# Introduction to CONVERGE 3.0: Inlaid Mesh

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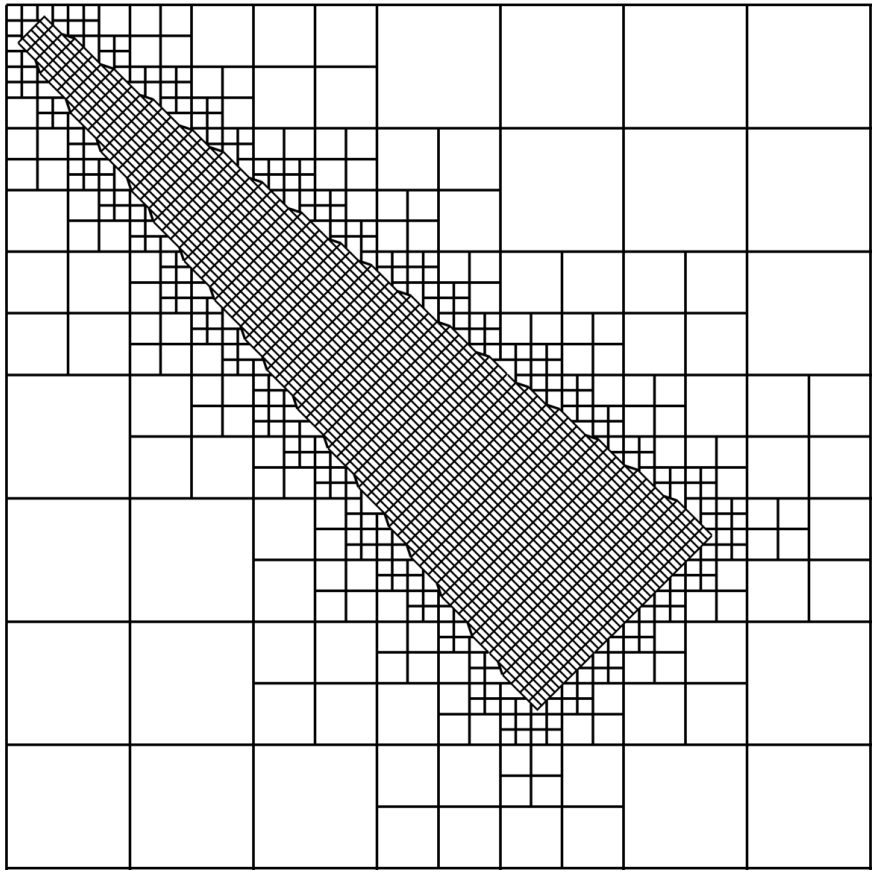
CONVERGE CFD SOFTWARE

# Outline

- What is an inlaid mesh? Why use one (什么是镶嵌网格?为何需要？）
- Creating an inlaid mesh （如何生成镶嵌网格)
- Sample cases（例子）
- Mesh quality considerations（网格质量的控制）

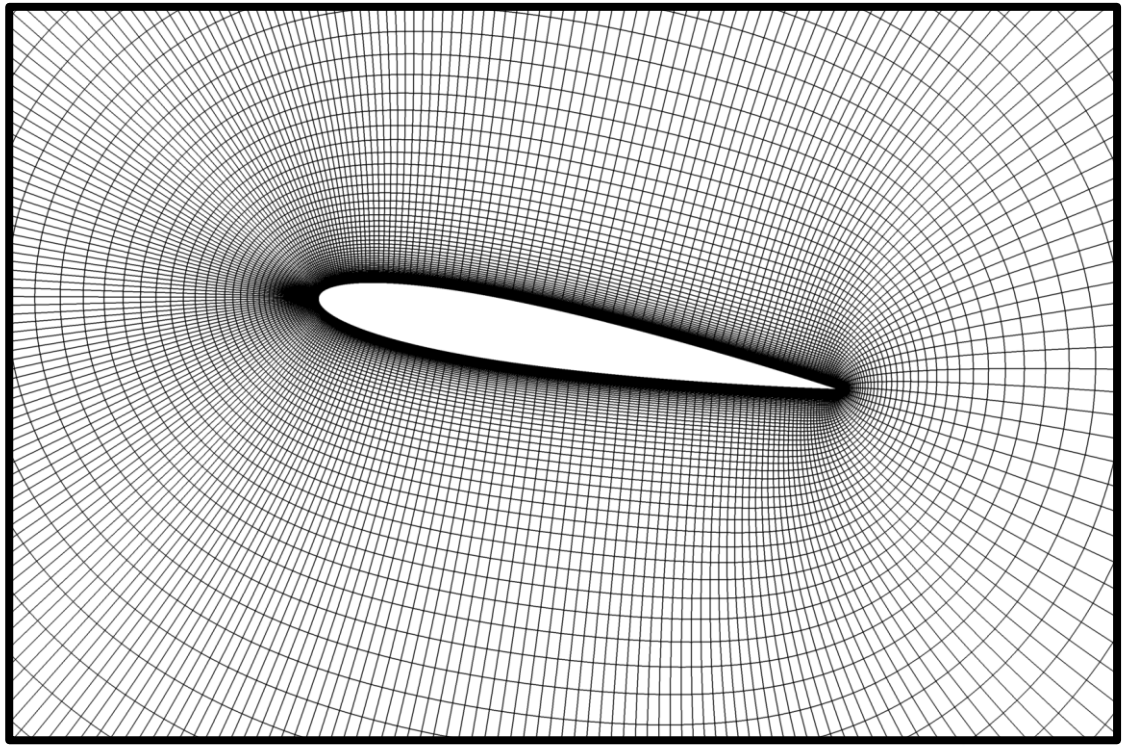
# What is an Inlaid Mesh?

- Alternative grid type in CONVERGE
  - Not part of the Cartesian cut-cell global mesh generated at runtime
  - Made up of cells with arbitrary shape, size, and orientation that make up some or all of the domain
  - Generated before the simulation, typically with CONVERGE Studio
- Inlaid meshes are made of surface triangles defined as FLOW_THROUGH



# Why Use an Inlaid Mesh?

- Inlaid meshes are **always optional** in CONVERGE
- Take advantage of *a priori* knowledge of the flow
  - Spray-aligned mesh
  - Boundary layer mesh
- Can get more accurate results with fewer cells

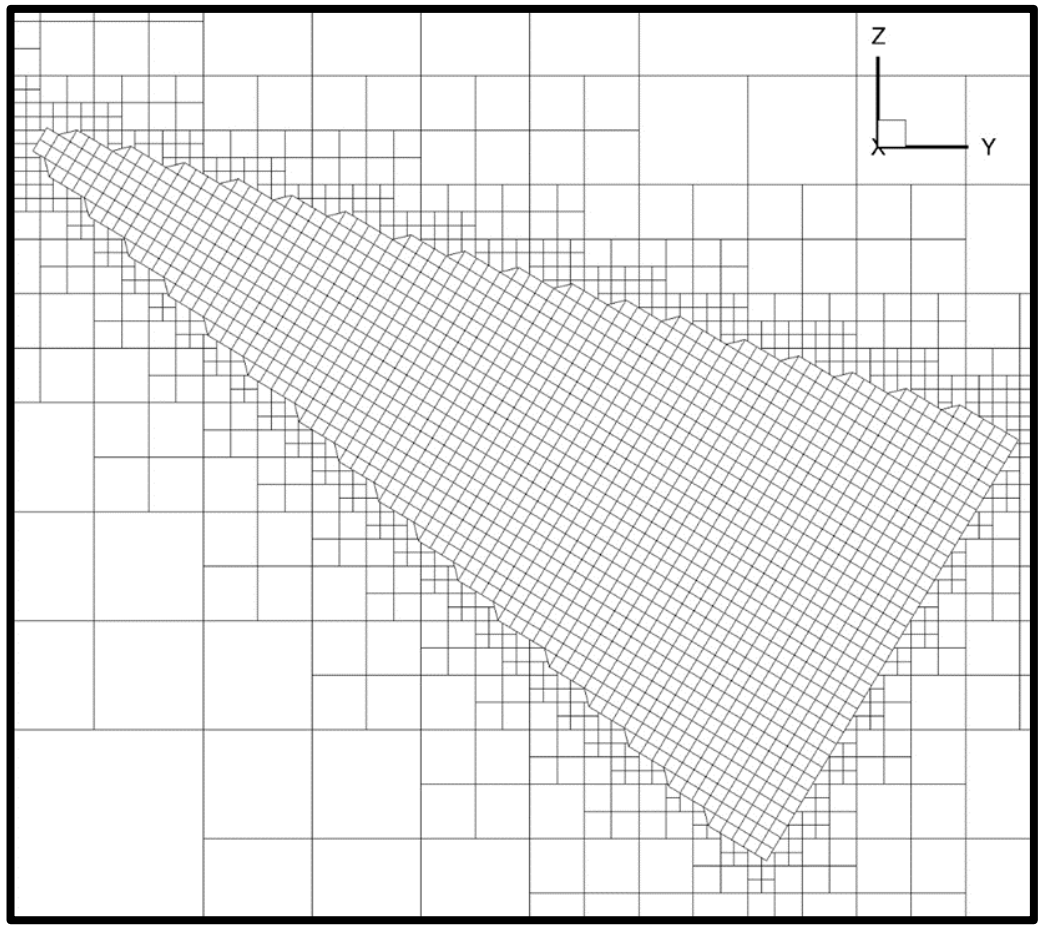


# Creating an Inlaid Mesh

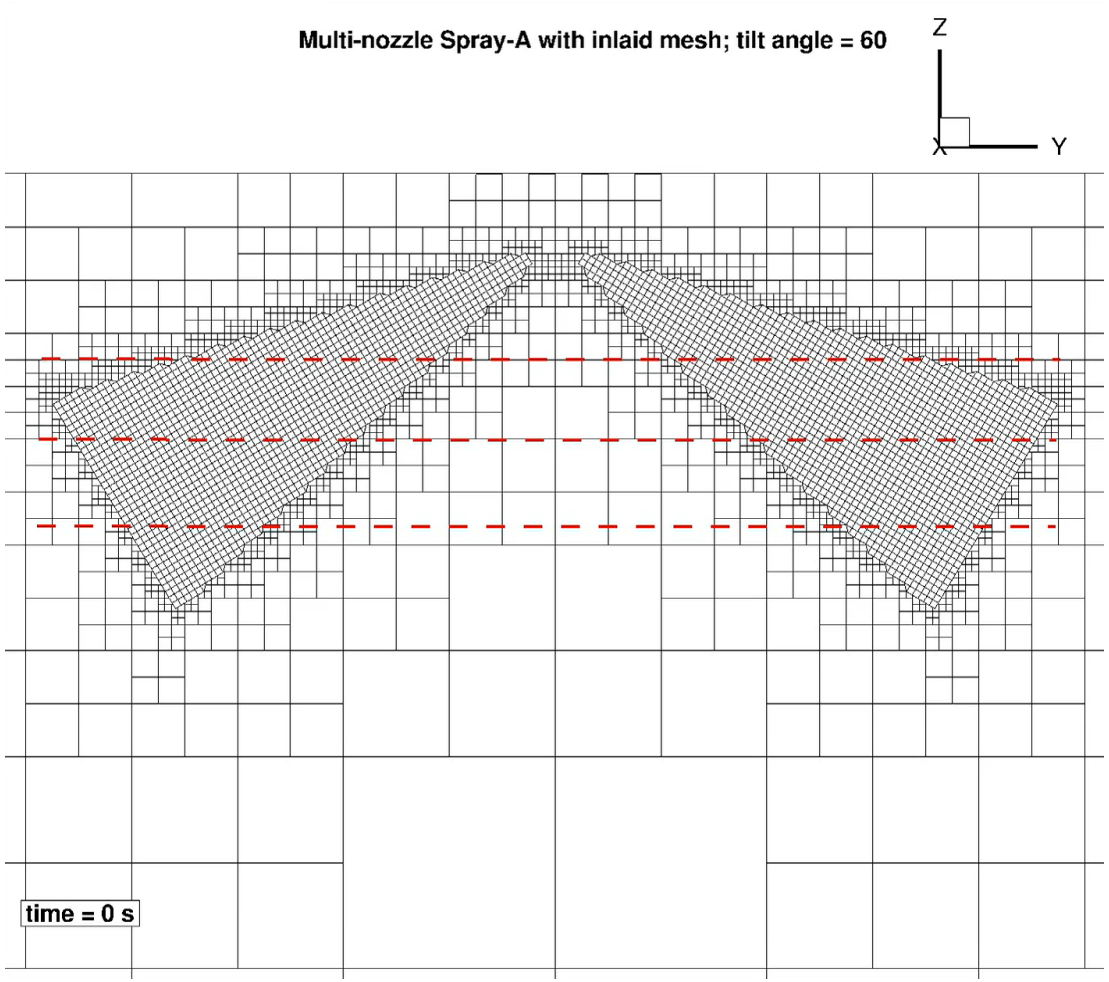
- Inlaid meshes are typically created in CONVERGE Studio
  - Define a shaped mesh away from surfaces (*e.g.*, a spray cone)
  - Extrude a mesh from a triangulated surface (*e.g.*, a boundary layer)
  - You can also import the mesh from the third-party software
- We will first consider a shaped inlaid mesh example

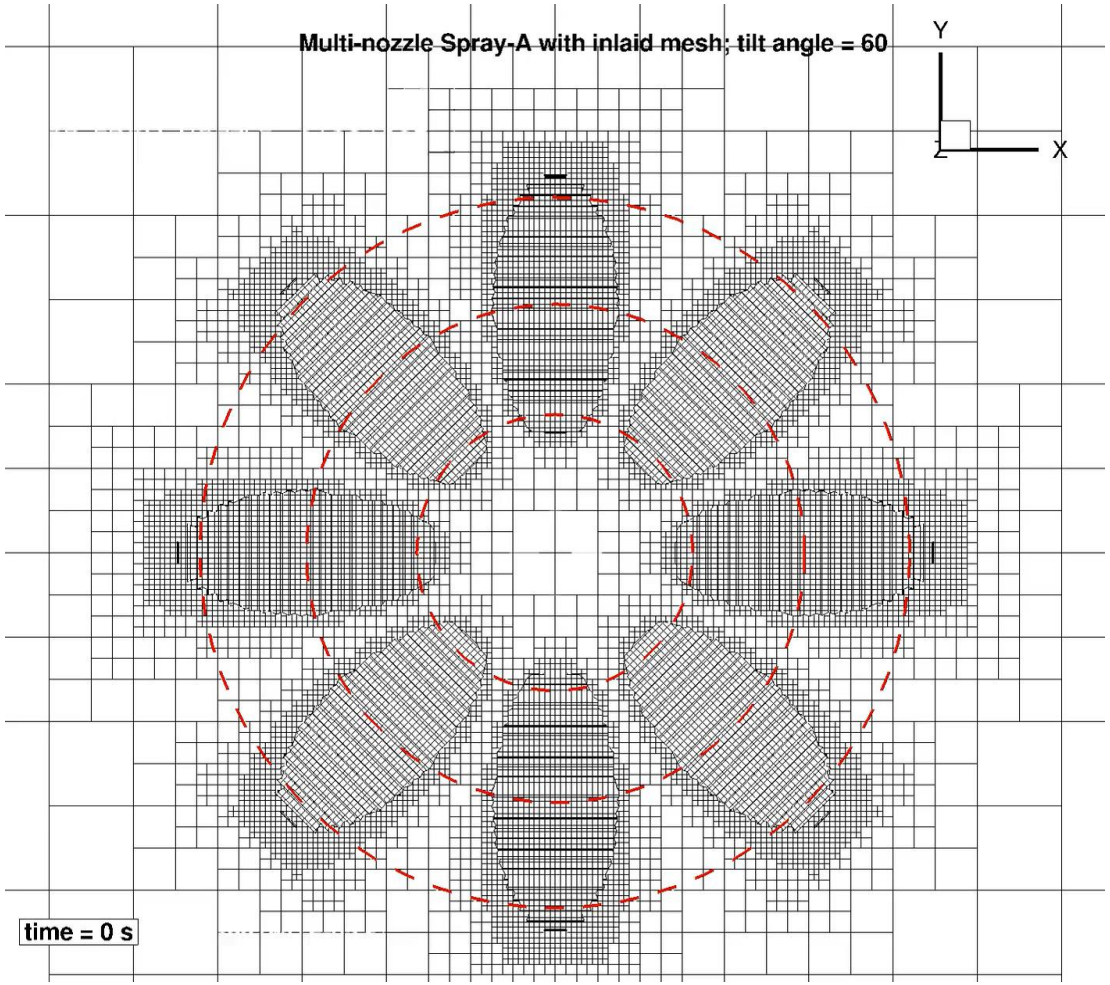
# Inlaid Mesh for Spray (1/3)

- Create a cone of structured cells
- Use embedding in the Cartesian base mesh to approximately match cell sizes

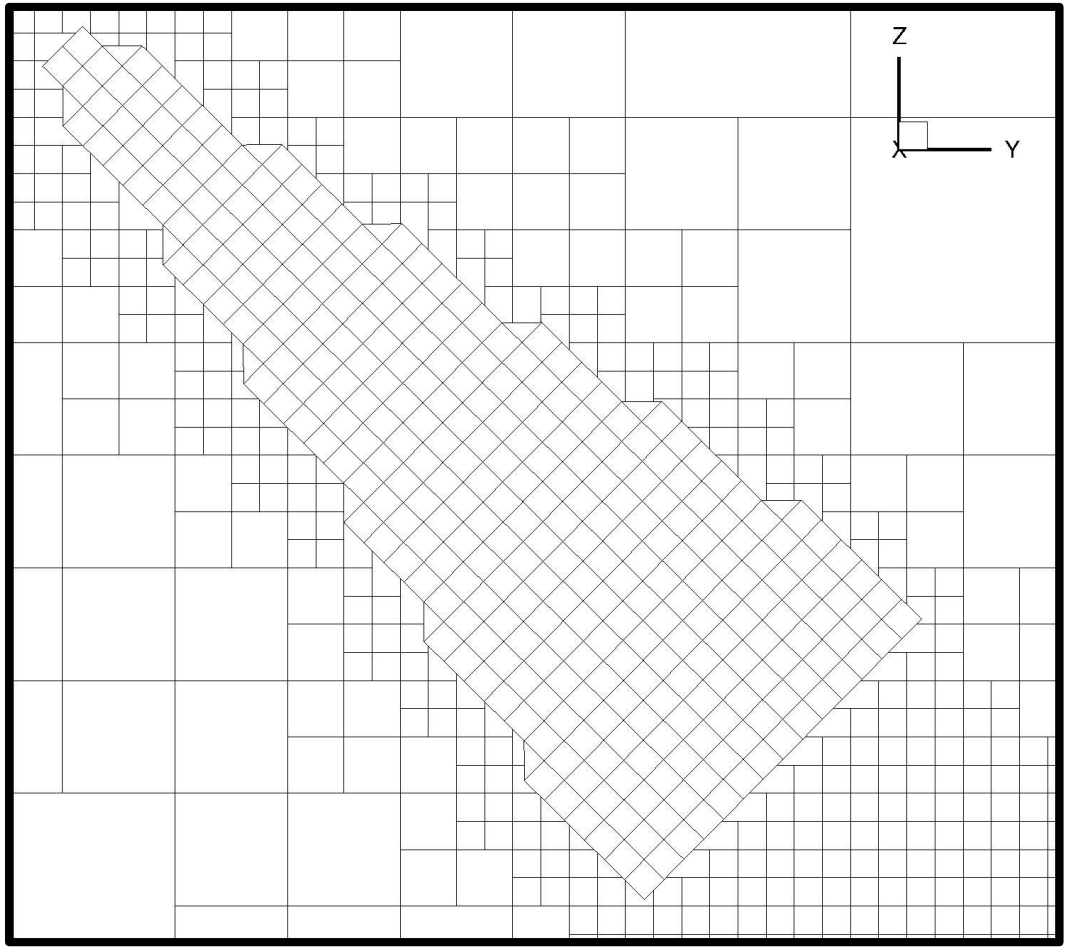


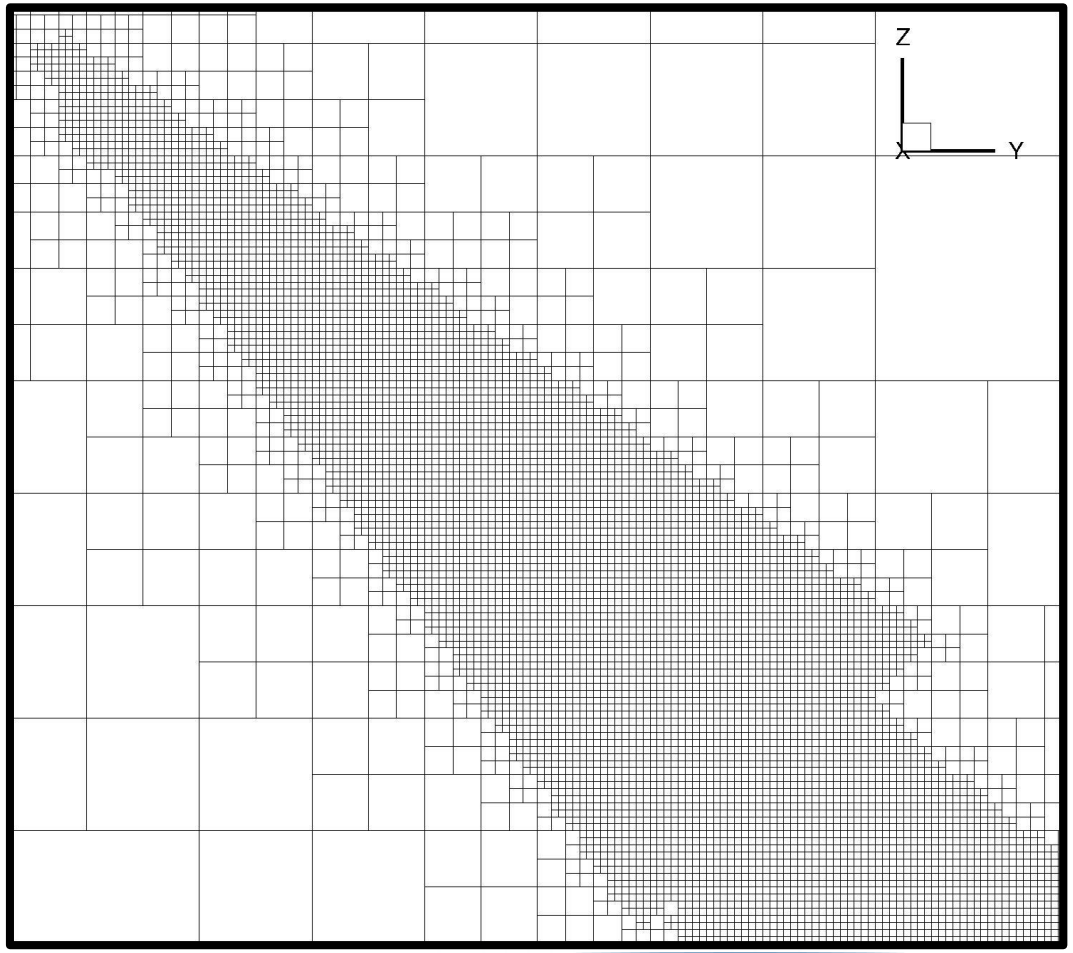
# Inlaid Mesh for Spray (2/3)



# Inlaid Mesh for Spray (3/3)

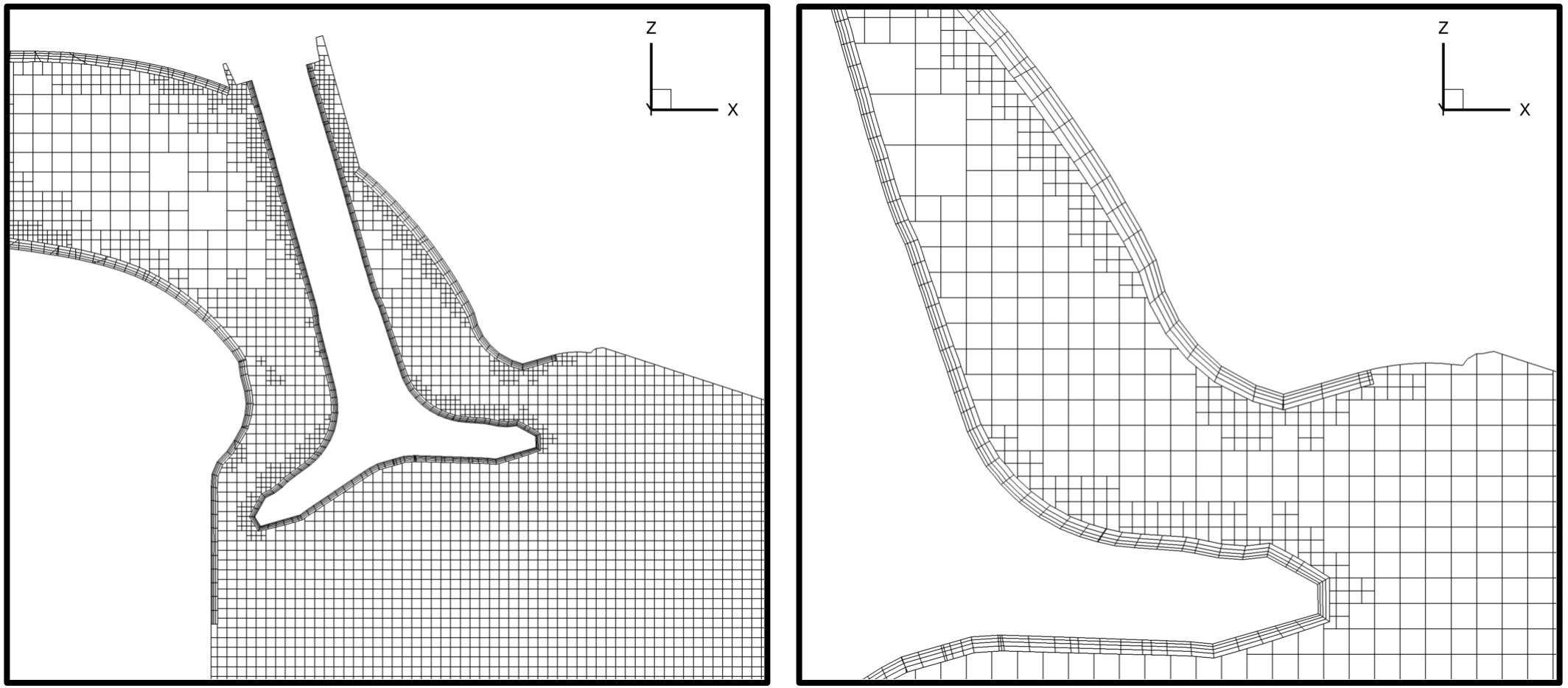


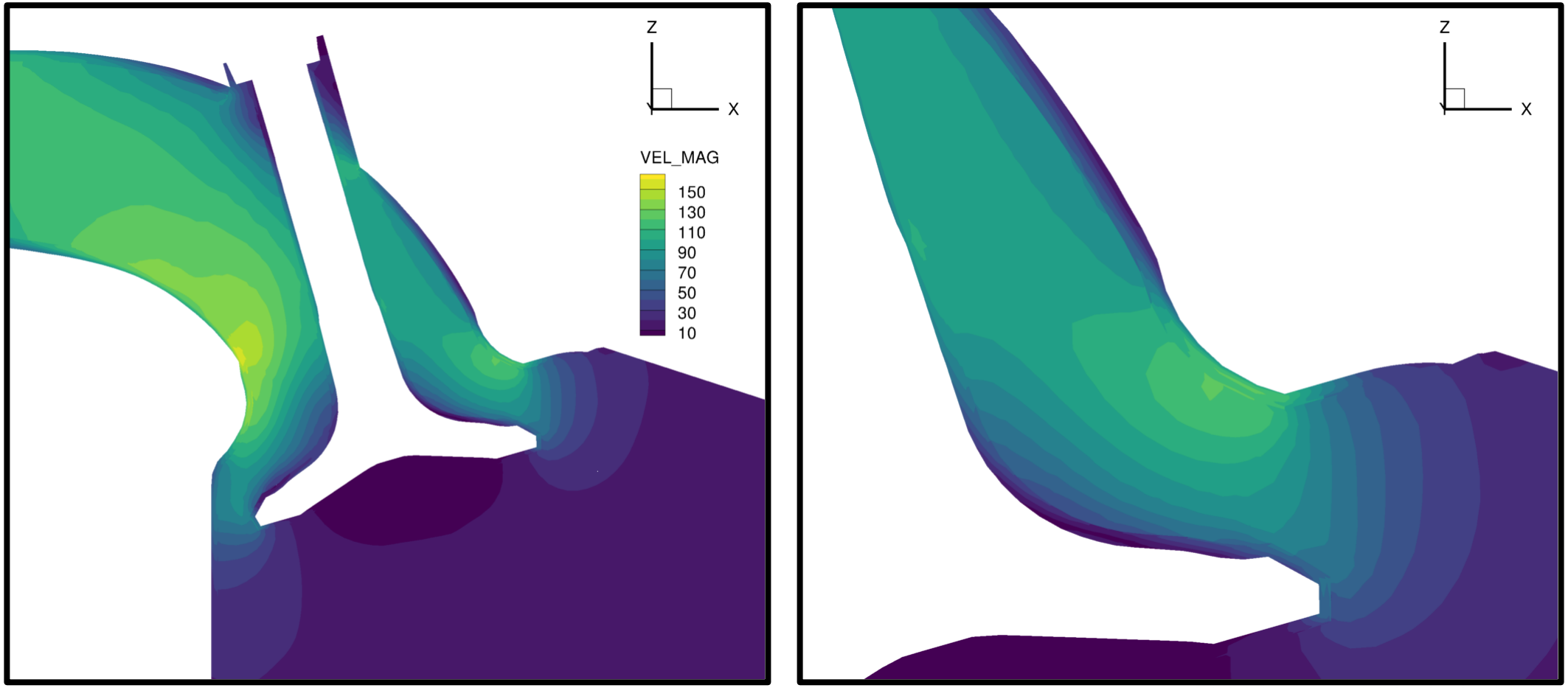
# Inlaid Mesh for Flowbench (1/3)

- CONVERGE Studio can extrude existing surface triangles to generate an inlaid mesh that is suitable for resolving a boundary layer
- Consider the example of the complex curved surface around an IC engine valve (a flowbench case)

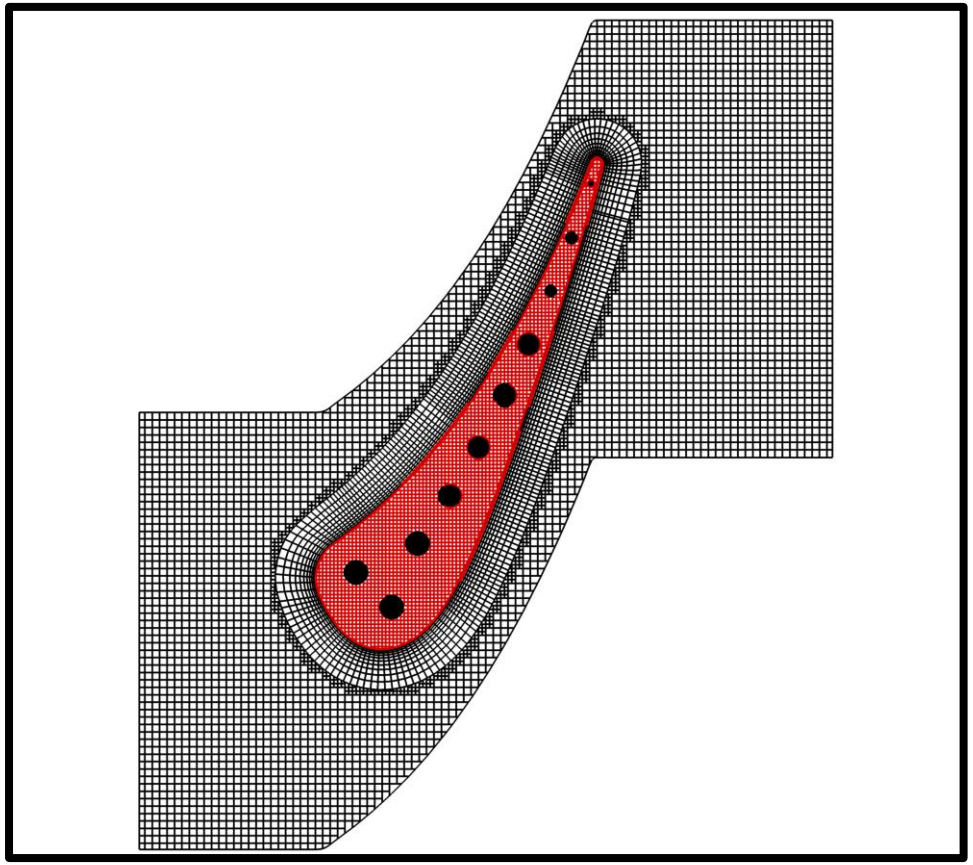
# Inlaid Mesh for Flowbench (2/3)

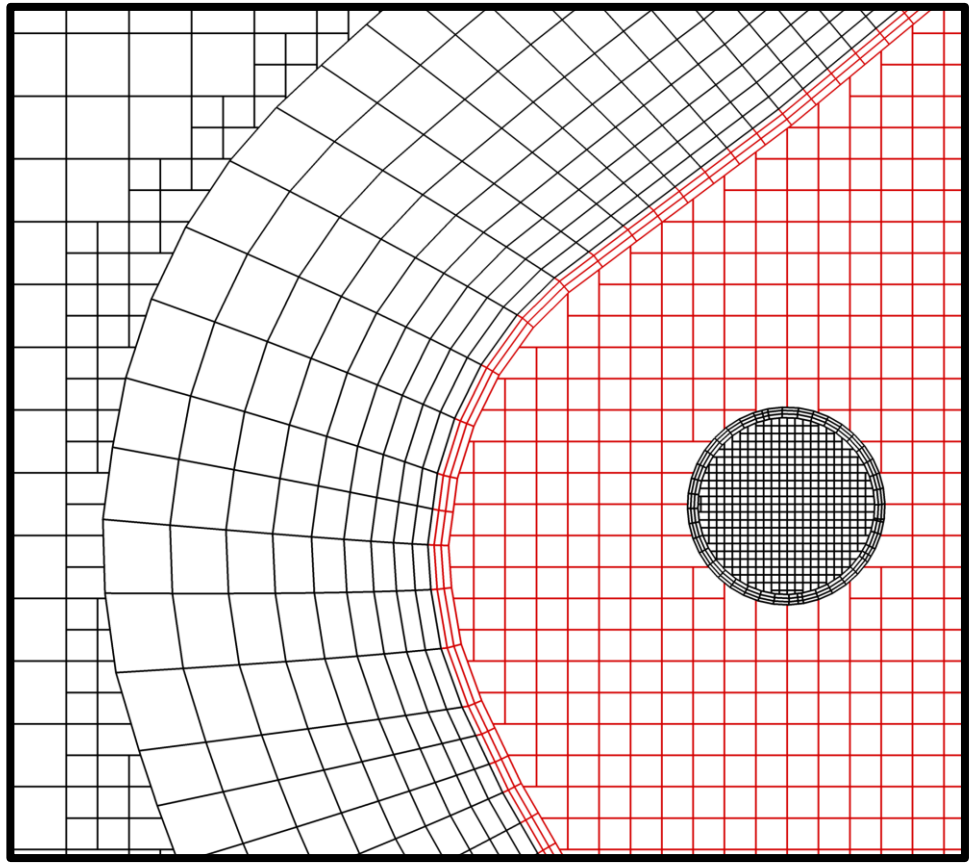


# Inlaid Mesh for Flowbench (3/3)

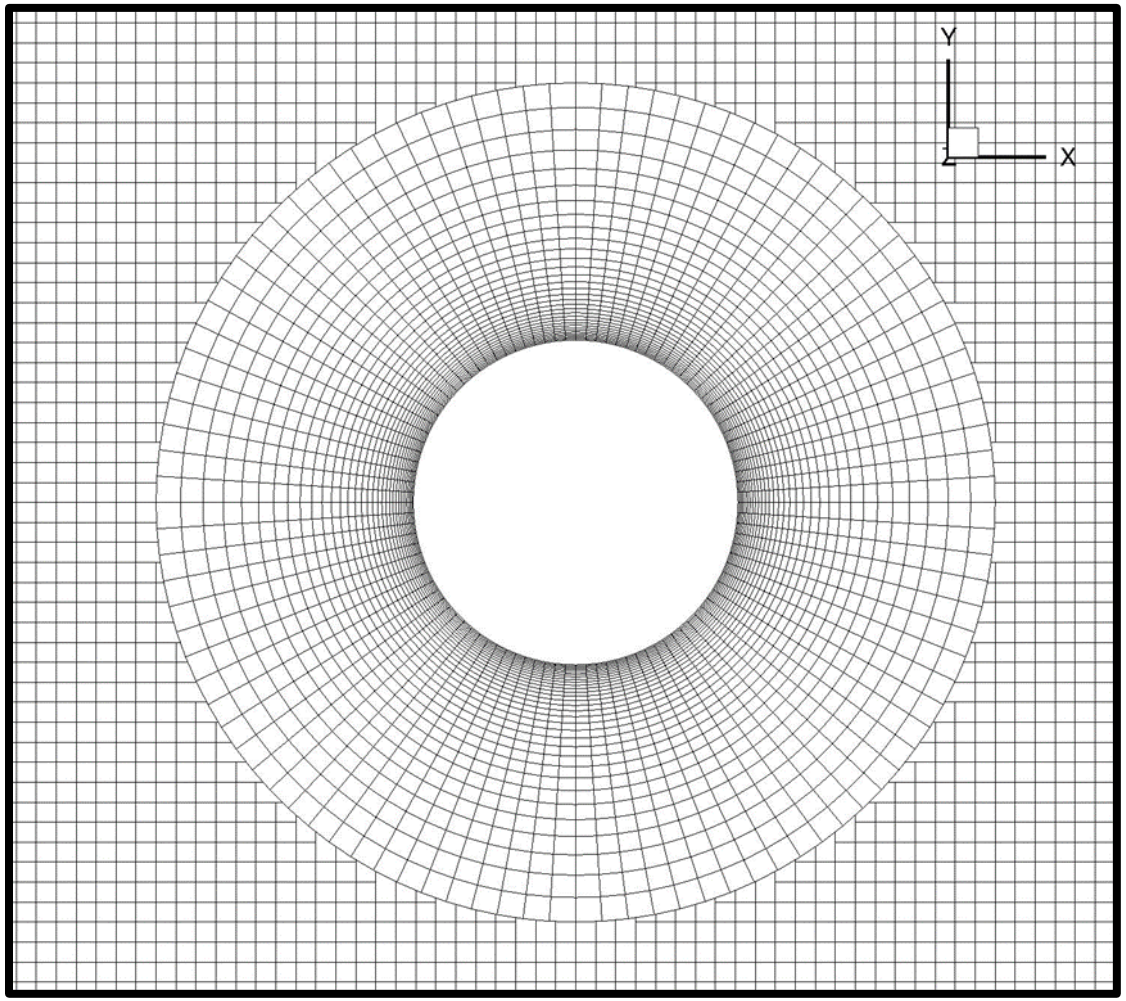


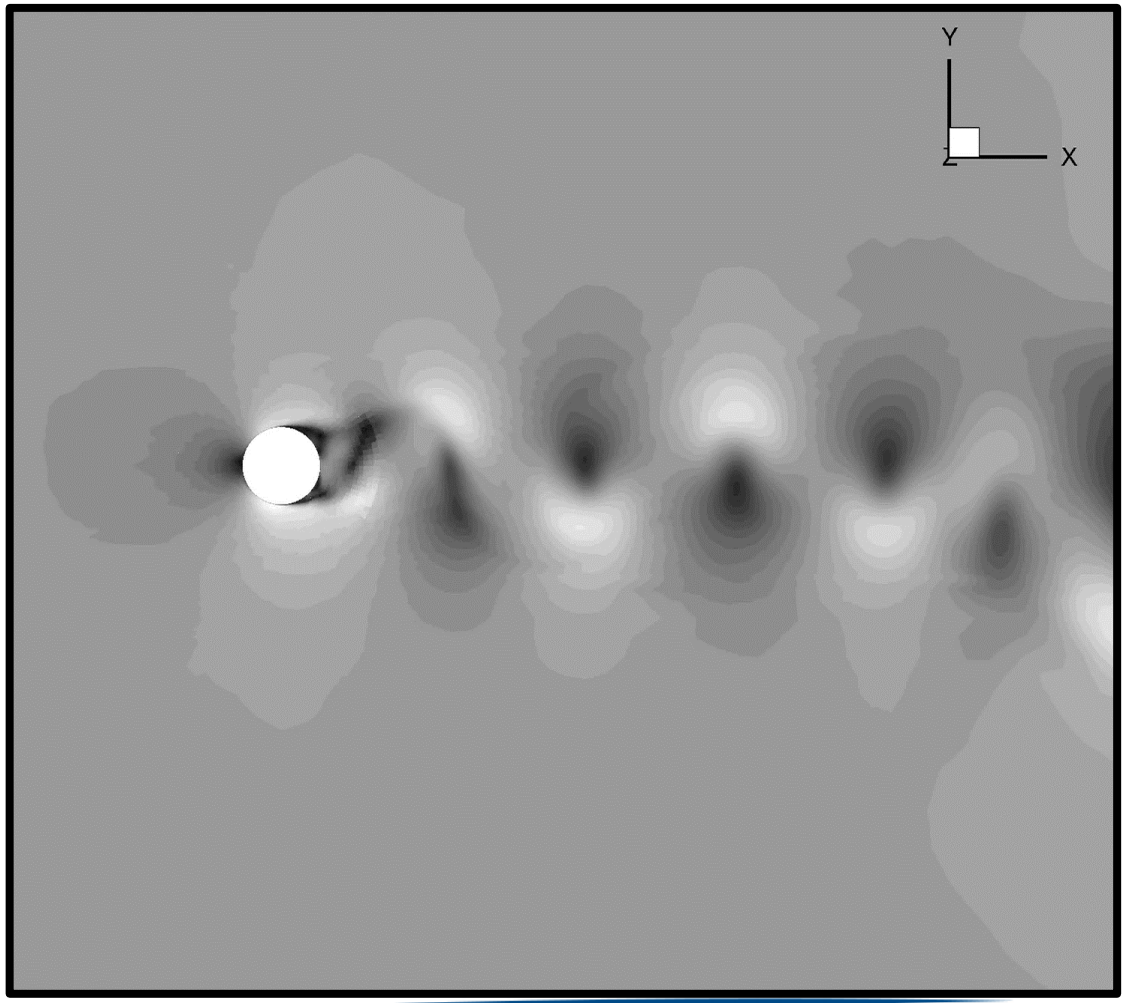
# Inlaid Mesh for Turbine Blade Heat Transfer





# External Aerodynamics: Flow Over a Cylinder



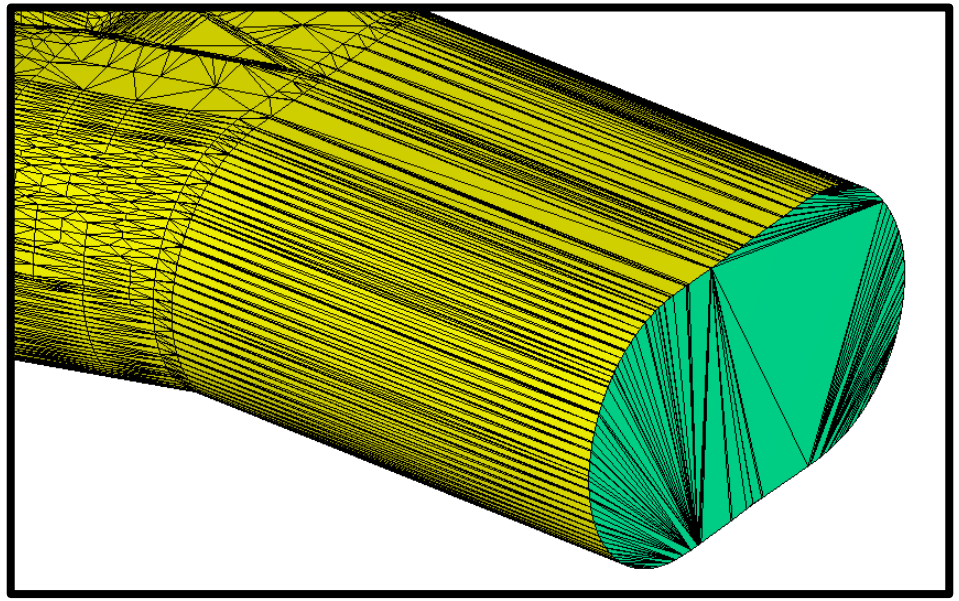



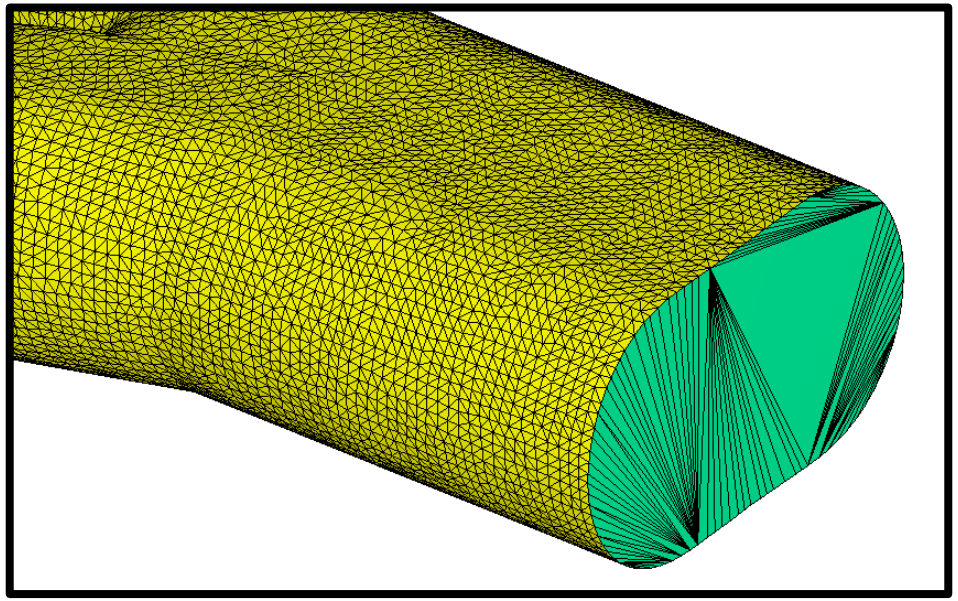
# Mesh Quality

- CONVERGE's autonomous cut-cell mesh approach controls the quality of the Cartesian mesh
- When you generate an inlaid mesh, you are in charge of mesh quality
  - You can direct CONVERGE to output mesh quality metrics by specifying *MESH_QUALITY* in *post.in*
- Things to consider
  - Surface triangulation (if extruding)
  - Shape of the inlaid cells
  - Interfaces between Cartesian and inlaid meshes

# Mesh Quality—Surface Triangulation

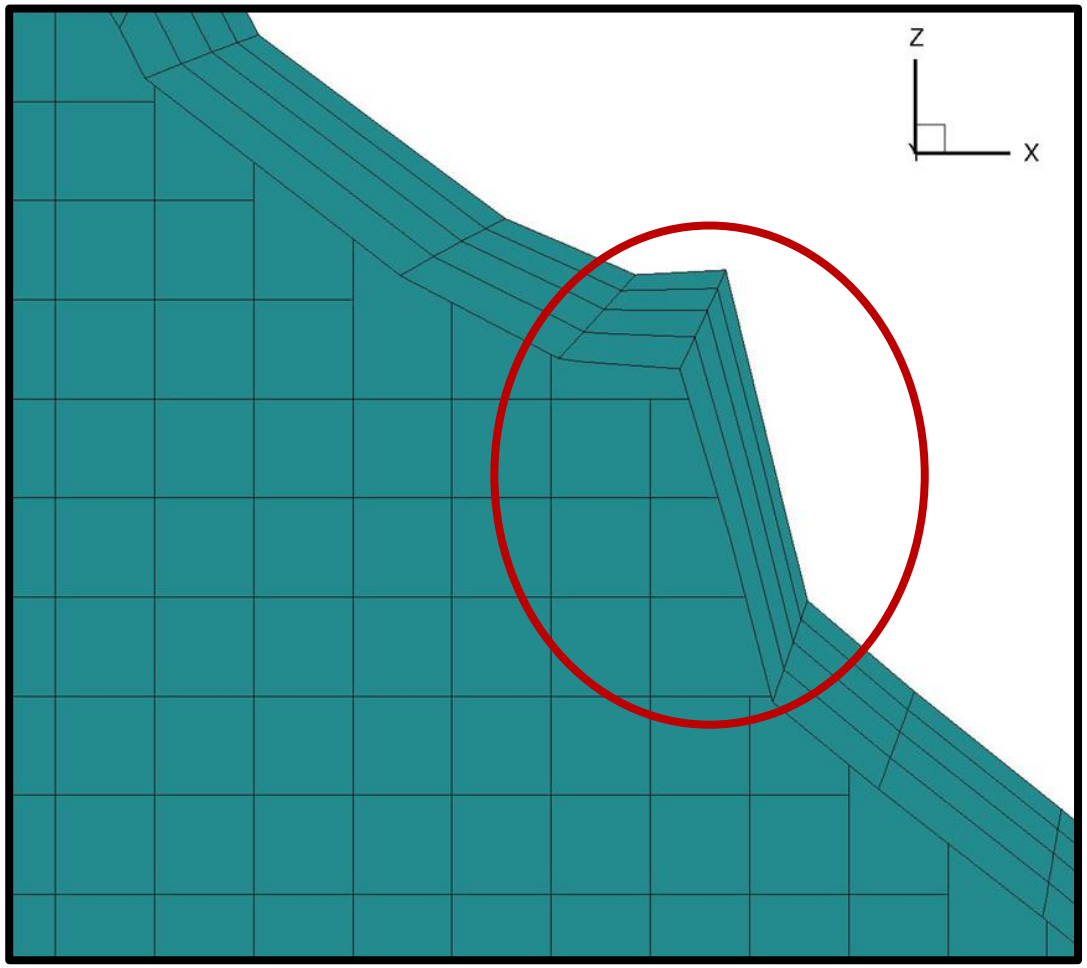
- If extruding from a surface, the triangulation needs to be relatively even
- Uneven triangulation leads to cells with large variation in size
  - This can reduce simulation stability and accuracy





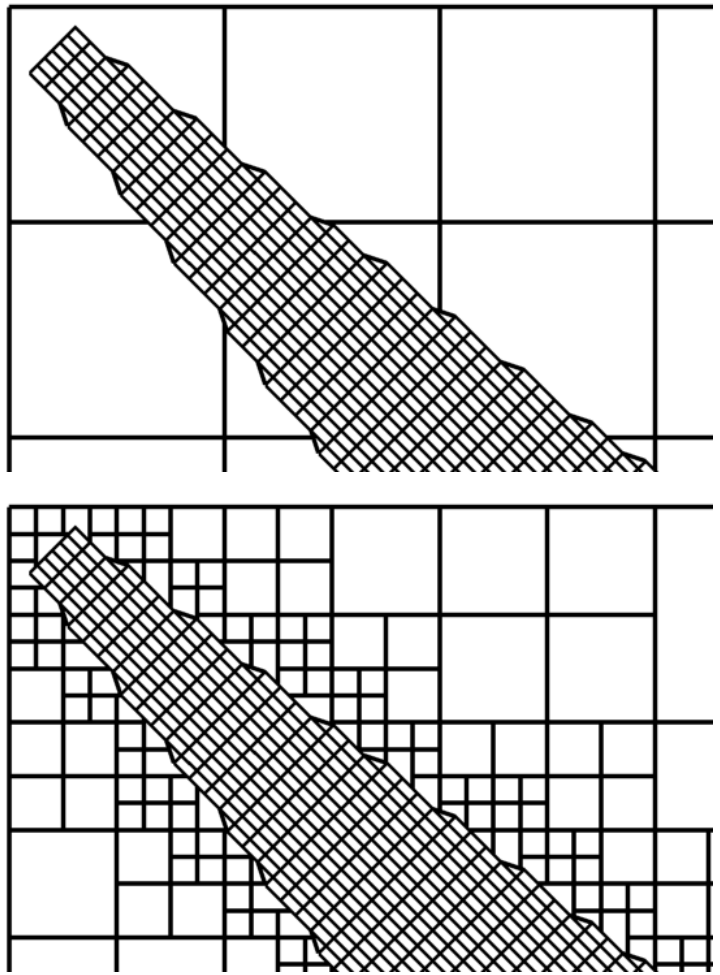
# Mesh Quality—Inlaid Cell Shape

- Several highly non-orthogonal/skewed cells cause recoveries on this mesh
- Getting rid of the inlaid cells in the problem area fixed the recoveries
- Improving the surface triangulation also helps in this situation



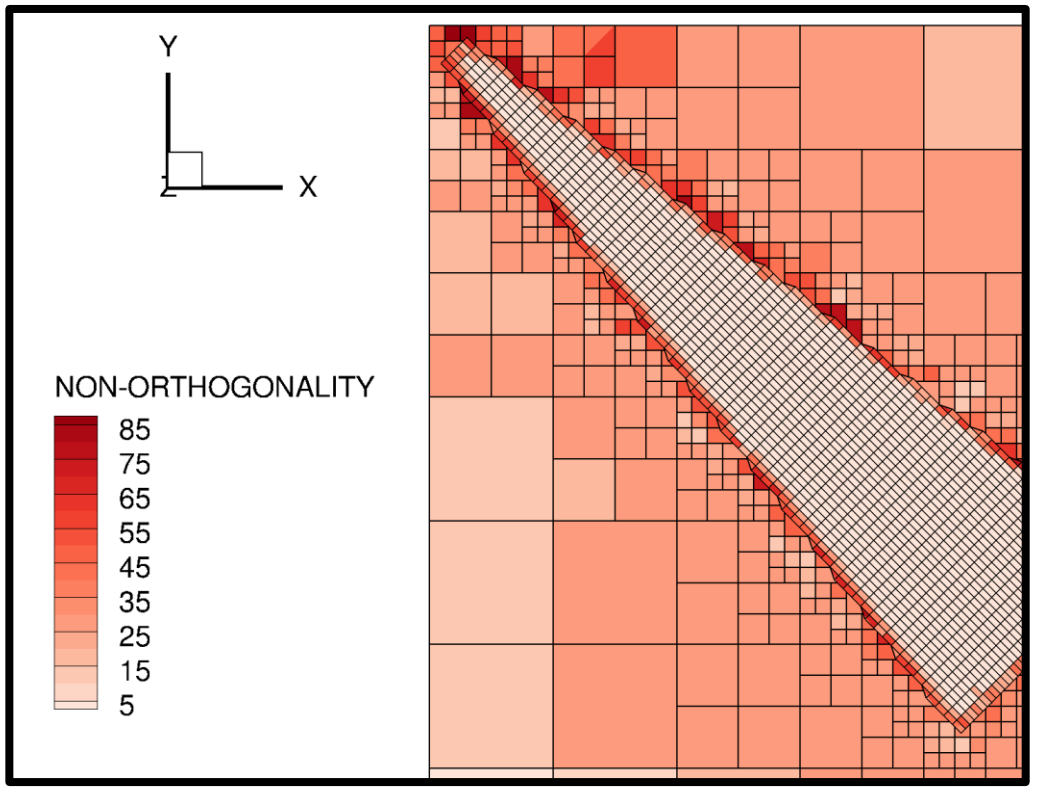
# Mesh Quality—Cartesian/Inlaid Interface

- Having too many neighbors across the interface can lead to instabilities
  - Many inlaid cells adjoining one Cartesian cell (shown)
  - Many Cartesian cells adjoining one inlaid cell
- May or may not be an issue depending on the case
- Ways to fix this issue
  - Shape/boundary embedding
  - AMR based on the number of neighbors across Cartesian/inlaid interface



# Mesh Quality—CONVERGE Quality Metrics

- If directed, CONVERGE will write out mesh quality metrics
  - Aspect ratio
  - Non-orthogonality
  - Skewness
  - Number of inlaid neighbors
  - Number of Cartesian neighbors
  - Face warpage



# Inlaid Mesh Restrictions

- Inlaid meshes cannot be generated on a moving boundary
- Moving boundaries and inlaid cells cannot intersect
- Inlaid cells cannot be refined with fixed embedding or AMR
  - Refinement is allowed in Cartesian cells that neighbor inlaid cells

# Want More Information?

- Section 6.6 in the CONVERGE Manual for details about the inlaid mesh feature
- Section 2.3.8 in the CONVERGE Studio Manual for details about generating an inlaid mesh in CONVERGE Studio

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