

Surface Preparation: Flagging Boundaries and Repairing Defects



CONVERGE
CFD SOFTWARE

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CONVERGE Studio Workflow

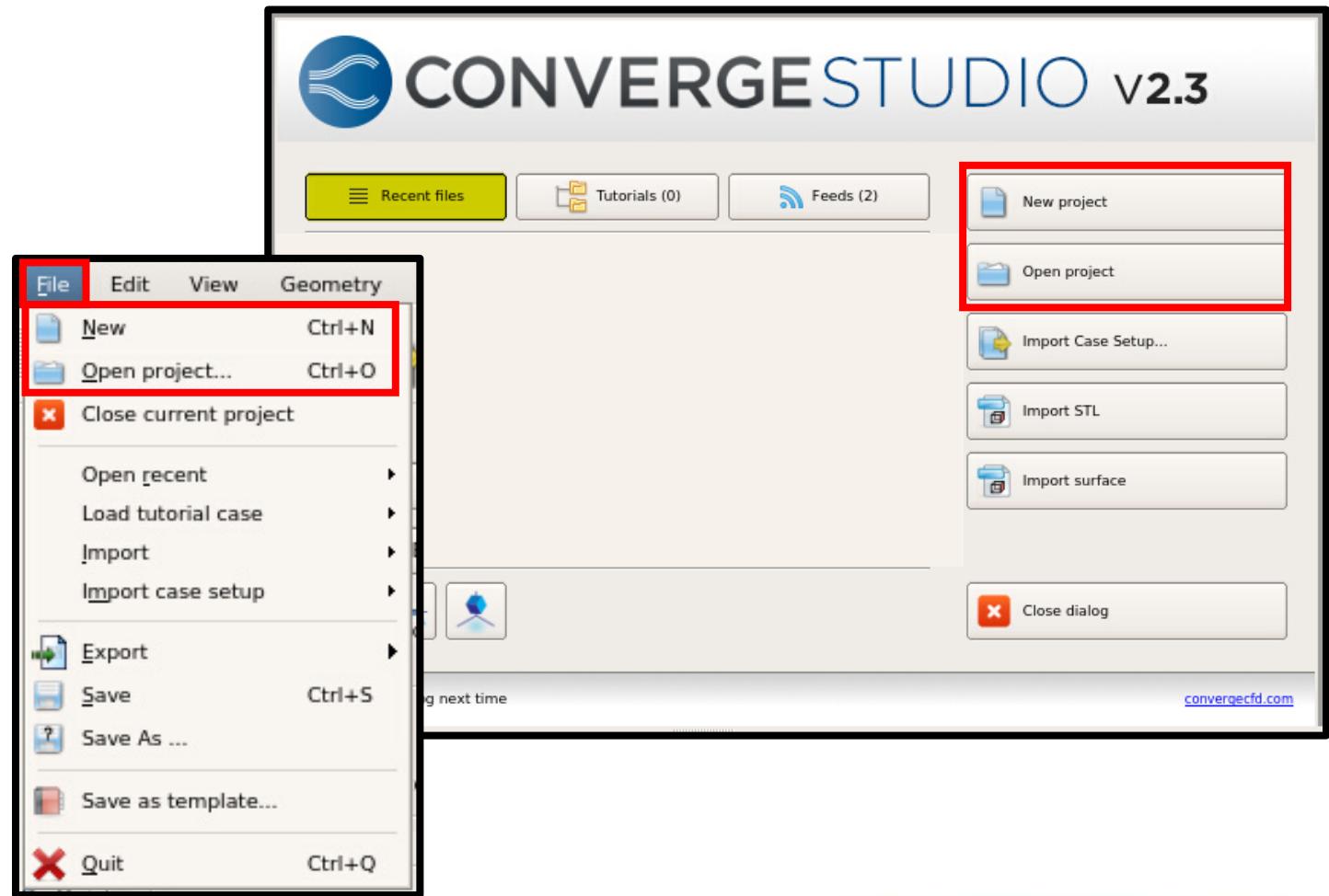
- ***Case Setup* module**
 - **Begin a project**
 - Import the surface geometry
 - Prepare the surface
 - Flag triangles to boundaries
 - Translate, rotate, and scale geometry
 - Find and repair surface defects
 - Save project (*.cvg) and export *surface.dat*
 - Configure case setup
 - Export input and data files to the Case Directory

-----Run CONVERGE simulation-----

- *Line Plotting* module
- *Post-Processing 3D* module

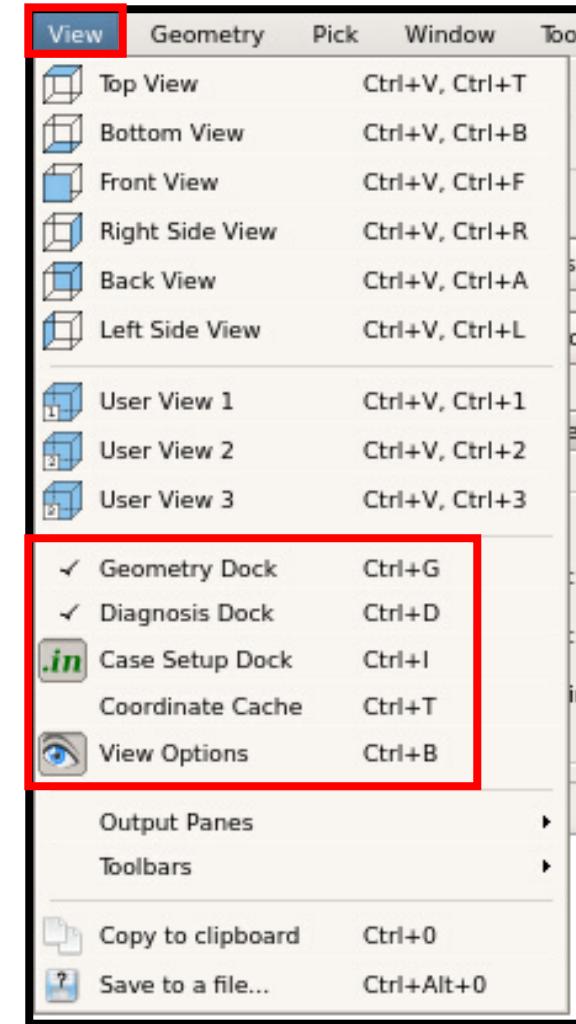
Begin a Project

- Open a new project or an existing *.cvg project
 - *Welcome* dialog box
 - *File* menu



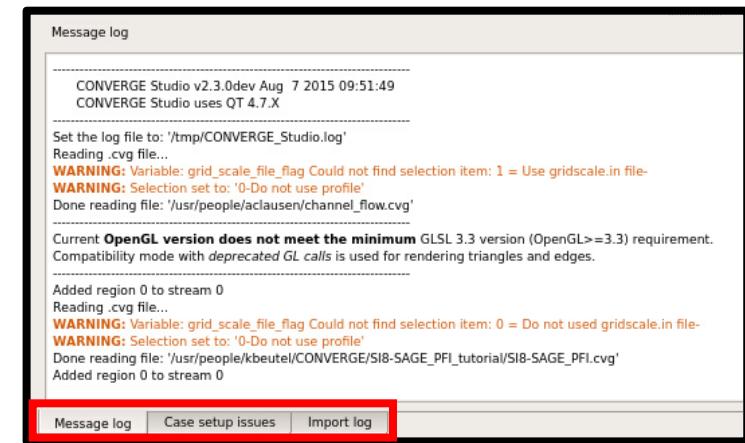
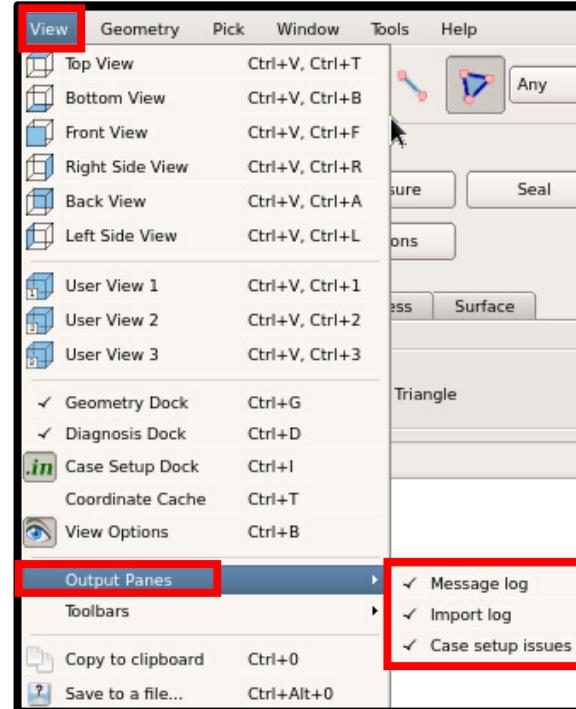
View Docks

- *Geometry dock*: Manipulate geometry
- *Diagnosis dock*: Identify problems with the geometry
- *Case Setup dock*: Configure physical models, initial conditions, and other parameters
- *Coordinate Cache dock*: Store coordinates and vectors from the geometry
- *View Options dock*: Change the view of the geometry



View a Log

- *Message log*: Displays information regarding the status of each operation
- *Import log*: Displays information regarding the imported *.in and *.dat files except *surface.dat*
- *Case setup issues*: Displays warnings and errors, each accompanied by a link, regarding case setup



CONVERGE Studio Workflow

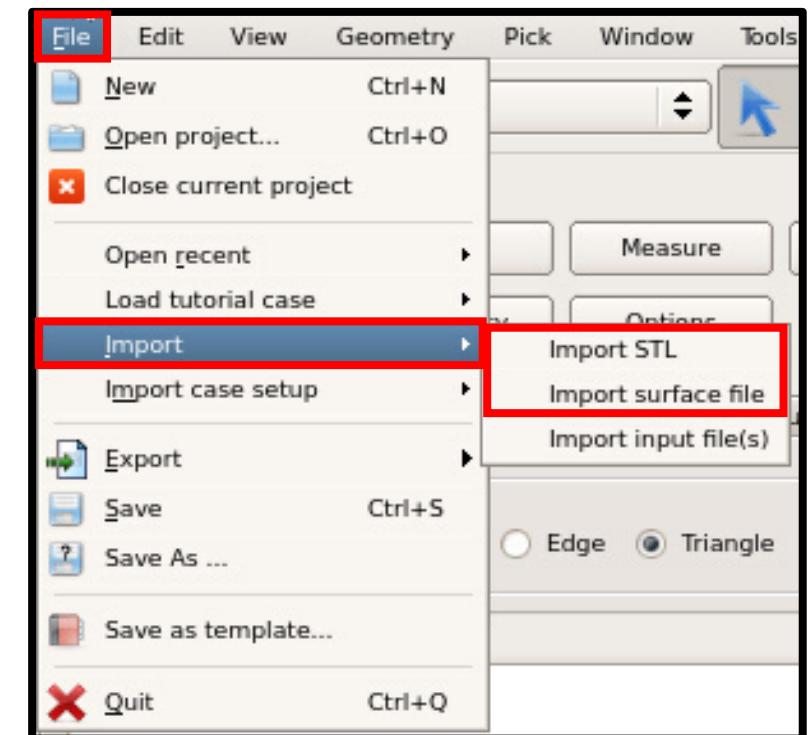
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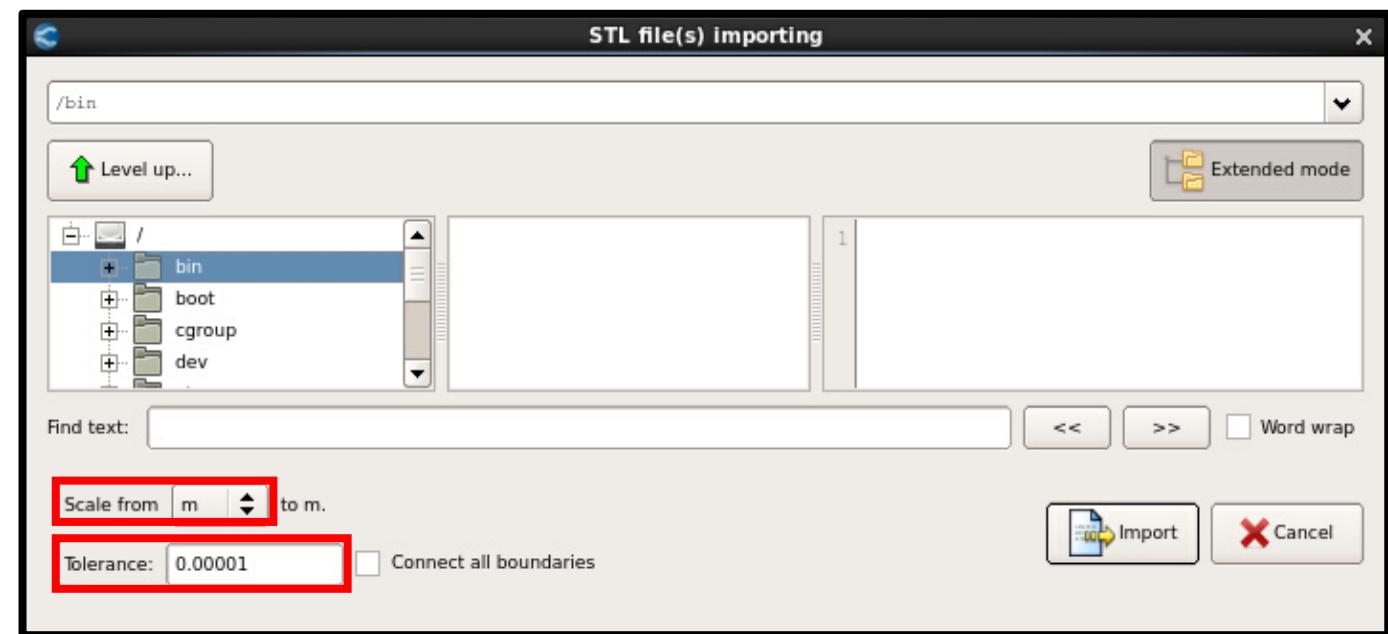
Import the Surface Geometry File (1/2)

- CONVERGE Studio requires triangulated surfaces with triangles defined by a unit normal and three vertices
- The surface geometry file can be formatted in one of two ways
 - An **.stl* file (exported from a CAD program)
 - A properly formatted **.dat* file that contains the surface geometry data
- If the surface geometry file requires extensive repair
 - Use a CAD program
 - Use Polygonica (available within CONVERGE Studio with a separate license)



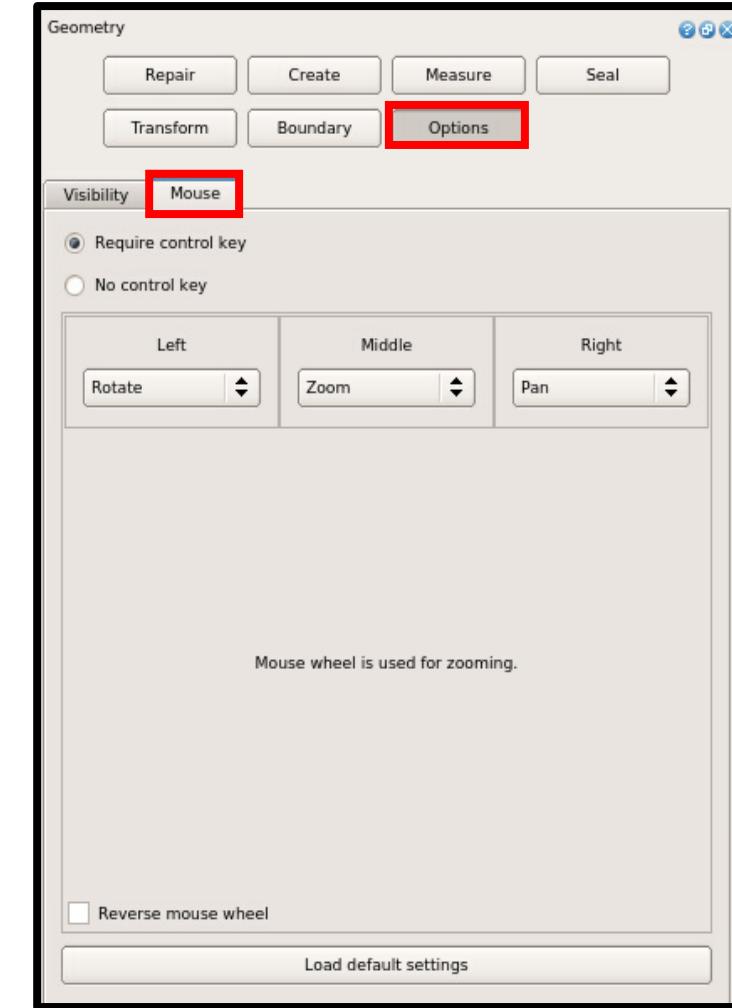
Import the Surface Geometry File (2/2)

- If you import an `*.stl` file, you must do the following
 - Convert the unit system from CAD units to CONVERGE units (*meters*)
 - Choose the tolerance for combining closely spaced vertices



Mouse Controls

- Rotate, zoom, and pan the geometry with the mouse buttons
 - Set mouse controls in the *Geometry* > *Options* > *Mouse*
- You can choose to require the *Ctrl* key to operate the mouse controls
- Use the drop-down menu to set the action associated with each mouse button (left, middle, and right)



How to Select an Entity with the *Objects* Toolbar

- Select an entity type (vertex, edge, or triangle)
- Choose a selection criterion (examples listed below)
 - By Arc: All edges that lie within a tolerance of a calculated arc
 - By Angle: All triangles with a normal vector deviation within a defined angular value or all edges with a directional deviation within a defined angular value
 - By Fence Neighbor: All triangles that share a vertex on the same boundary fence
 - By Manifold: All adjacent triangles not separated by a nonmanifold edge



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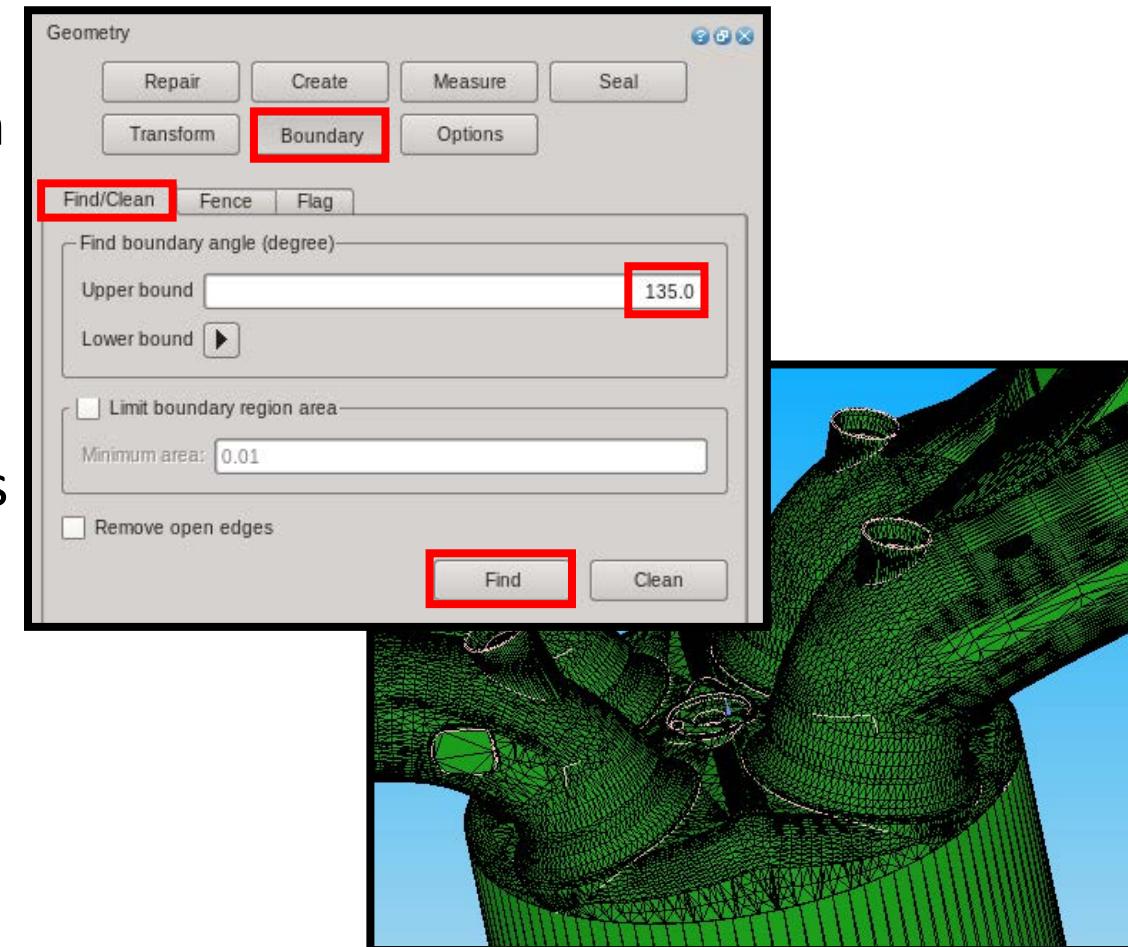
- *Line Plotting* module
- *Post-Processing 3D* module

Flag Triangles to Boundaries (1/8)

- To easily manipulate the geometry and to set up boundary conditions and other features, you should assign (“flag”) surface triangles to groups (“boundaries”)
- Once you have flagged triangles to boundaries, you can
 - Hide selected boundaries to make it easier to see and repair surface defects
 - Set up boundary conditions
 - Specify grid refinement per boundary
 - Define volumetric regions to set initial conditions
 - Etc.

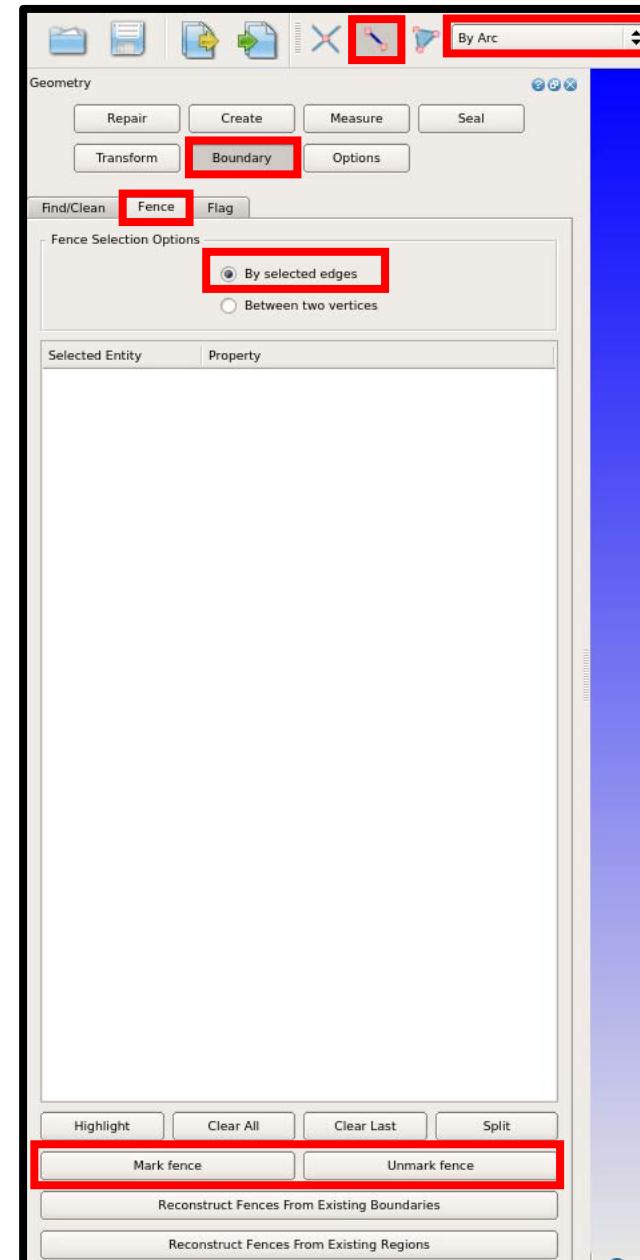
Flag Triangles to Boundaries (2/8)

- Boundary fences are white virtual borders on the surface geometry
- You can create boundary fences to help with flagging boundaries
- There are two ways to place boundary fences in the *Geometry* dock
 - Automatically with the *Find/Clean* tab
 - Specify an *Upper bound* or a *Lower bound* (in degrees)
 - Manually with the *Fence* tab

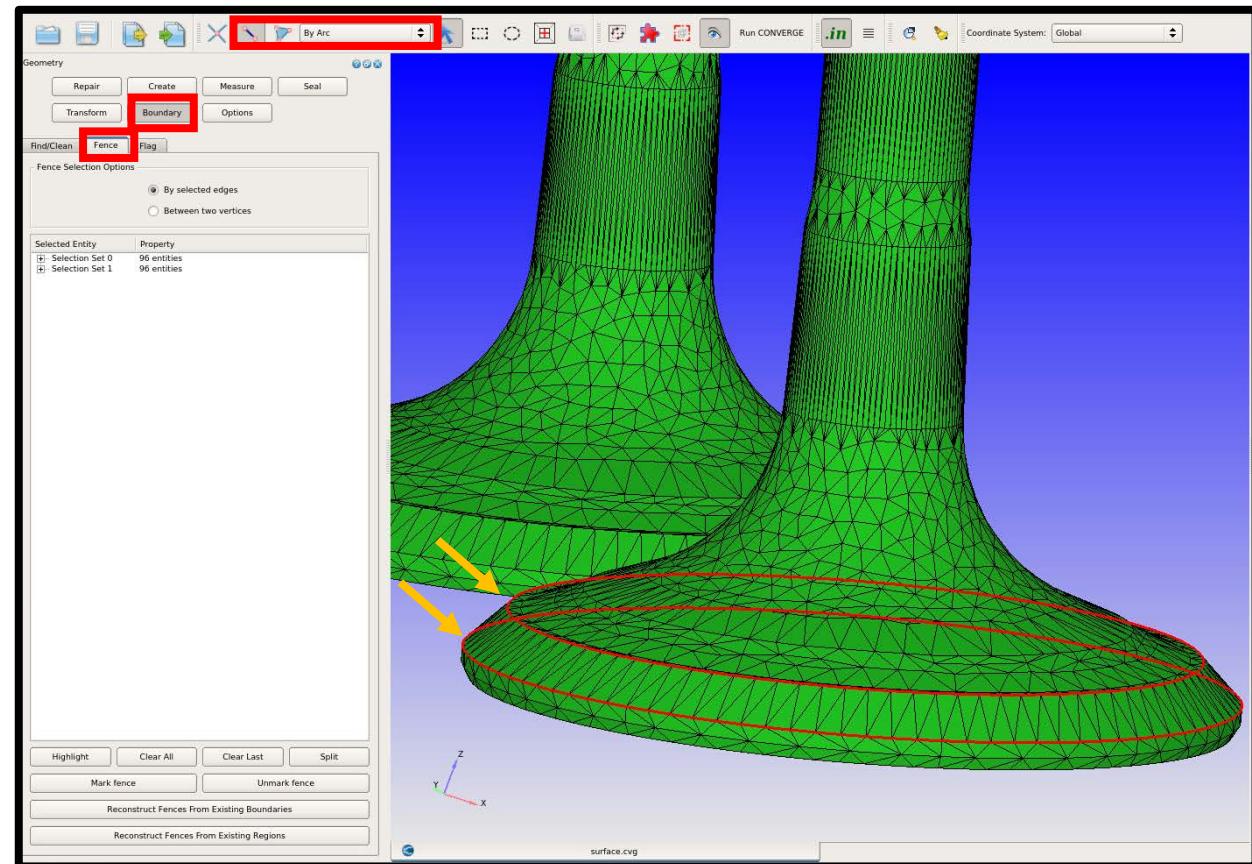


Flag Triangles to Boundaries (3/8)

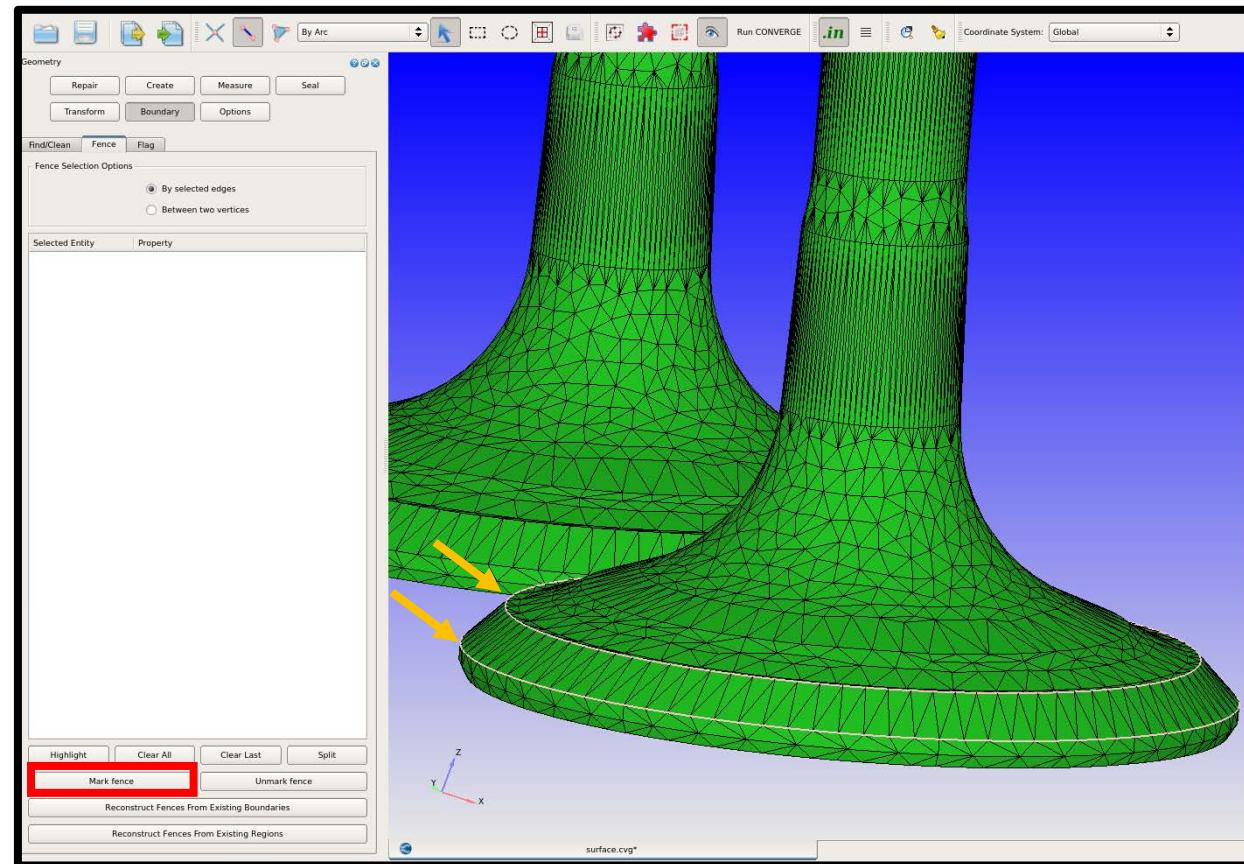
- You may need to manually mark or unmark boundary fences, especially in a complex surface
- Go to *Boundary > Fence*
- Select the edges
 - We recommend using the By Arc or By Angle selection filter
- Click Mark Fence or Unmark Fence



Flag Triangles to Boundaries (4/8)



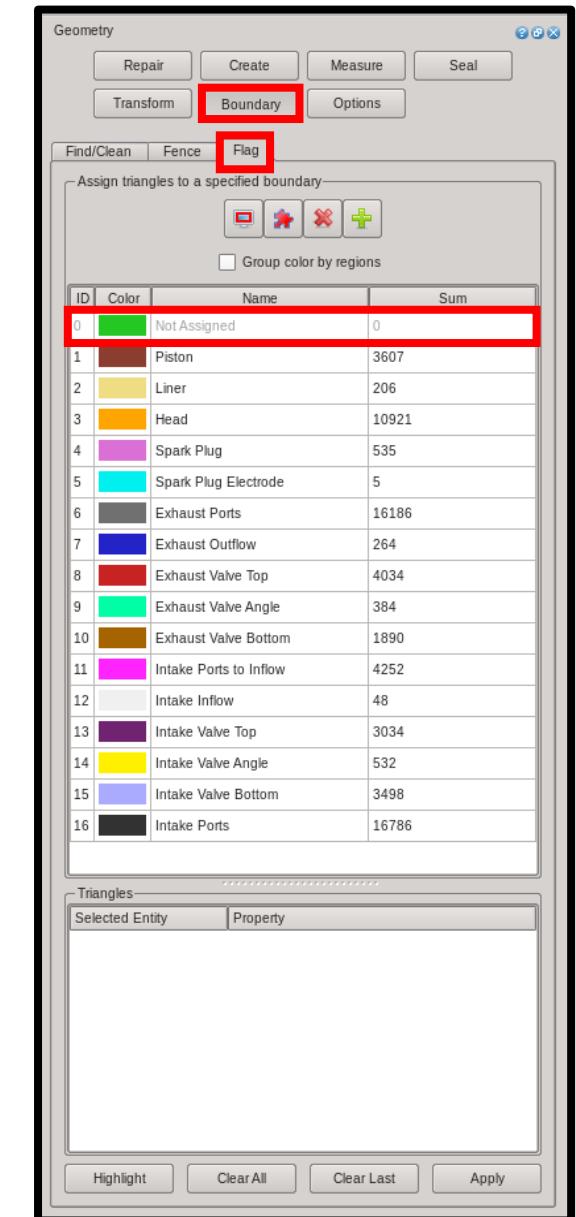
Select edge(s)



Click Mark Fence to create fence(s)

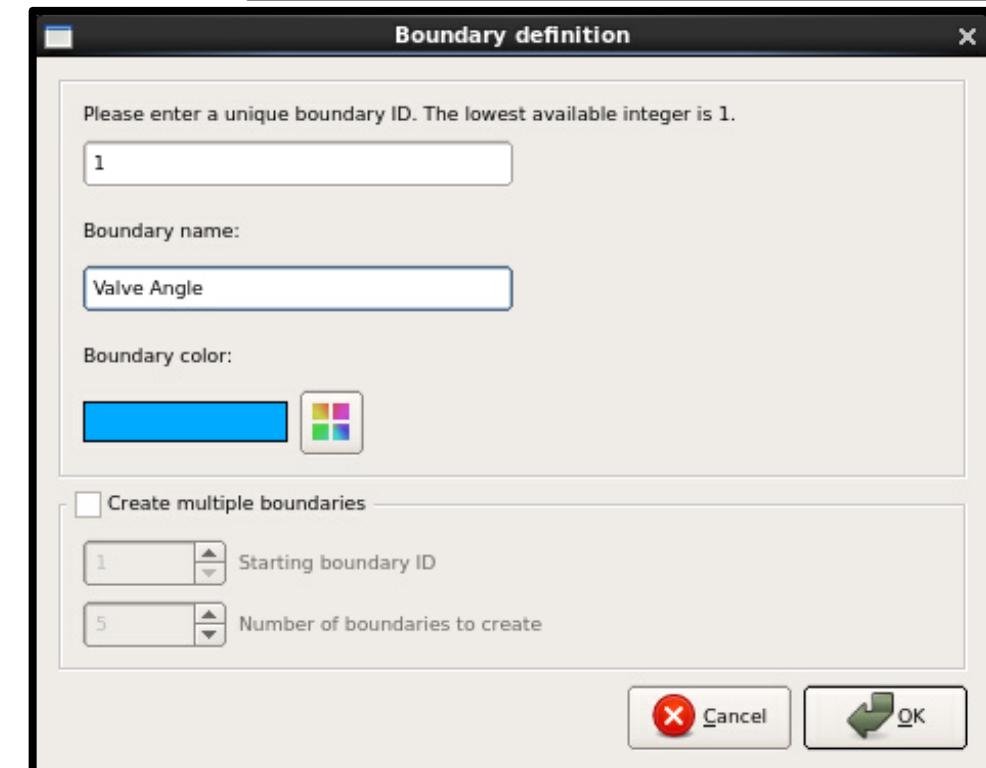
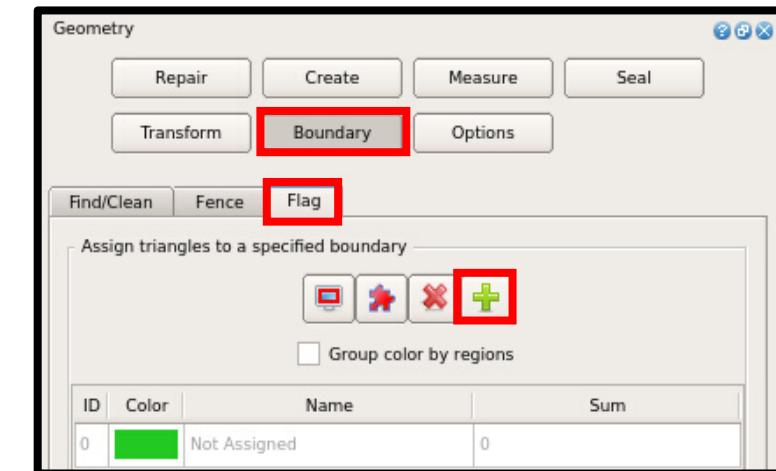
Flag Triangles to Boundaries (5/8)

- Initially all triangles are in the NotAssigned boundary
- You should create as many boundaries as desired (piston, liner, etc.) and flag all triangles so that no triangles remain in the NotAssigned boundary
- Flagging boundaries in CONVERGE Studio will not modify case setup boundary conditions

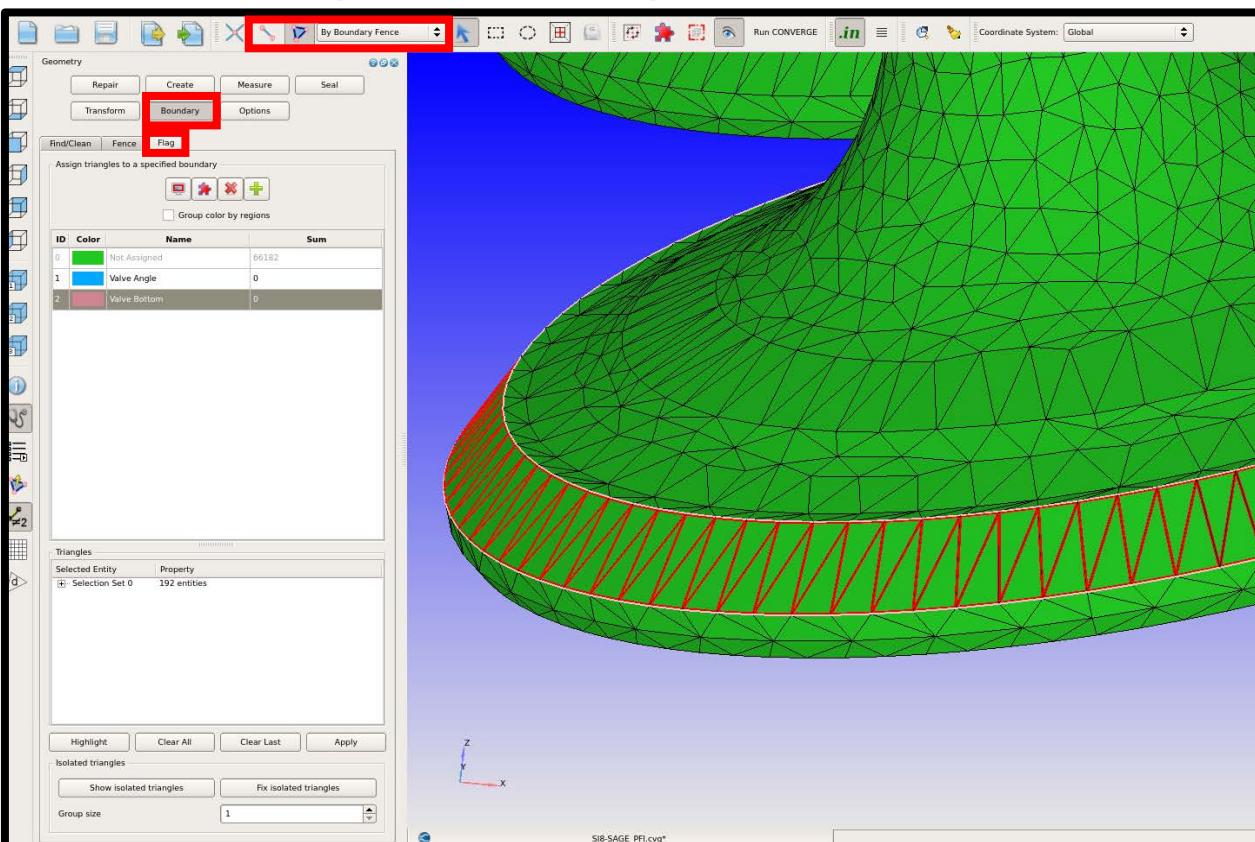


Flag Triangles to Boundaries (6/8)

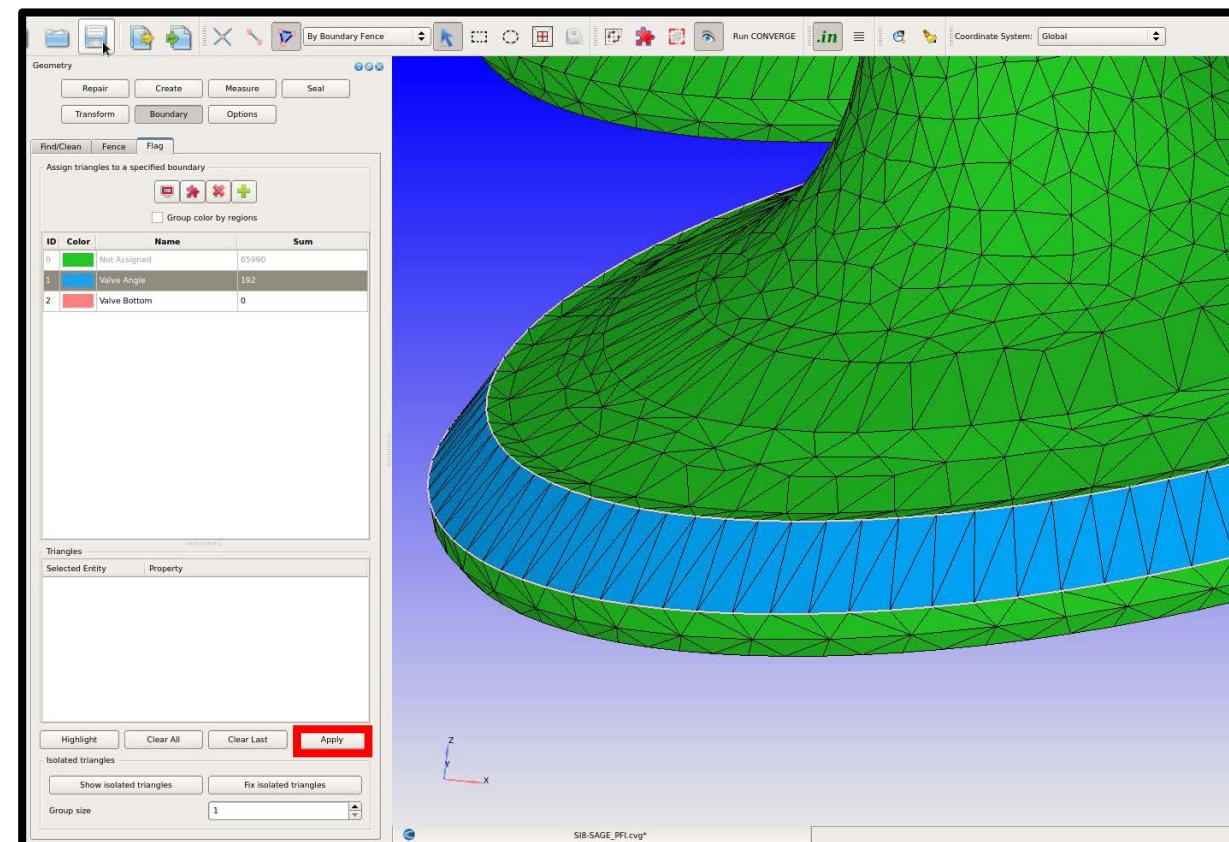
- After placing boundary fences, go to *Boundary* > *Flag* and click  to create and name new boundaries (e.g., Piston, Liner, Head)
- Use the By Boundary Fence selection filter to select triangles
- Click on the appropriate boundary in the *Boundary* > *Flag* list and then click Apply to flag the selected triangles to the boundary



Flag Triangles to Boundaries (7/8)



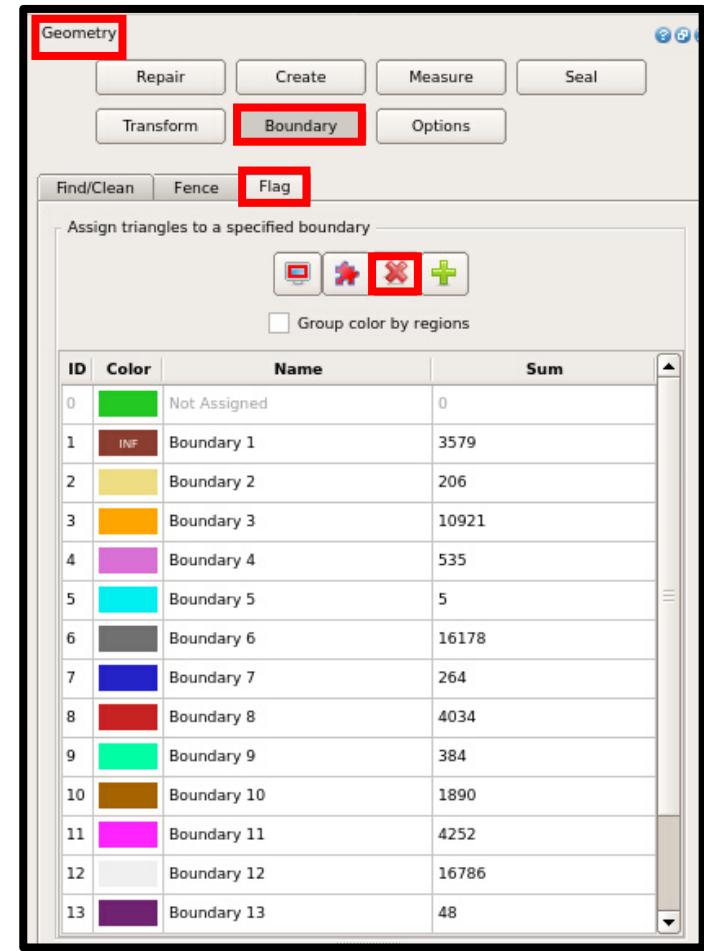
Select triangles between fences using
By Boundary Fence filter



Assign selected triangles to
valve angle boundary

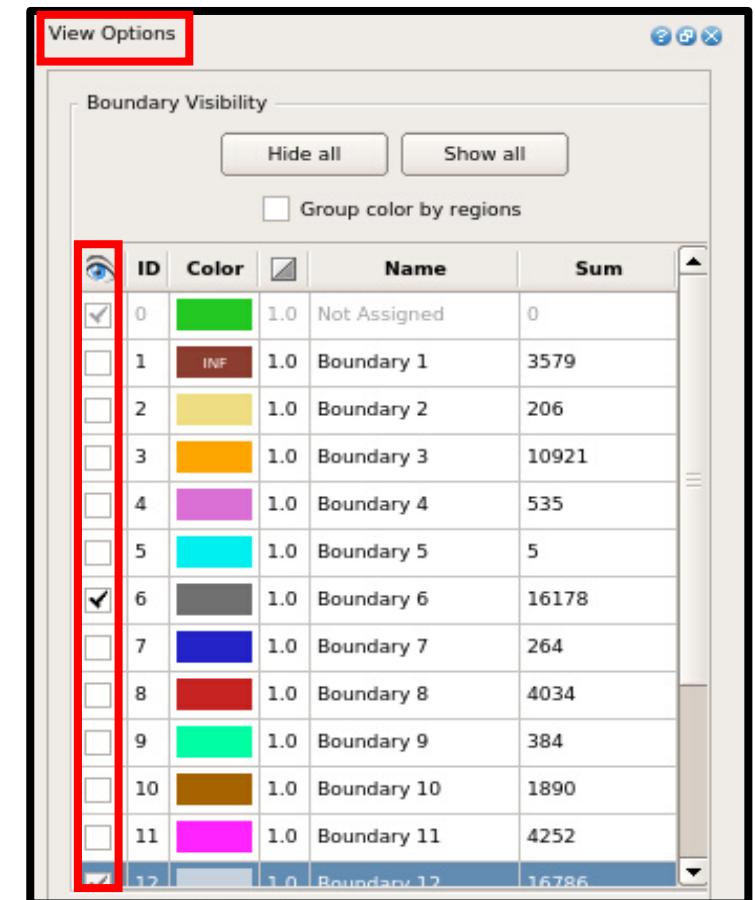
Flag Triangles to Boundaries (8/8)

- In *Geometry > Boundary > Flag*
 - To unflag triangles from a boundary, click the  button
 - CONVERGE Studio deletes the boundary name and moves the triangles to the NotAssigned boundary
 - To flag triangles to a different boundary, select and drag one boundary to another boundary



Hide/Show Flagged Triangles

- In the *View Options* dock
 - Uncheck a box to hide that boundary
 - Check a box to show that boundary



CONVERGE Studio Workflow

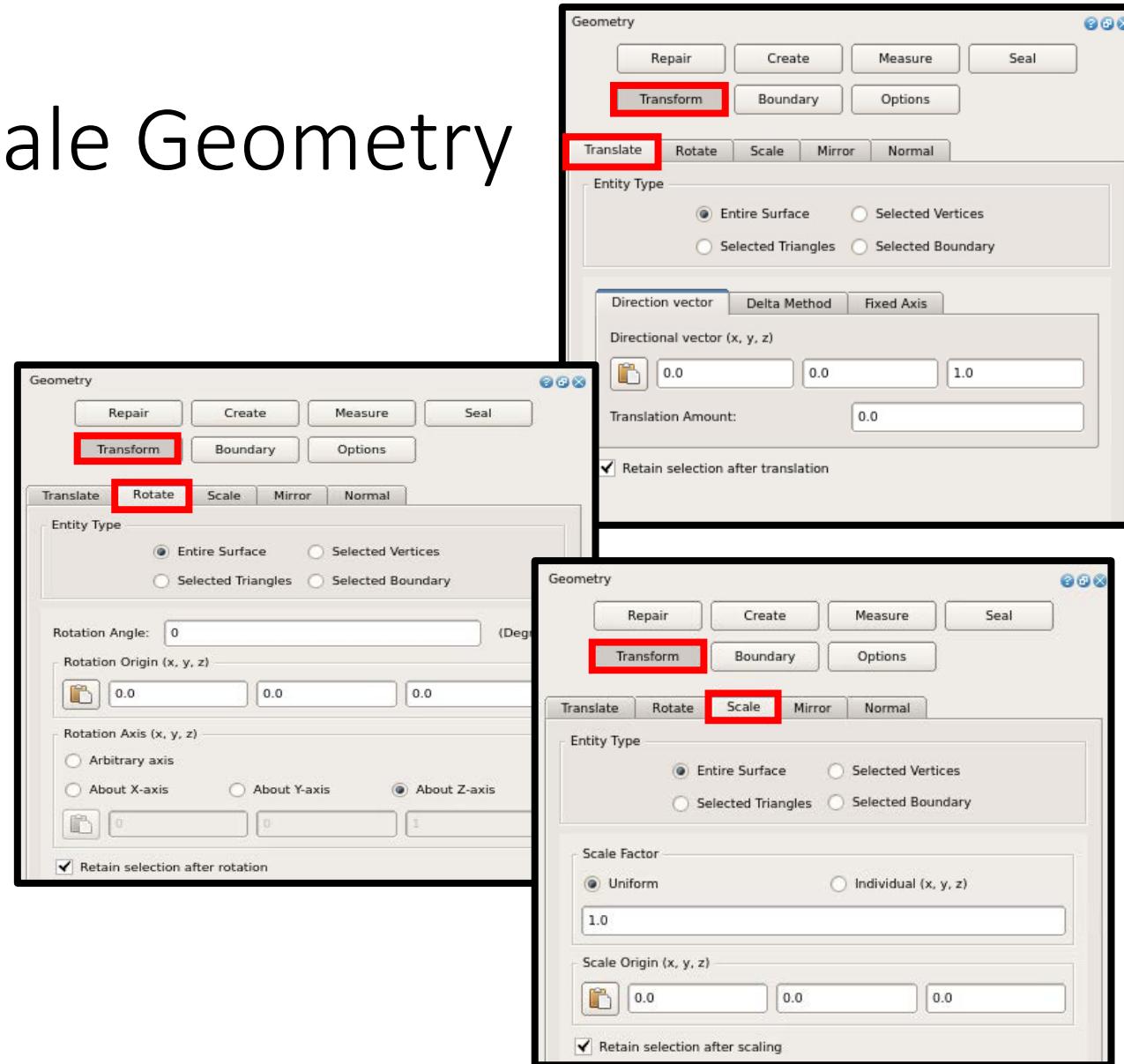
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Translate, Rotate, and Scale Geometry

- CONVERGE Studio can translate, rotate, or scale a surface, triangle, vertex, or boundary
 - Translate*: Move the entire surface or portion of the surface
 - Rotate*: Rotate the entire surface or portion of the surface a specified angle about a specified point
 - Scale*: Shrink or expand the entire surface or portion of the surface by a specified factor about a specified point



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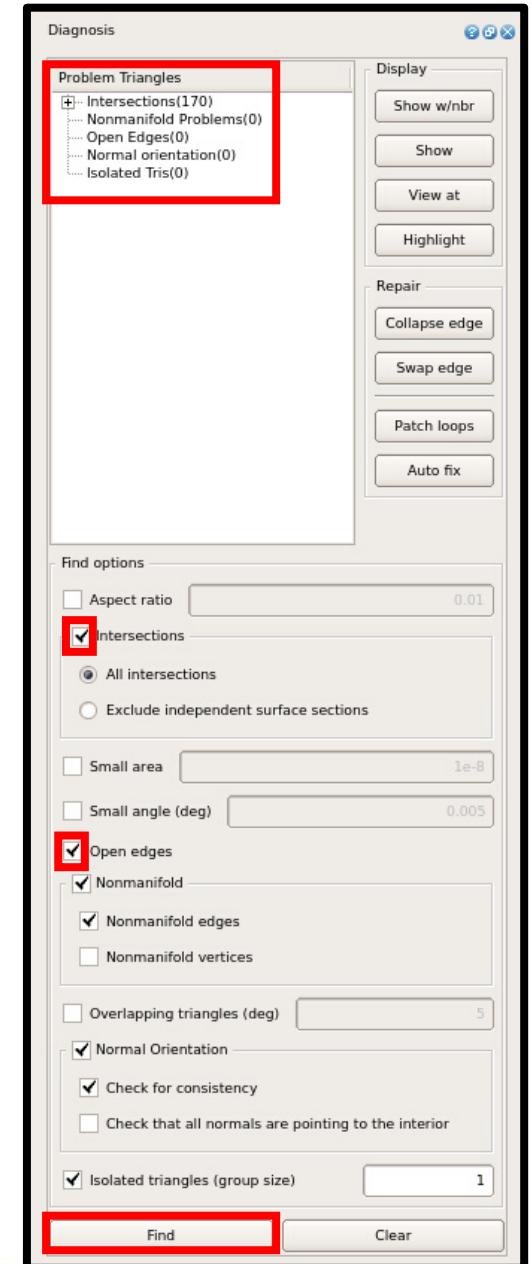
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Find and Repair Surface Defects

- Use the *Diagnosis* dock to identify defects

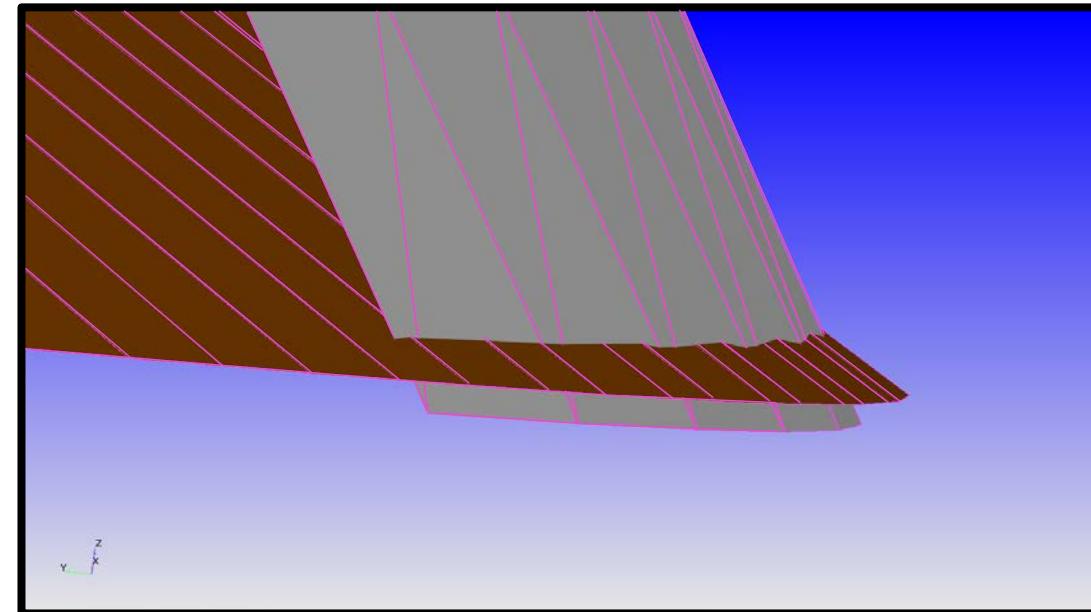
- **Intersections***
- **Nonmanifold edges***
- **Normal orientation***
- **Open edges***
- Overlapping triangles
(user-specified)
- Isolated triangles
- Aspect ratio (user-specified)
- Small area (user-specified)
- Small angle (user-specified)



*These defects will prevent the CONVERGE solver from running

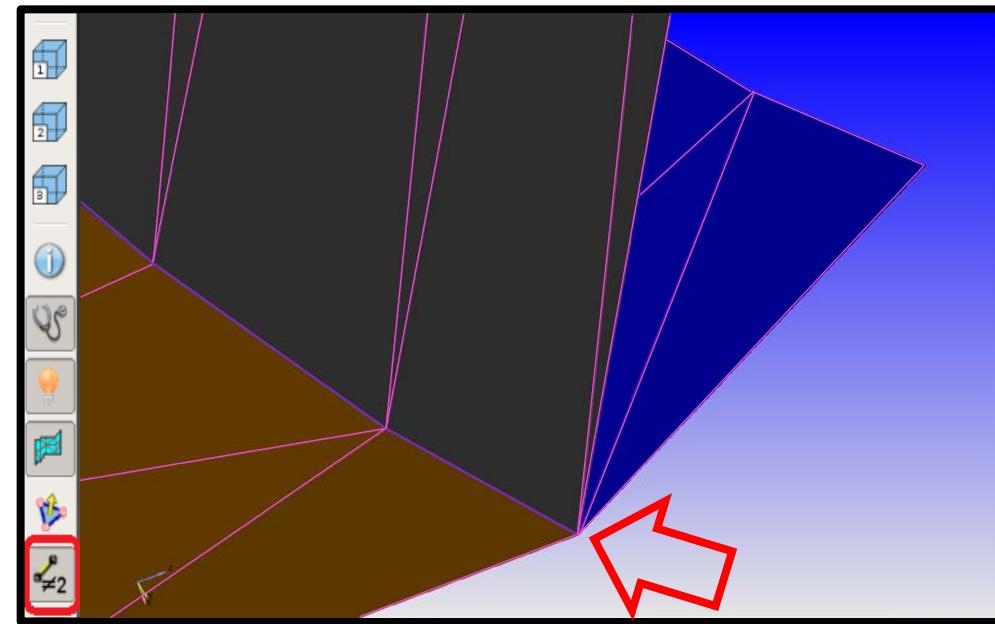
Defect: Intersections

- Triangles that pass through one another, as indicated by inconsistent surface coloration
- Intersecting triangles will be magenta-highlighted
- This defect will prevent CONVERGE from running a simulation



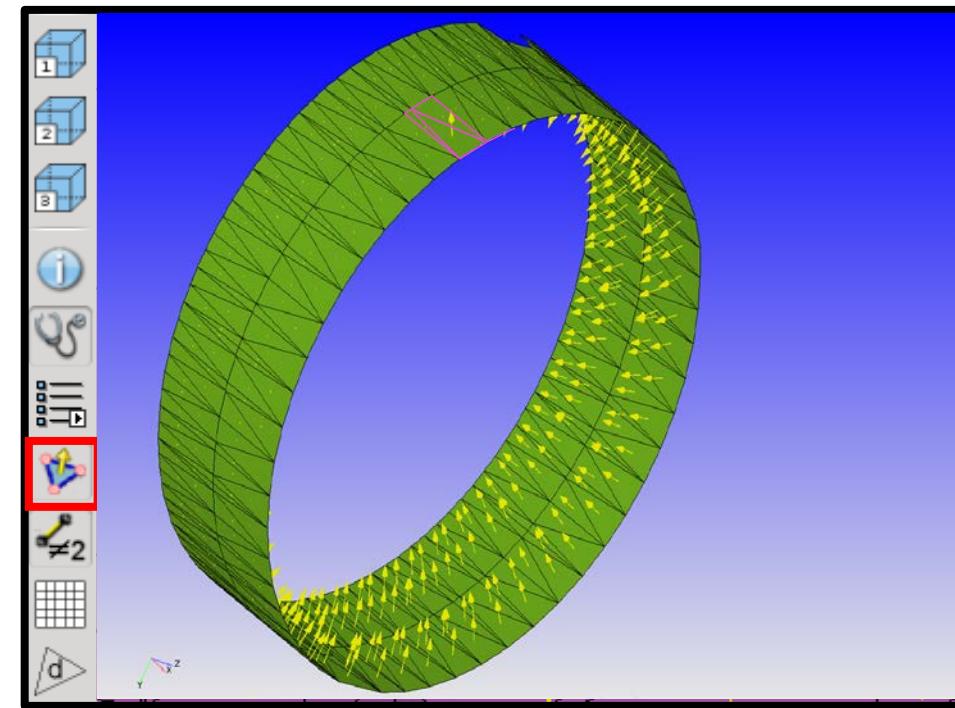
Defect: Nonmanifold Edges

- Edges that border more than two triangles (also known as T-junctions)
- Nonmanifold edges are **purple**-highlighted
- Triangles with at least one nonmanifold edge will be **magenta**-highlighted
- This defect will prevent CONVERGE from running a simulation unless it exists on an **INTERFACE** boundary



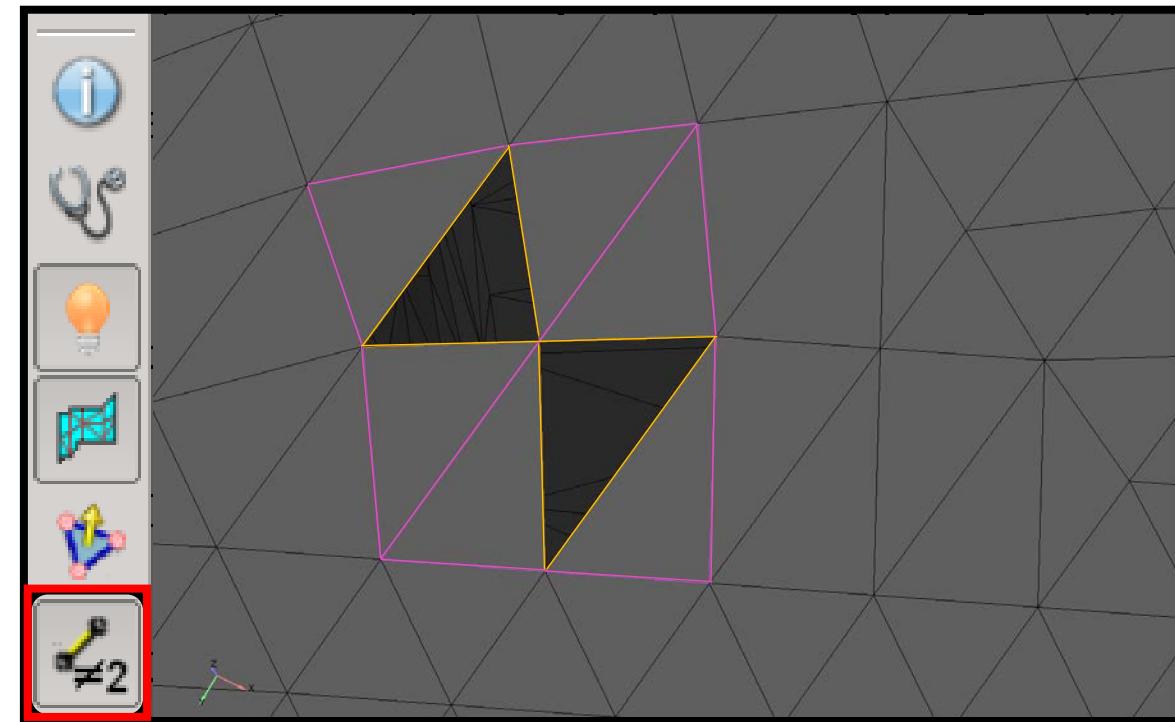
Defect: Normal Orientation

- Triangles whose normal vectors are inconsistent with the normal vectors of adjacent triangles per the right-hand rule
- The normal vector for each triangle must point toward the computational domain
- Triangles with inconsistent normal vectors and adjacent triangles are magenta-highlighted
- This defect will prevent CONVERGE from running a simulation



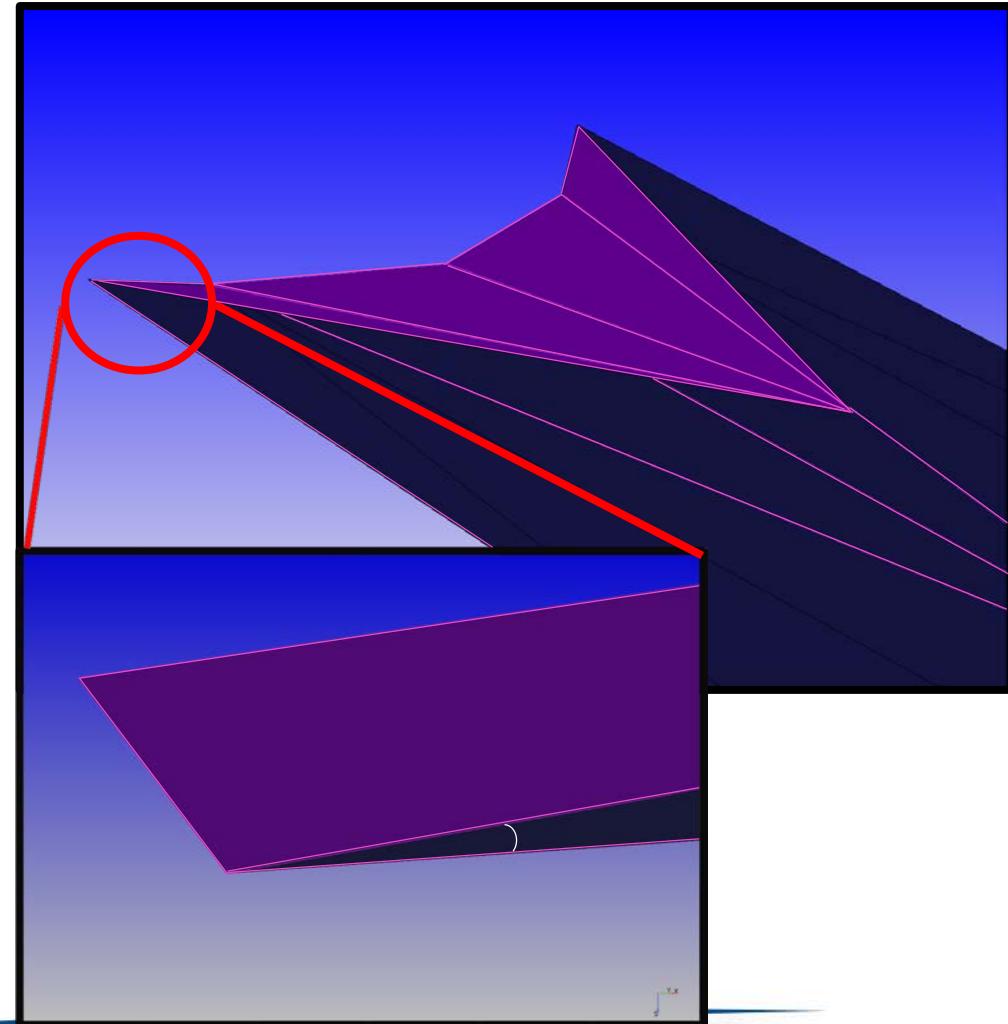
Defect: Open Edges

- Edges that border only one triangle
- Triangles with at least one open edge are magenta-highlighted
- Open edges are orange-highlighted
- This defect will prevent CONVERGE from running a simulation



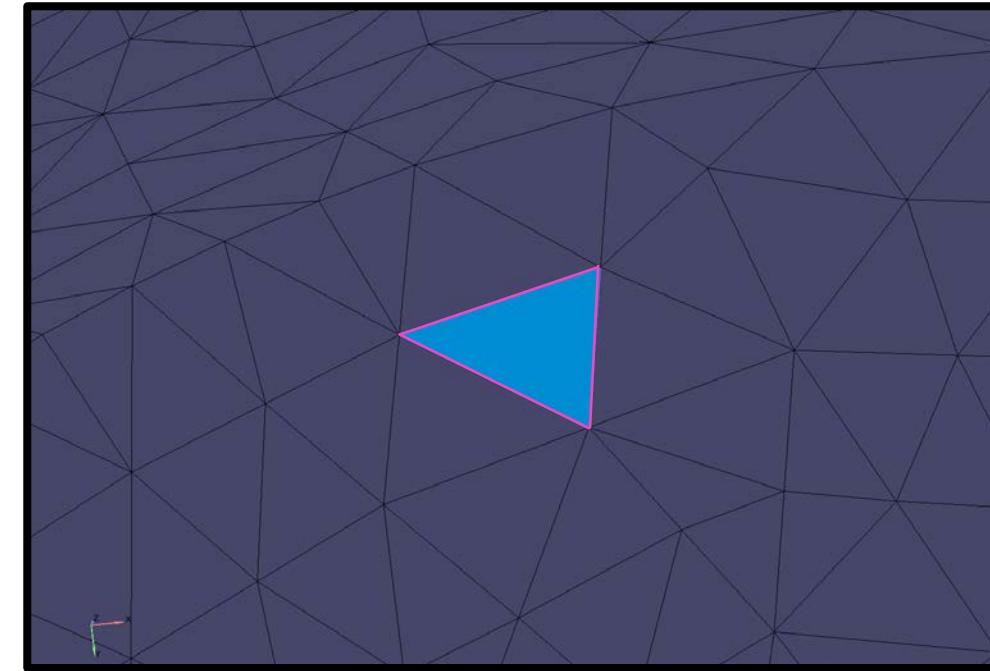
Defect: Overlapping Triangles

- Triangles that meet other triangles at an angle less than the user-specified tolerance (e.g., 5°)
- Overlapping triangles are magenta-highlighted
- CONVERGE can run a simulation with this defect, but it will lead to small cut-cells



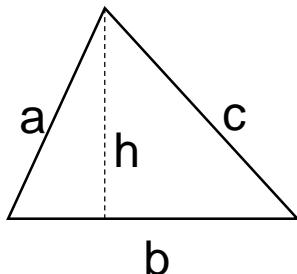
Defect: Isolated Triangles

- One or more triangles surrounded by neighboring triangles that are all flagged to a different boundary
 - Set the maximum number of triangles required for this defect in the *Diagnosis* dock
- This blue isolated triangle is magenta-highlighted
- Isolated triangles may cause problems when setting up boundary conditions
- CONVERGE can run a simulation with this defect



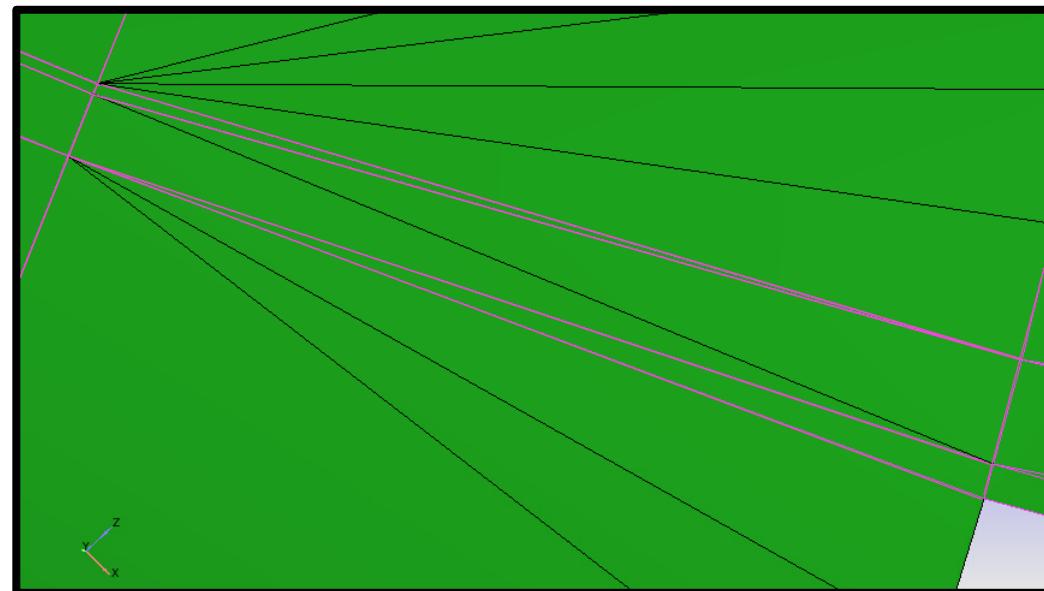
Defect: Aspect Ratio

- A triangle that satisfies the inequality based on a specified tolerance



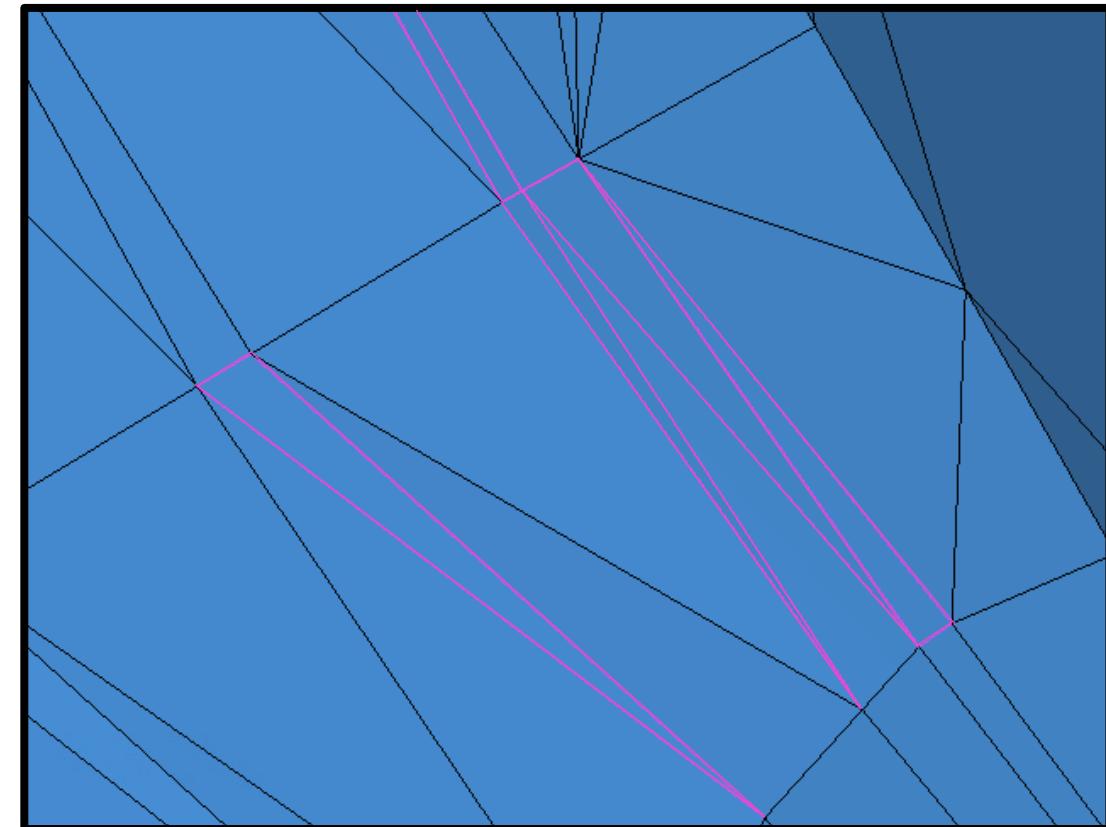
$$\frac{2\left(\frac{bh}{2}\right)}{a^2+b^2+c^2} < \text{User specified value}$$

- Aspect ratio triangles are magenta-highlighted
- CONVERGE can run a simulation with this defect



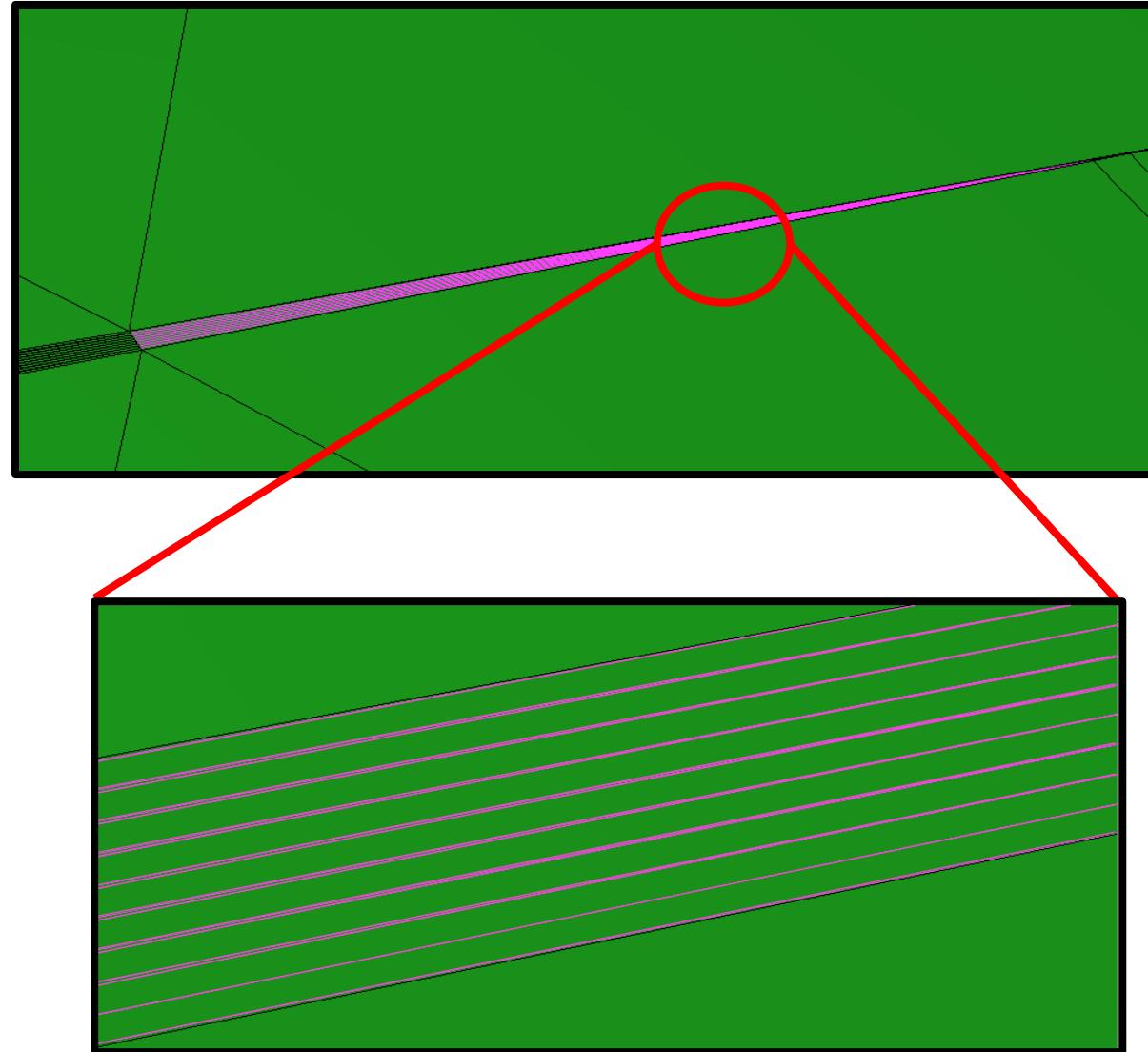
Defect: Small Area

- A triangle that has an area less than the user-specified tolerance value
- These triangles will be magenta-highlighted
- CONVERGE can run a simulation with this defect



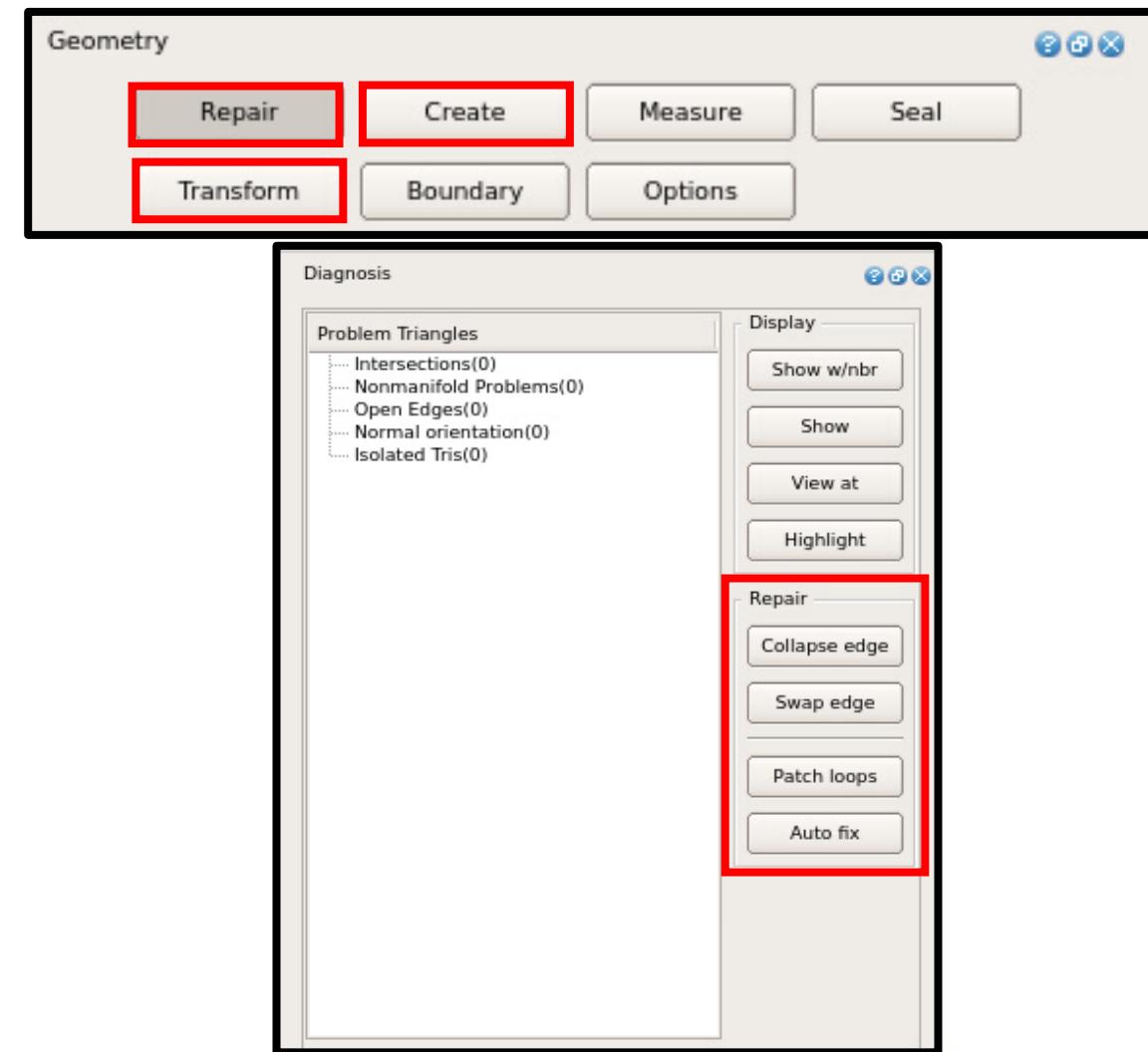
Defect: Small Angle

- A triangle that contains at least one angle that is less than the user-specified tolerance value
- These triangles will be magenta-highlighted
- CONVERGE can run a simulation with this defect



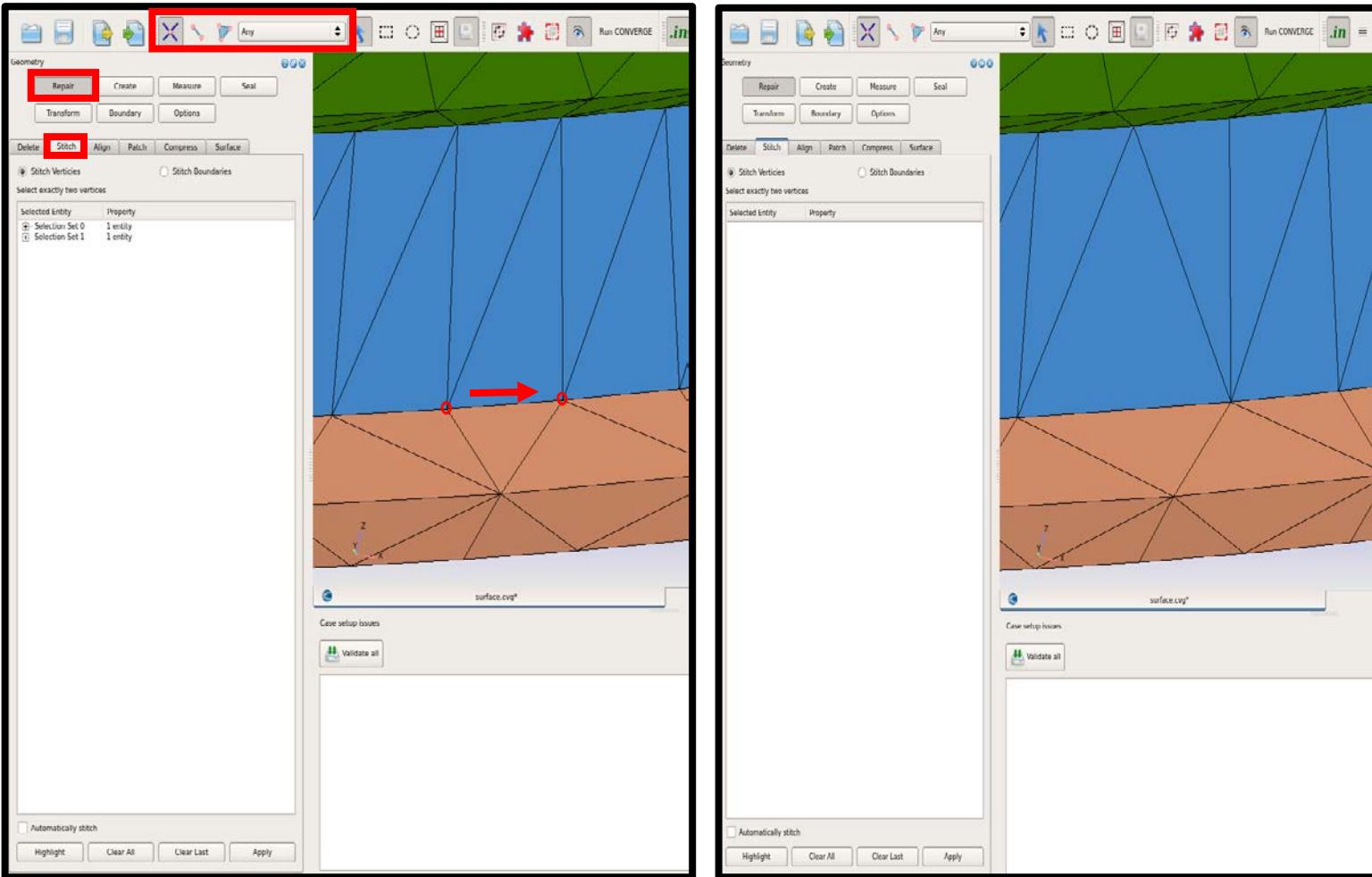
Repair Surface Defects

- You have two options for repairing surface defects
 - Repair operations in the *Geometry* dock
 - Full functionality to fix any defect listed in previous slides
 - May be more time-consuming
 - Best with complex geometries
 - Repair tools in the *Diagnosis* dock
 - Faster but limited functionality
 - Useful for repairing open edges
 - Best with simple geometries



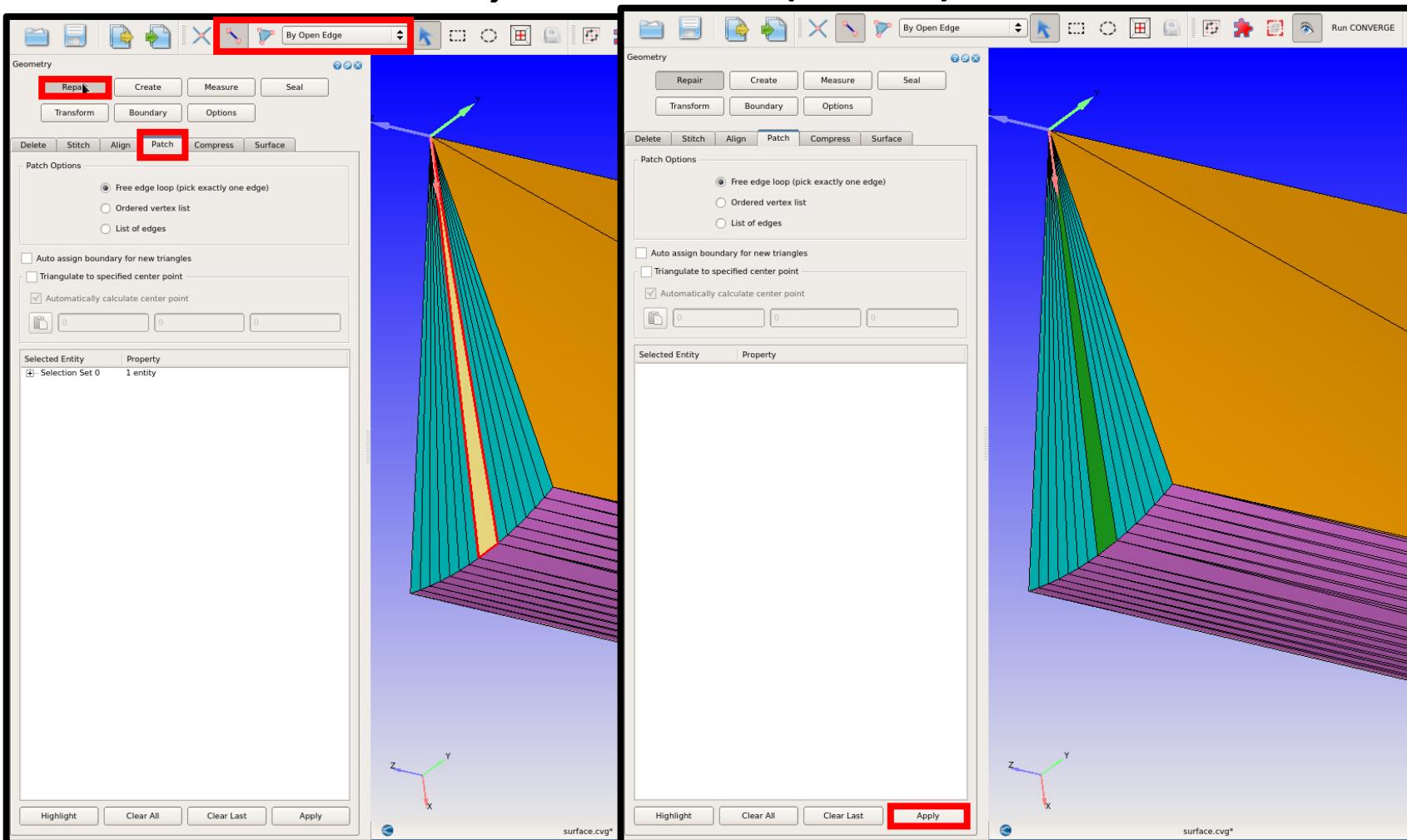
Repair: Using the Geometry Dock (1/6)

- *Stitch*: Merges two vertices to fix defects such as open edges and intersecting triangles
 - Select two vertices
 - CONVERGE Studio will merge the first vertex to the second vertex



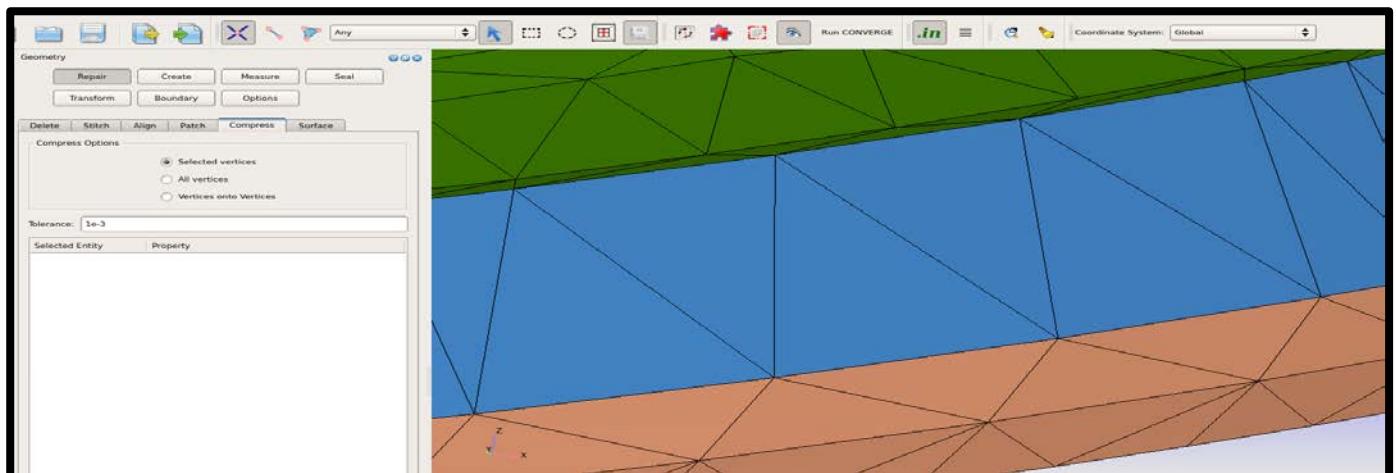
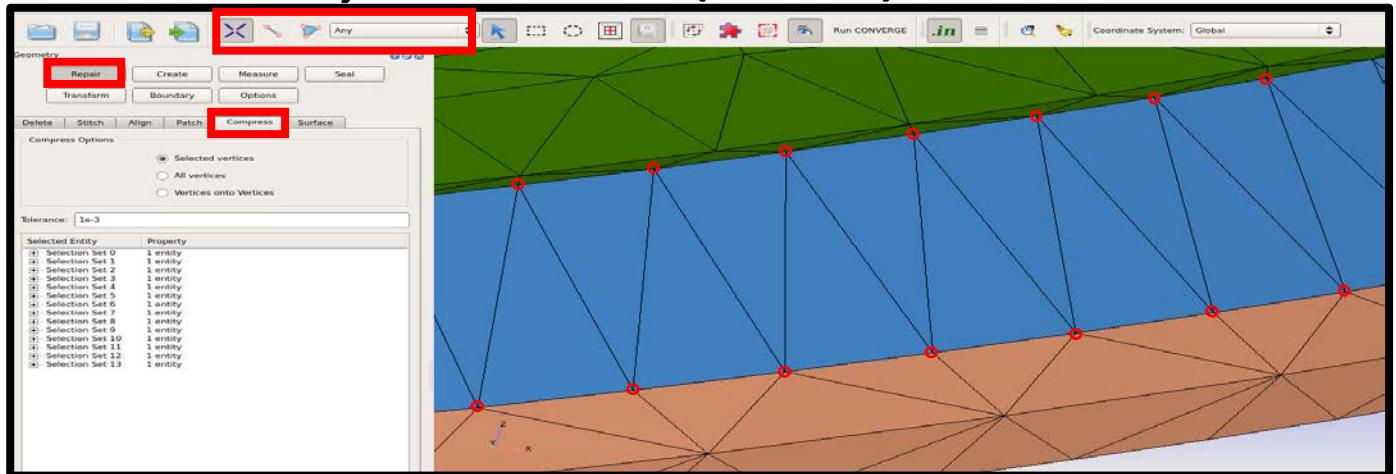
Repair: Using the Geometry Dock (2/6)

- *Patch*: Creates triangles to close open edge defects
- Use entity selection criterion of Edge or Vertex to highlight the open edge



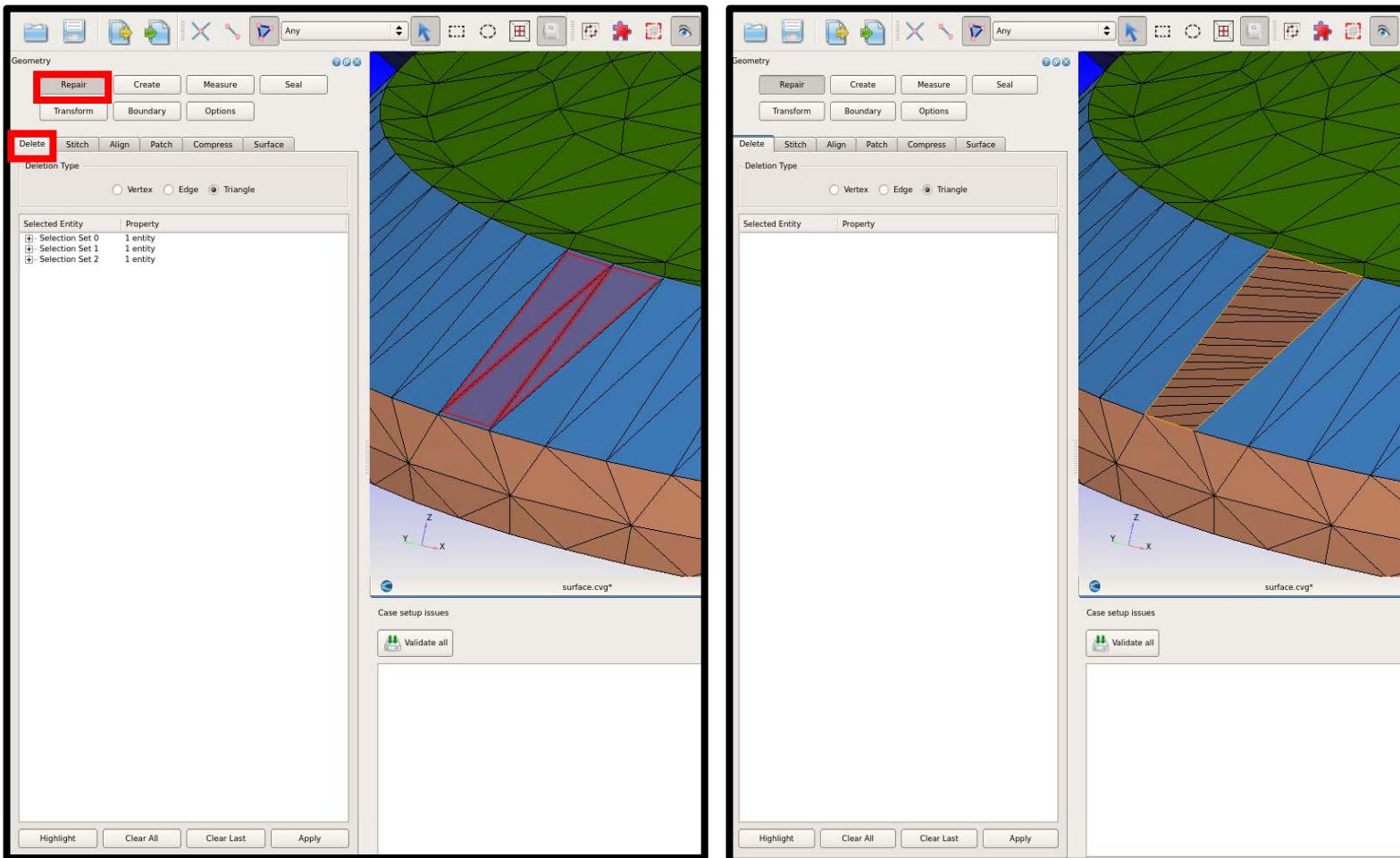
Repair: Using the Geometry Dock (3/6)

- *Compress*: Merges vertices that are within a user-specified tolerance to fix defects such as intersecting triangles
 - Select one or more vertices
 - Set the proximity tolerance



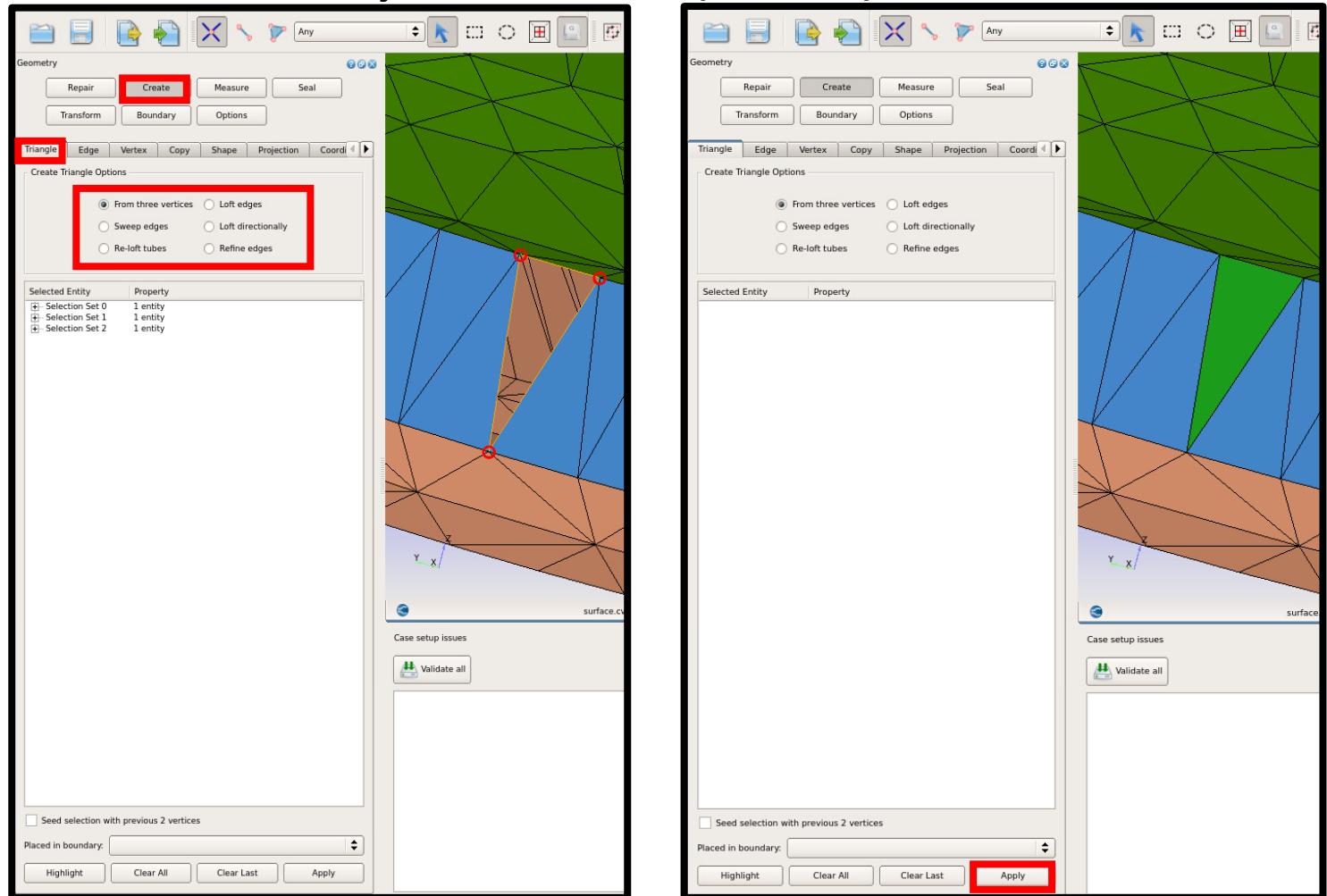
Repair: Using the Geometry Dock (4/6)

- *Delete*: Removes user-specified triangle(s) to fix defects such as small angle or small area
 - Select one or more triangles you wish to delete



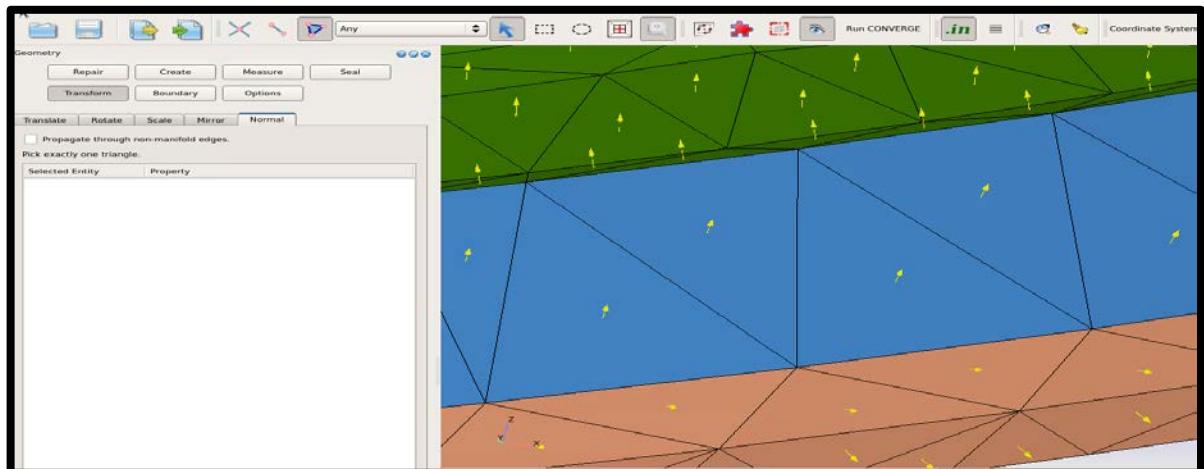
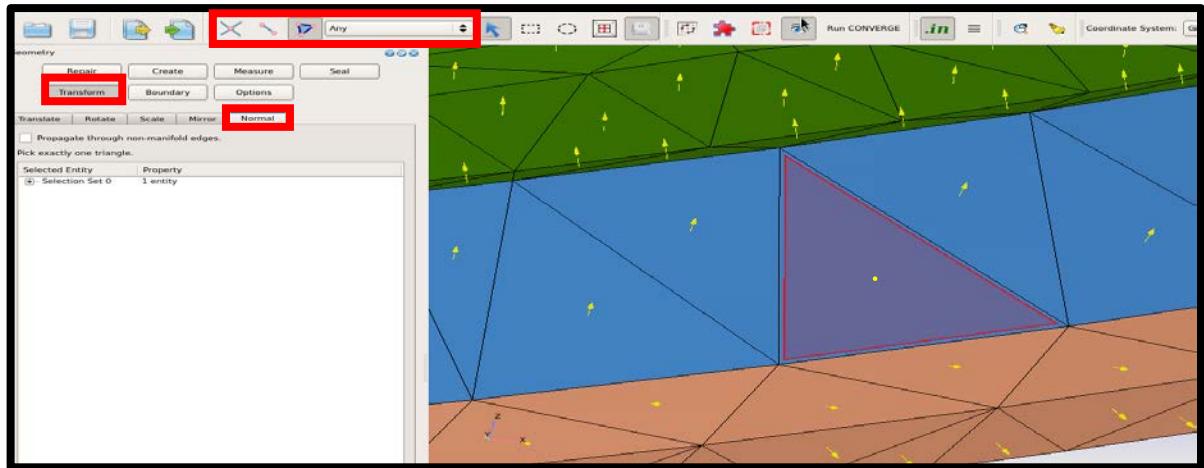
Repair: Using the Geometry Dock (5/6)

- *Triangle*: Adds new triangles to repair defects such as open edges
 - Select three vertices where you wish to create a new triangle
- Remember to assign the new triangles to the correct boundary



Repair: Using the Geometry Dock (6/6)

- *Normal*: Reverses the normal vector of the selected triangle and all adjacent triangles with similar normal vectors to fix normal orientation defects
 - Select the triangle with the opposite orientation



CONVERGE Studio Workflow

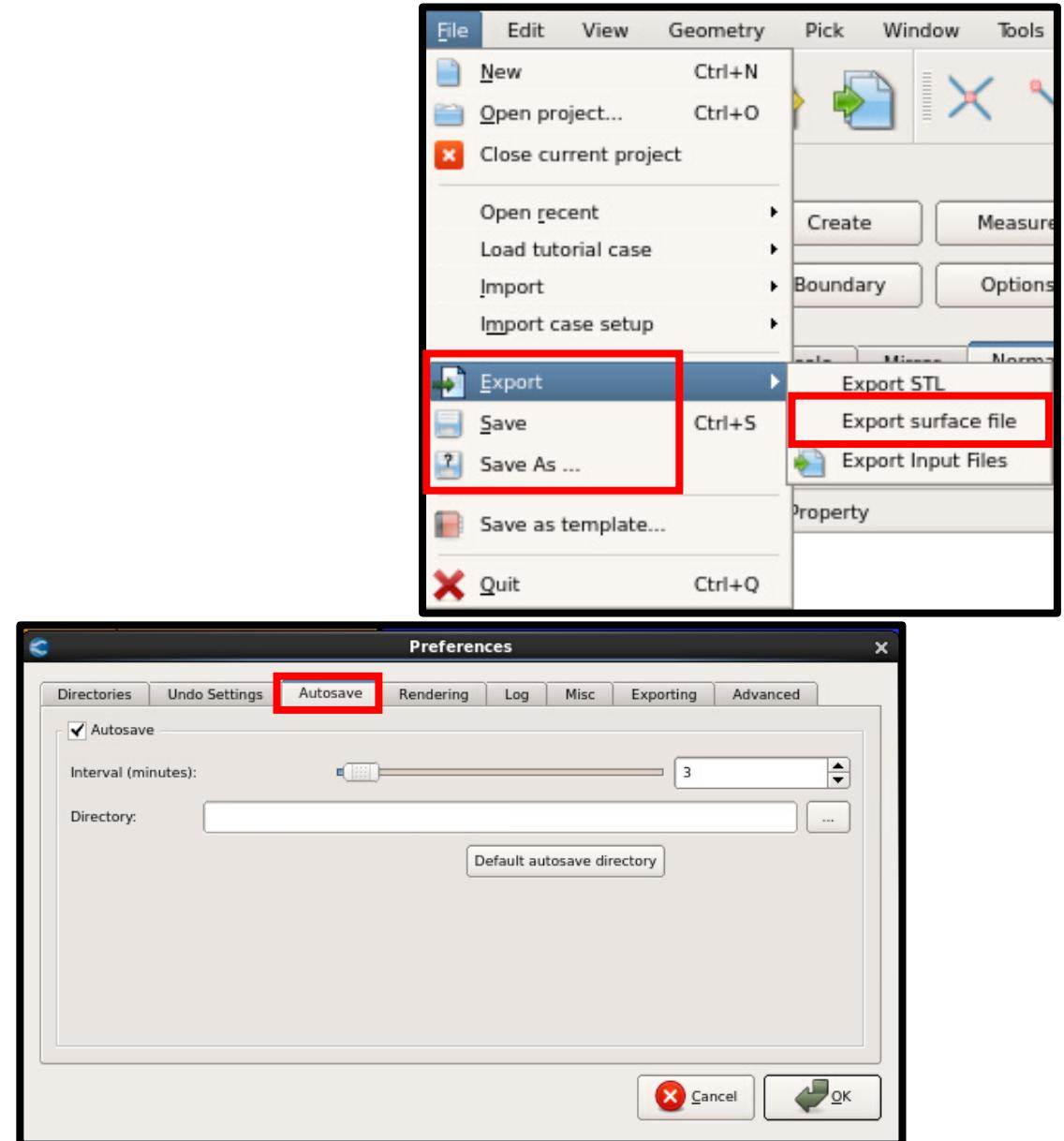
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Save Your Project

- Click *Save* or *Save As ...* to save your project as a **.cvg* file
- Click *Export > Export surface file* to export the *surface.dat* file that you need to run a CONVERGE simulation
- To autosave your project, go to *Edit > Preferences > Autosave*
 - Check the *Autosave* box
 - Set the time interval and *Case Directory*



THANK YOU!

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