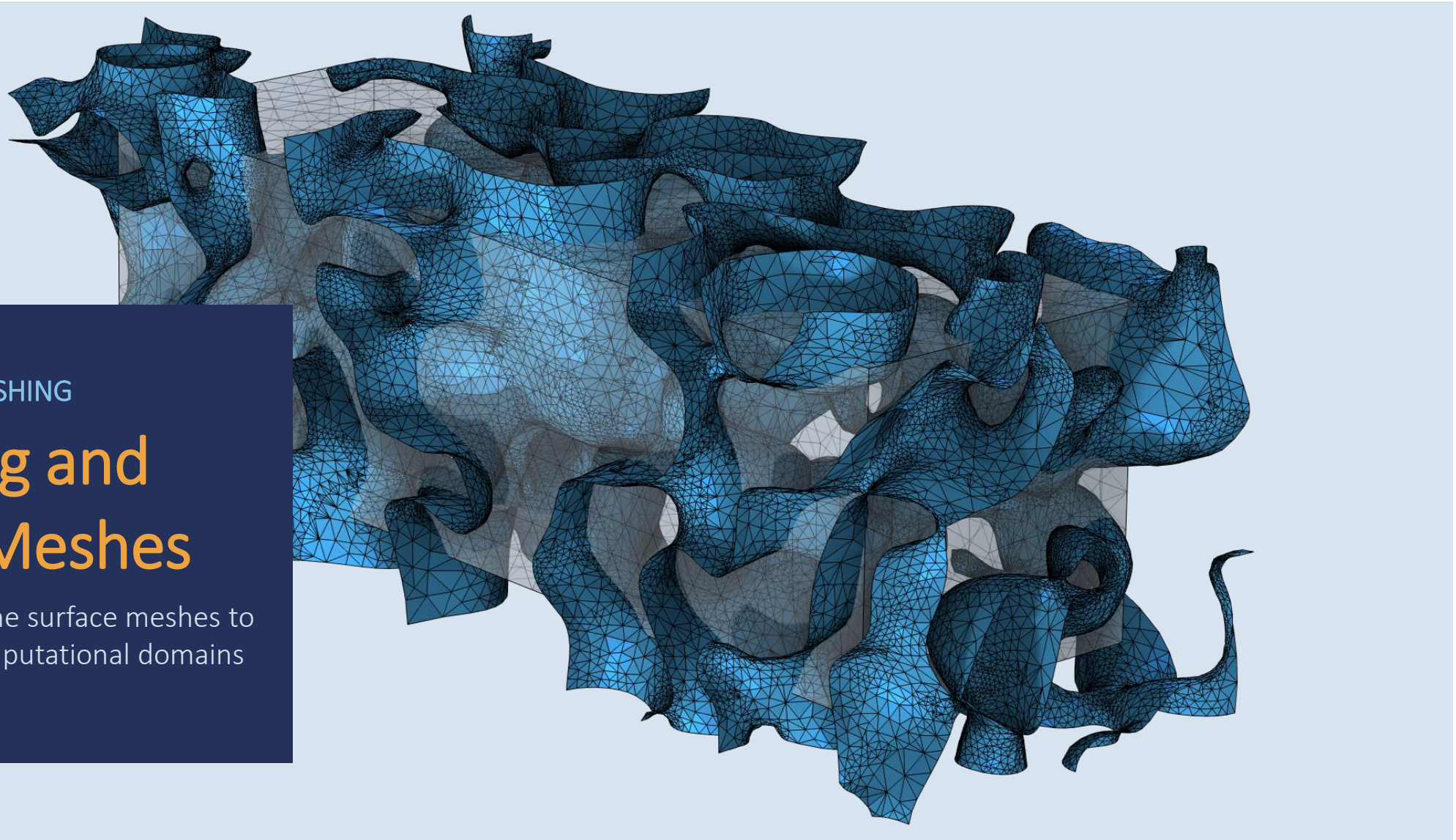
- Segmented geometry of lungs generated by Medical Imaging Toolbox in MATLAB and stored as STL file
- Remeshing and repair of imported mesh
- Combining imported mesh with local geometry
- Visualization and statistic methods

Lungs Import: Importing STL

- Minimization of imported boundaries improves the imported mesh quality
- Visible effect of segmentation to be further smoothed out



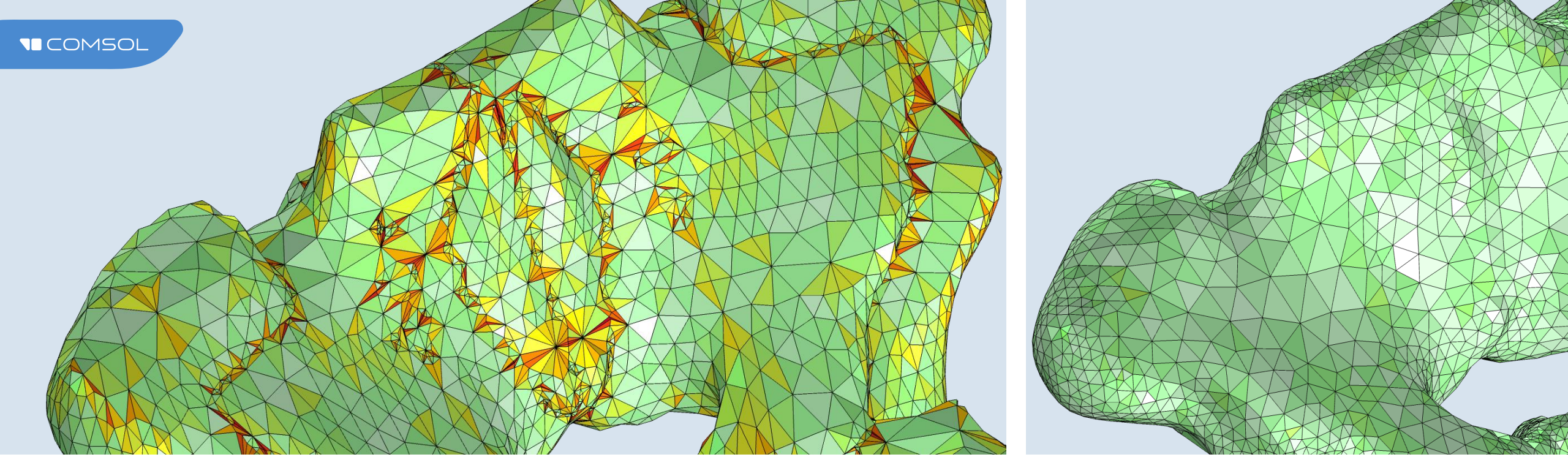
COMSOL



OVERVIEW OF MESHING

Repairing and Editing Meshes

Repair and combine surface meshes to generate new computational domains for simulations.



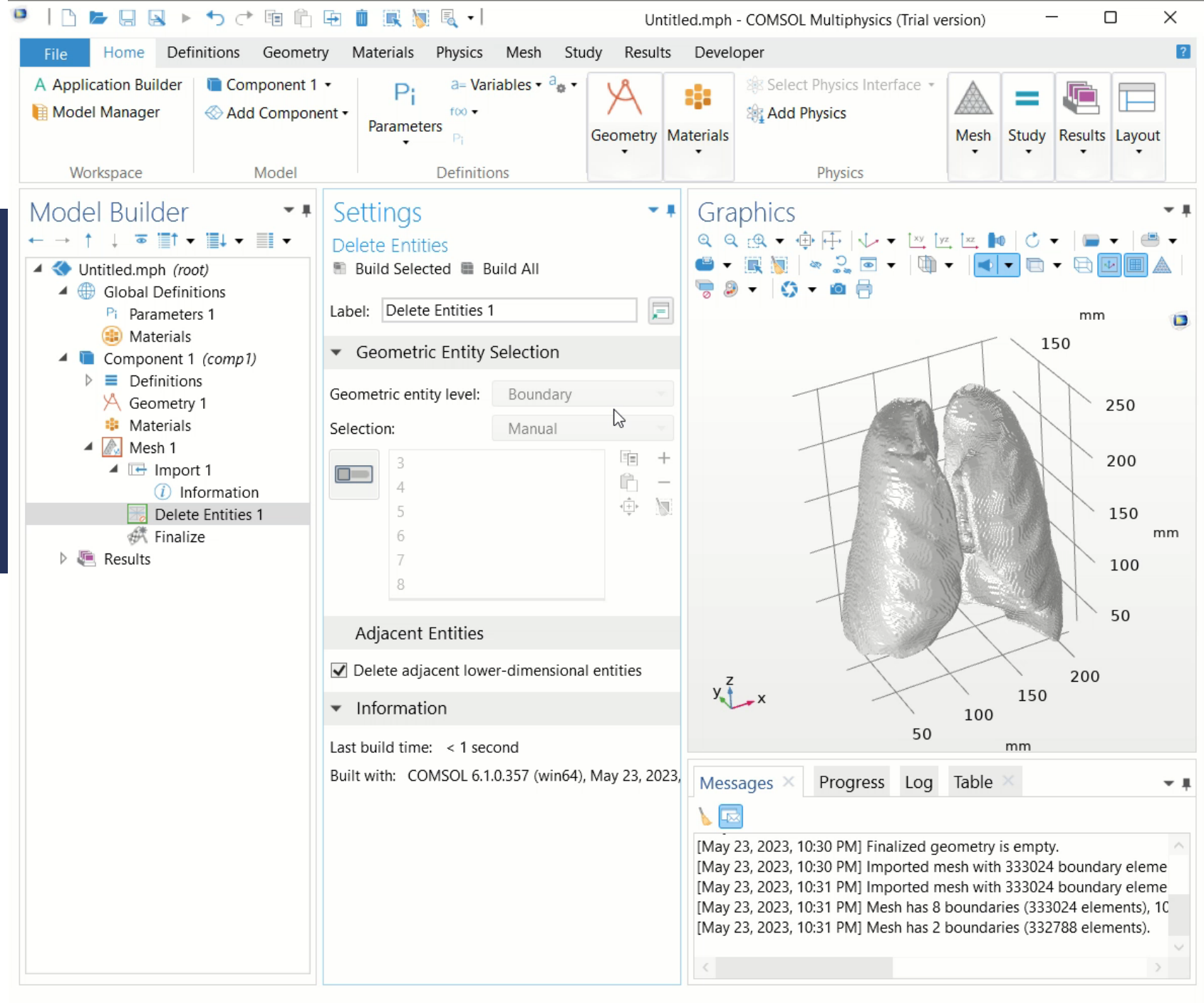
Modifying Imported Meshes

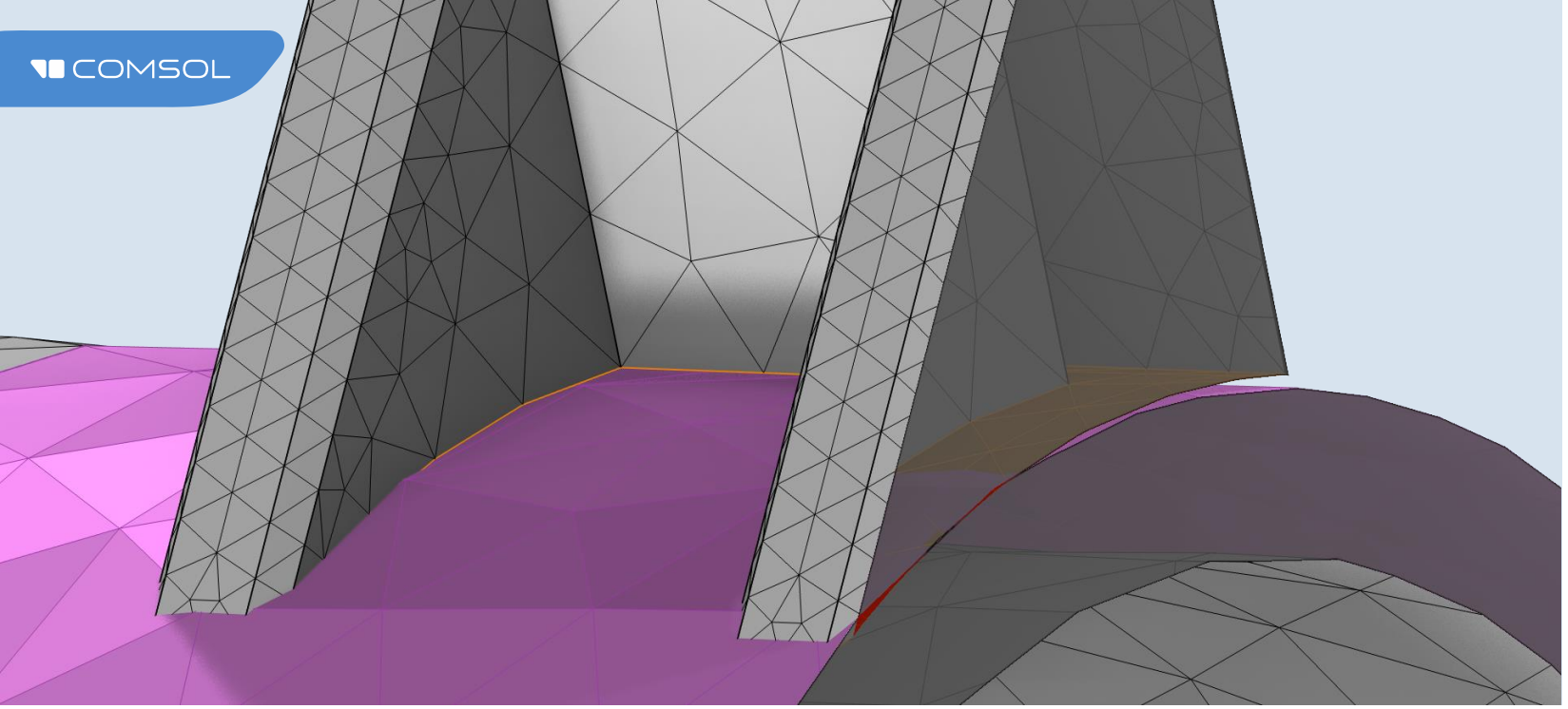
- Generate new mesh or modify the surface mesh to improve quality and control the element size.
- Watertight regions in surface meshes can be filled with tetrahedral, swept, and boundary layer mesh.

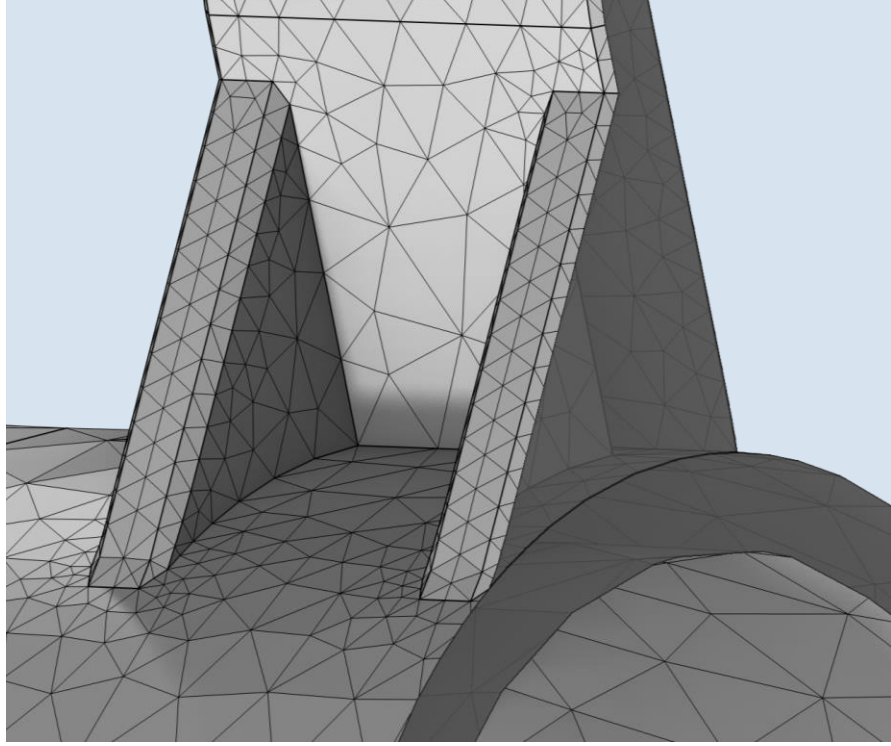
The STL geometry is provided courtesy of Mark Yeoman, Continuum Blue, U.K.

Lungs Import: Remeshing Surface Mesh

- Remeshing surface mesh with *Free Triangular* operation with minimal size value identical to the segmentation value – 0.5 cm

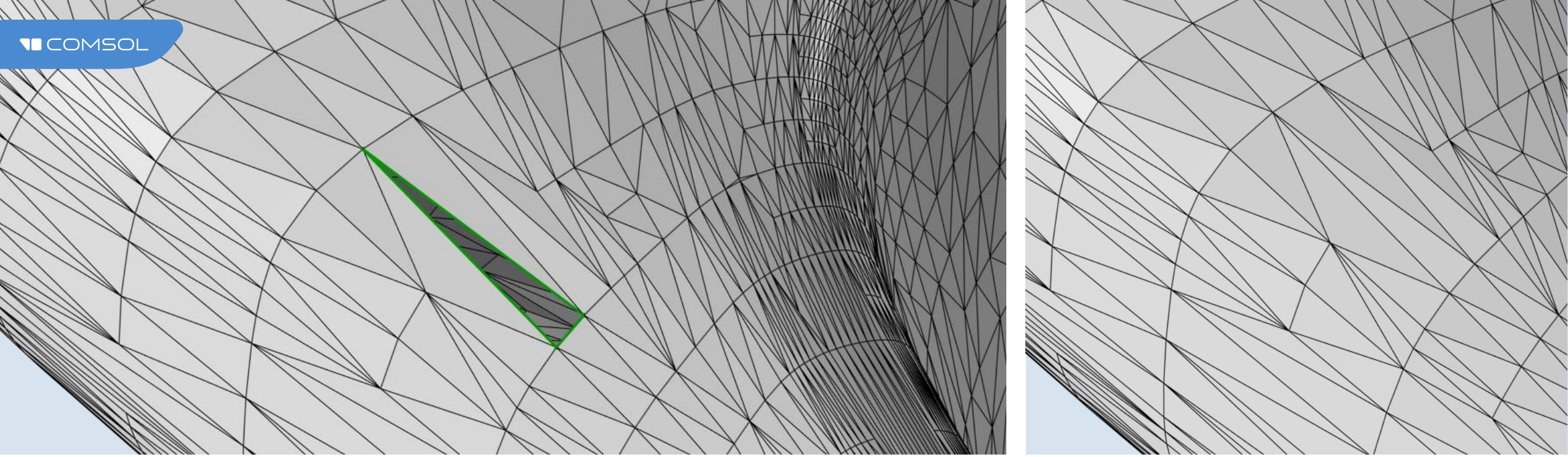






Repairing Small Overlaps and Gaps

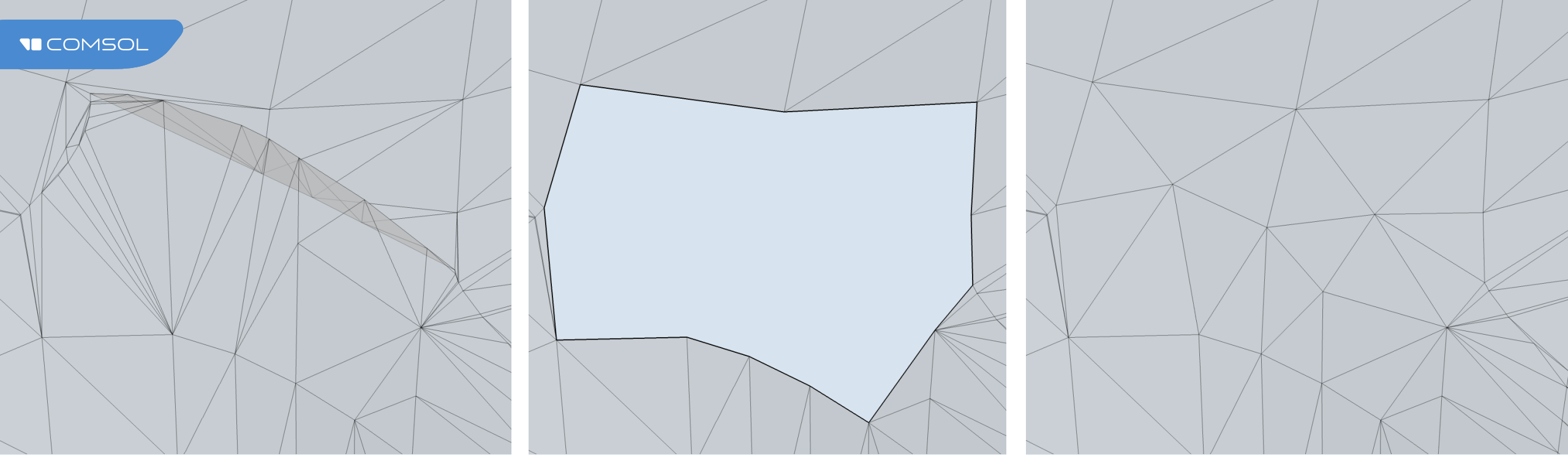
- Use to repair imported surface meshes or as an alternative to geometry repair for misaligned CAD models
- Merge of nearby faces, edges, or vertices in meshes for easier meshing



Repairing Holes

- Automatic repair of small holes during mesh import
- Use the *Fill Holes* operation to automatically repair holes based on hole perimeters
- Use *Create Faces* to generate meshed faces after manually selecting hole edges

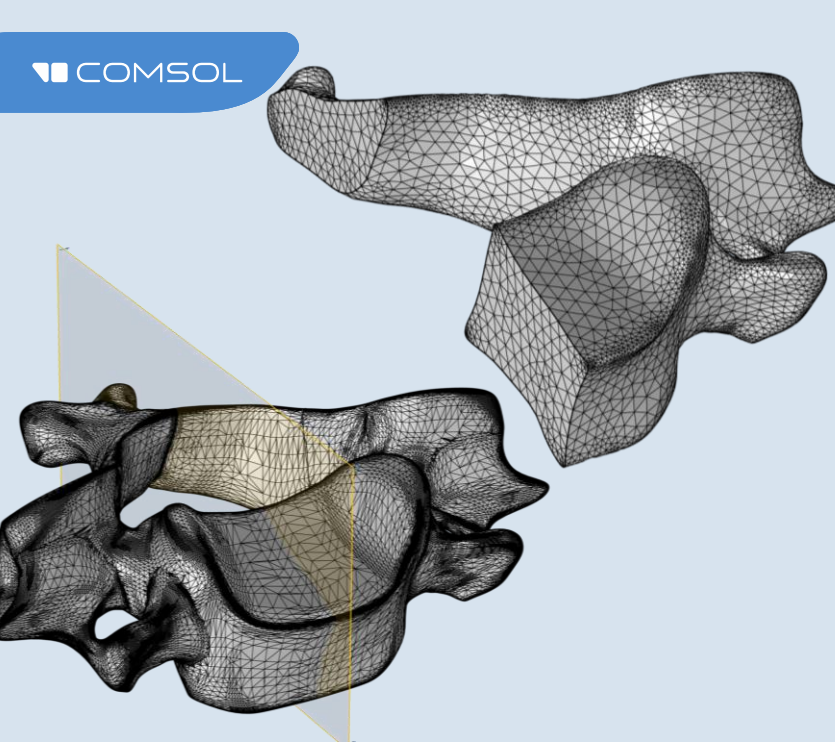
The STL geometry is provided courtesy of Mark Yeoman, Continuum Blue, U.K.

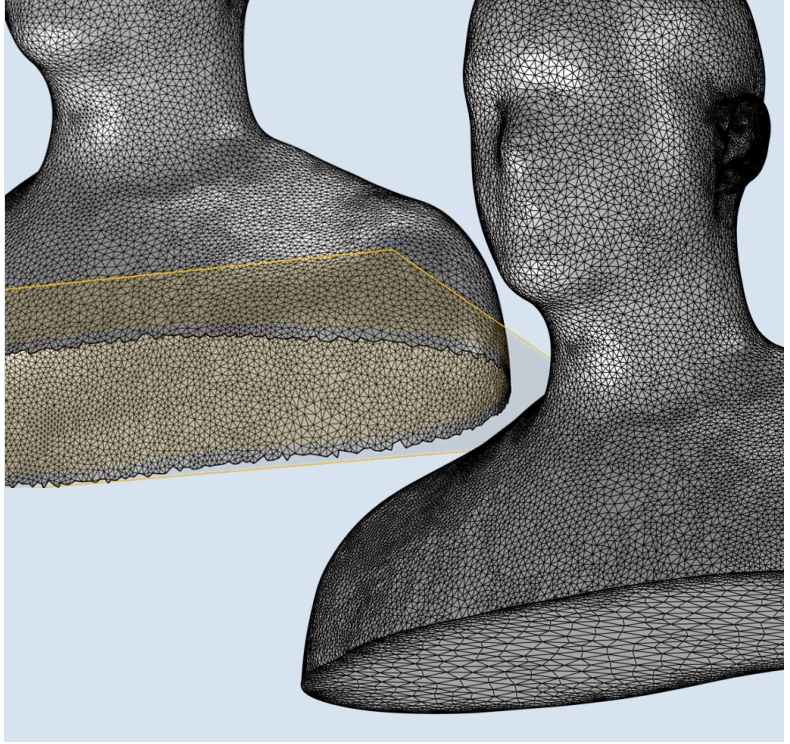


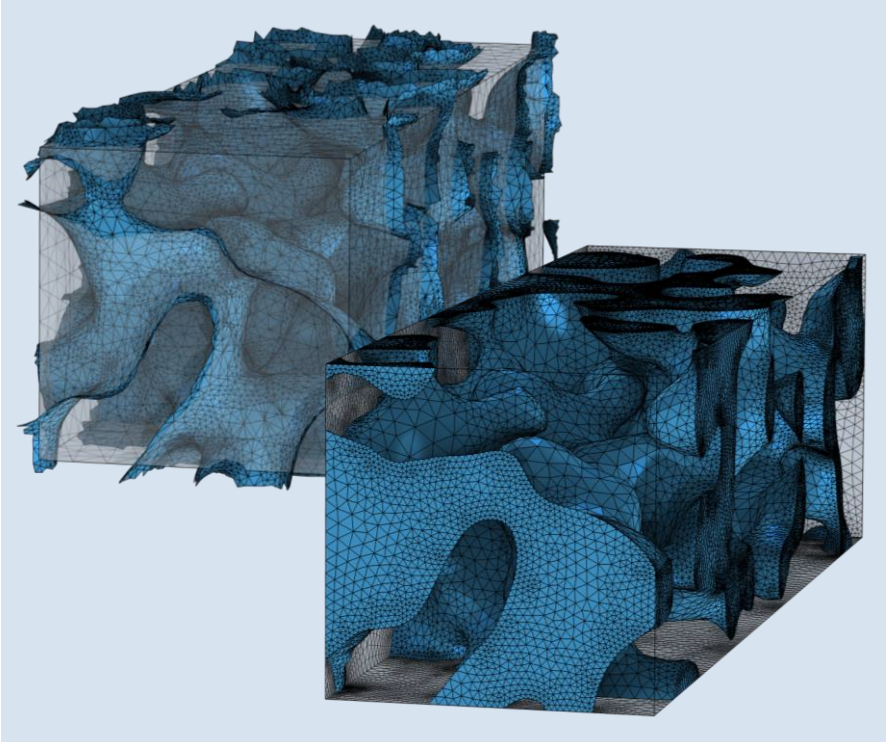
Removing Sharp Irregularities

- Automatic removal of smaller irregularities when:
  - Creating geometry from mesh
  - Remeshing faces
- Manually isolate irregularities and replace with new meshed faces

The STL geometry is provided courtesy of Mark Yeoman, Continuum Blue, U.K.







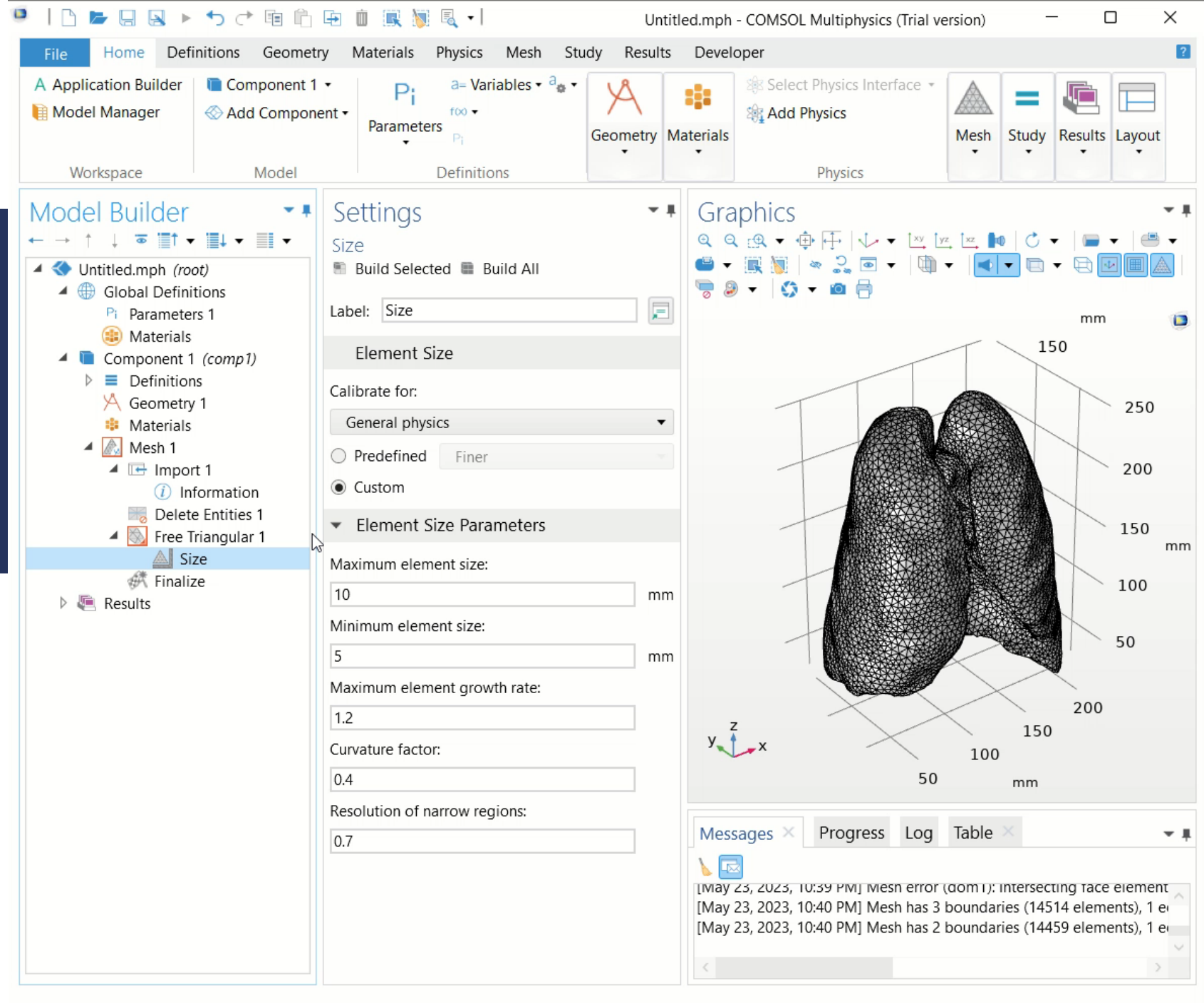
Creating Domains from Surface Meshes

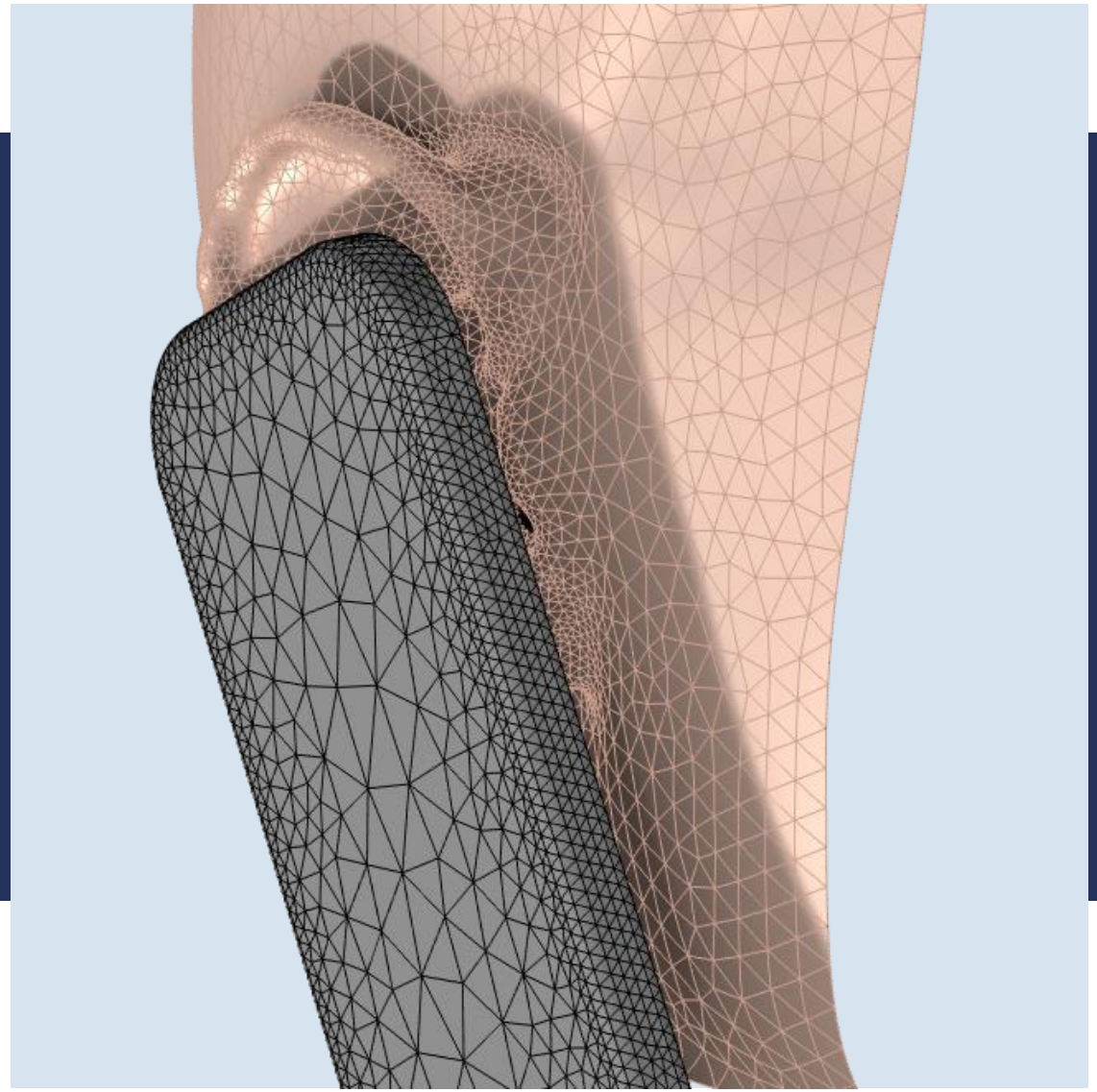
- Unite meshes to form new computational domains
  - Automatic cleanup of small elements
- Intersect meshes with a plane (3D) or straight line (2D)
  - Intersection faces created within edge loops

The STL geometry on the left is provided courtesy of Mark Yeoman, Continuum Blue, U.K.

Lungs Import: Repairing Imported Mesh

- Surface mesh needs to be repaired to create volume
- Faulty elements can cut out and replaced by new mesh
- Only now domains can be formed





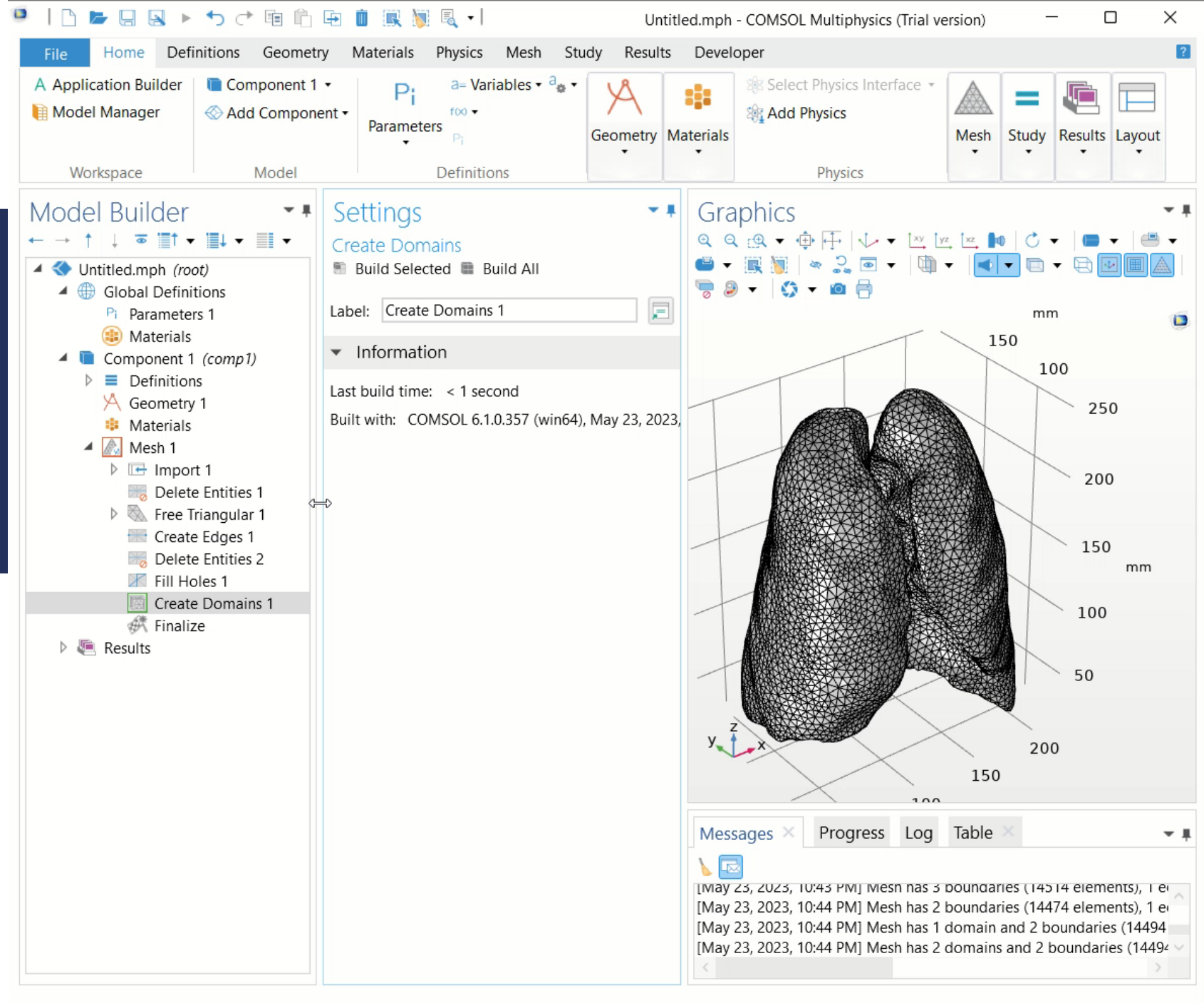
Combining Imported Meshes with CAD

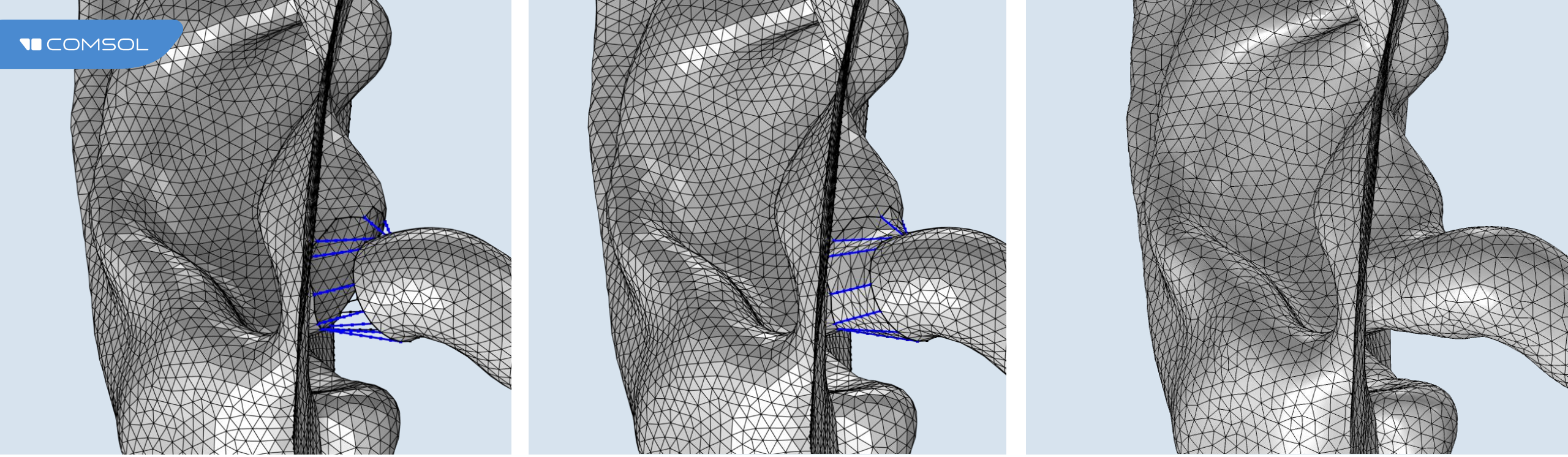
The geometry of a cellphone is united with the scanned data of an ear.

The geometry can be created in COMSOL Multiphysics® or imported from CAD files and then be combined with the imported mesh.

Lungs Import: Joining with Geometry

- Object created under *Geometry* node handled by an imported mesh node
- Each object still has its own mesh unaffected by the other



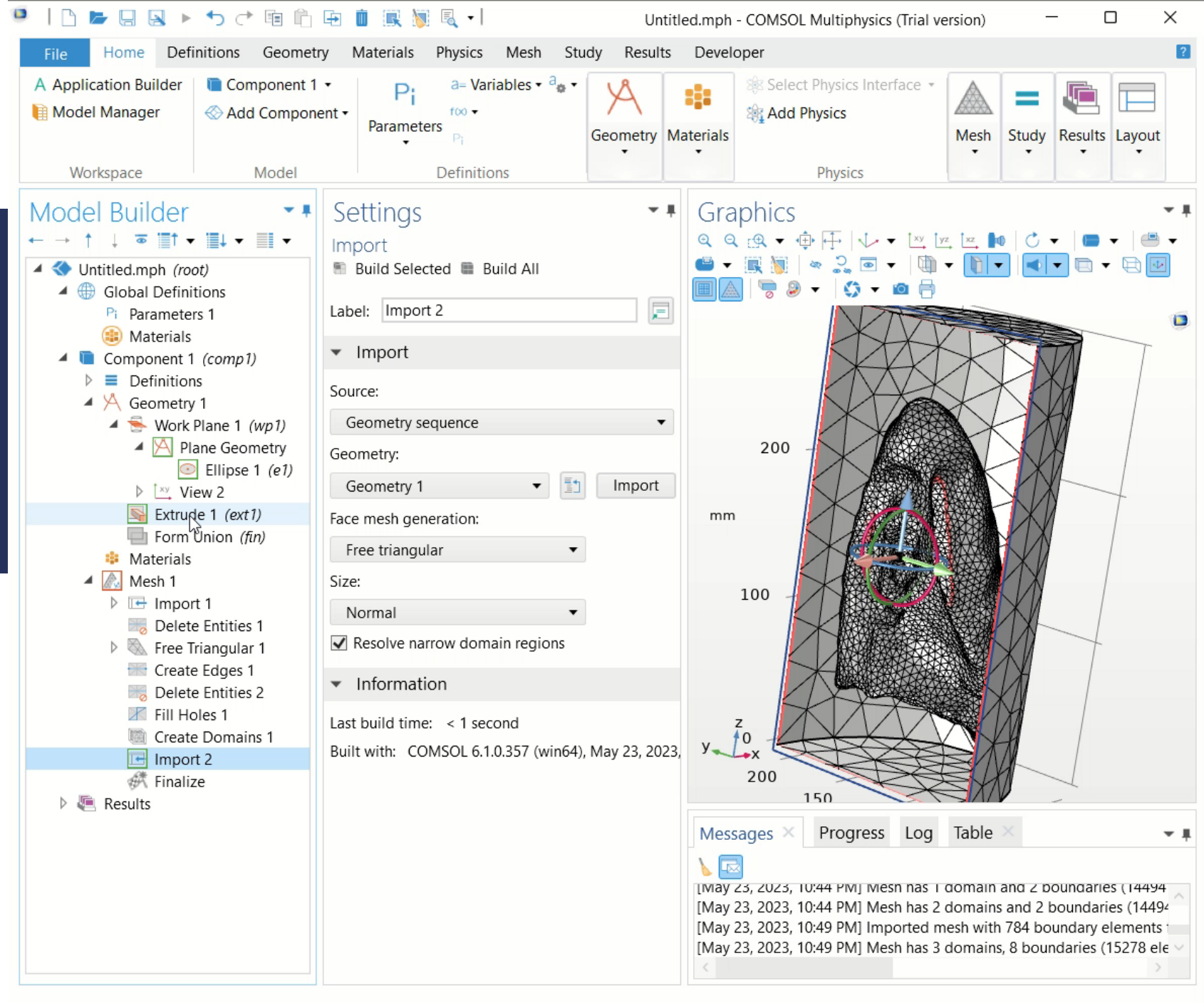


Connecting Meshes

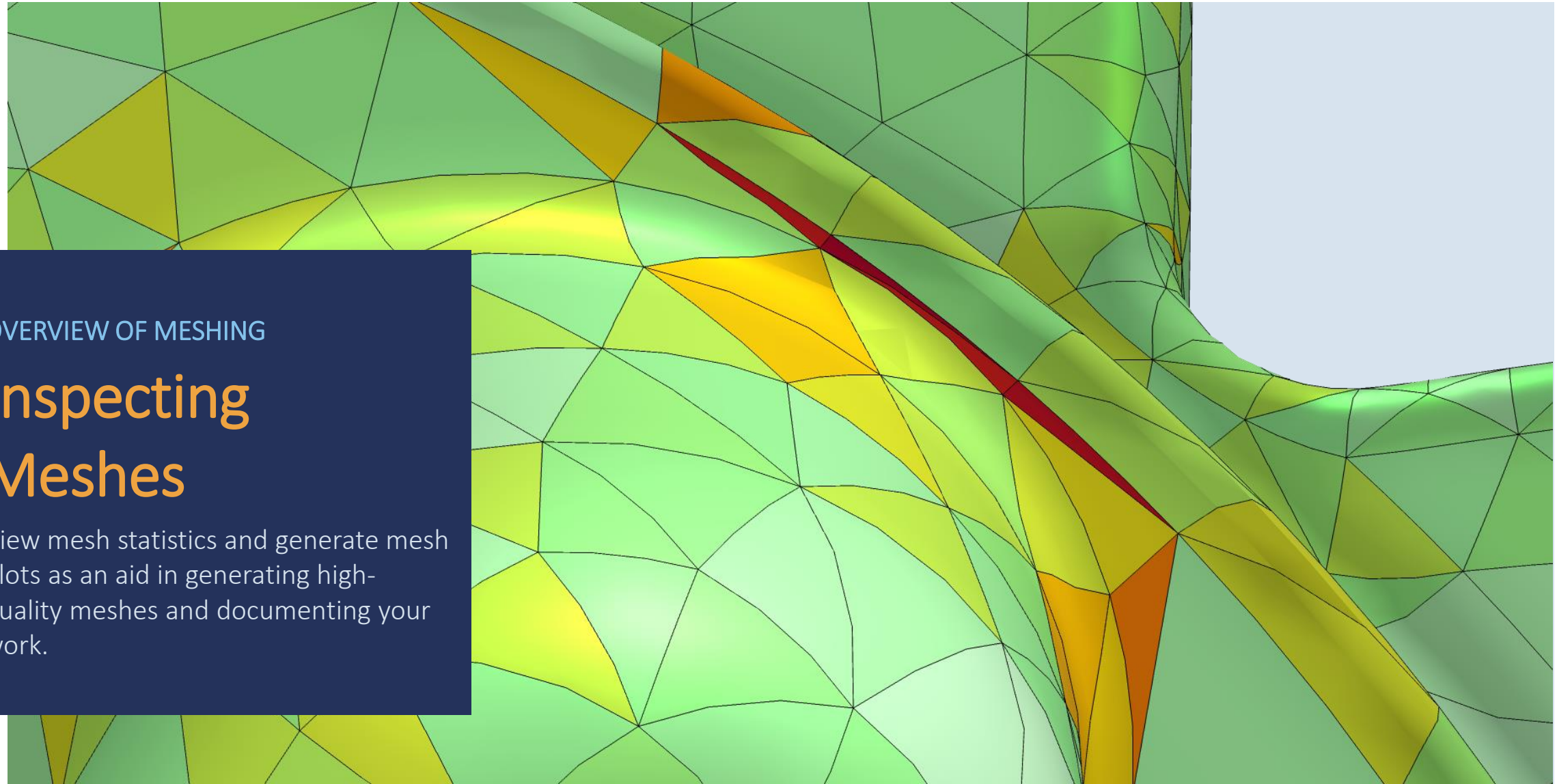
Bridge gaps between meshes by creating meshed edges and faces, and then generate new mesh to improve the mesh quality.

Lungs Import: Mesh Finalization

- *Union* operation unifies the mesh of the geometry object together with the lungs and creates one continuous mesh
- Operation Finalize checks the mesh compliance with FEM requirements



COMSOL



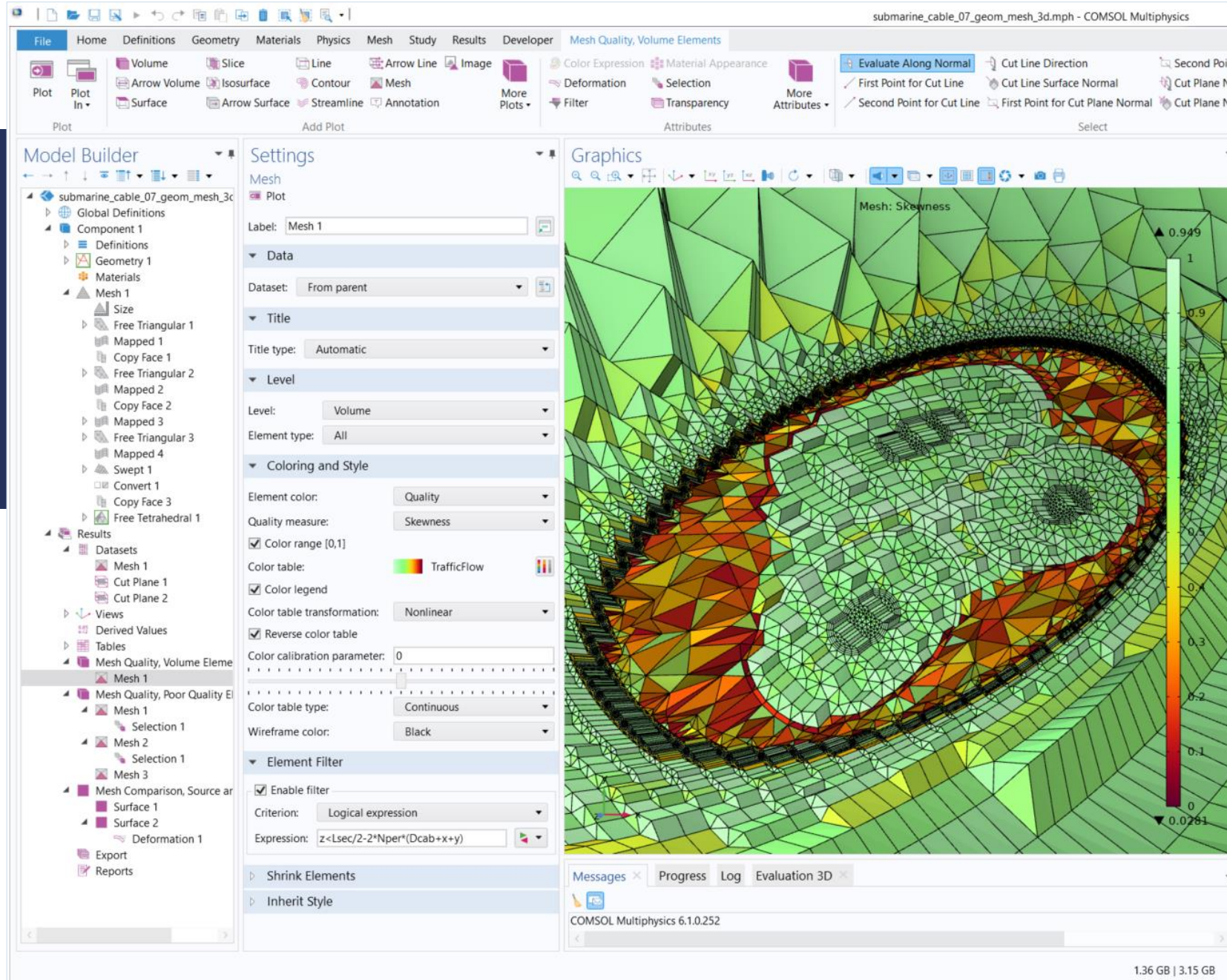
OVERVIEW OF MESHING

Inspecting Meshes

View mesh statistics and generate mesh plots as an aid in generating high-quality meshes and documenting your work.

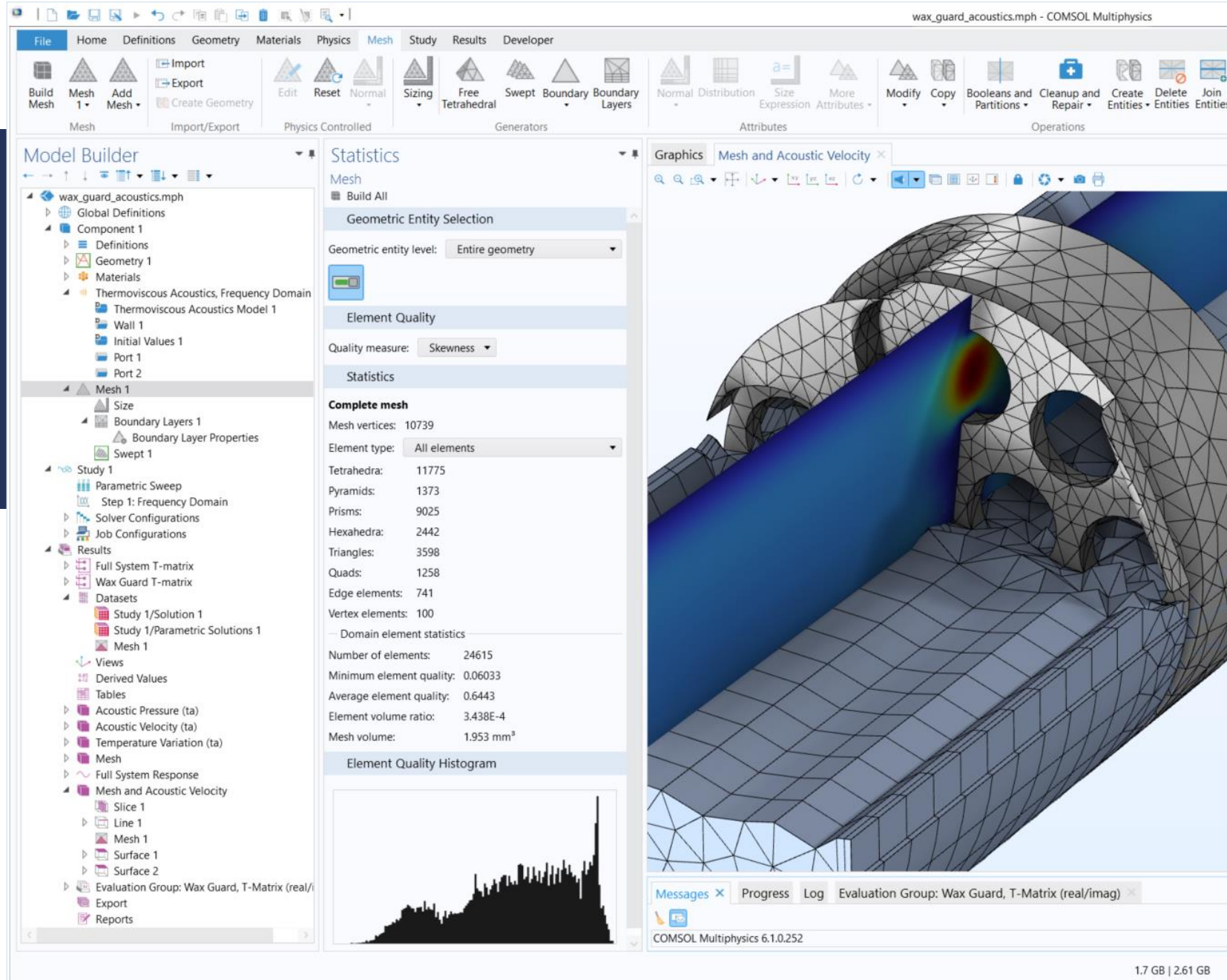
Plotting the Mesh

Create high-quality meshes by detecting low-quality elements and making appropriate adjustments.



Mesh Statistics

View the element quality histogram and other statistics, such as the minimum and average element quality.



Lungs Import: Mesh Visualization and Statistics

- Creating *Mesh Plot* to check for elements quality and visualization
- Statistical evaluation of Mesh to quantify the overall mesh quality