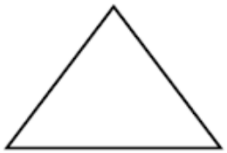
Computational Grid

Geometry definition

- Sources of geometry definitions
  - CAD definition of the structure (complex “engineering” geometries)
  - Mathematical definition of surfaces (simple geometries)
  - Surface grid (previous CFD or other computations)
- Need to be converted for input to grid generation tools
  - Preferable in “clean surface definitions” (e.g. splines)
  - Cleaning of CAD definitions no at all a trivial task

Element types

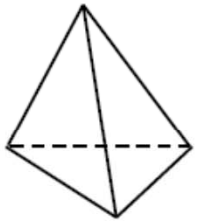
- 2D:



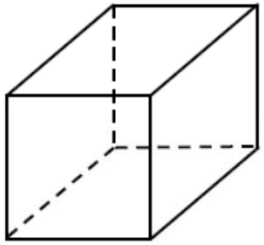
triangle
(**"tri"**)

2D prism
(**quadrilateral**
or **"quad"**)

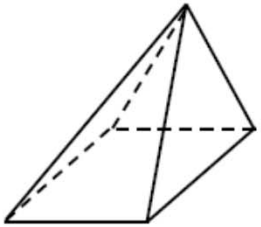
- 3D:



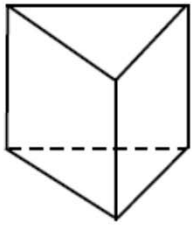
tetrahedron
(**"tet"**)



prism with
quadrilateral base
(**hexahedron** or **"hex"**)



pyramid



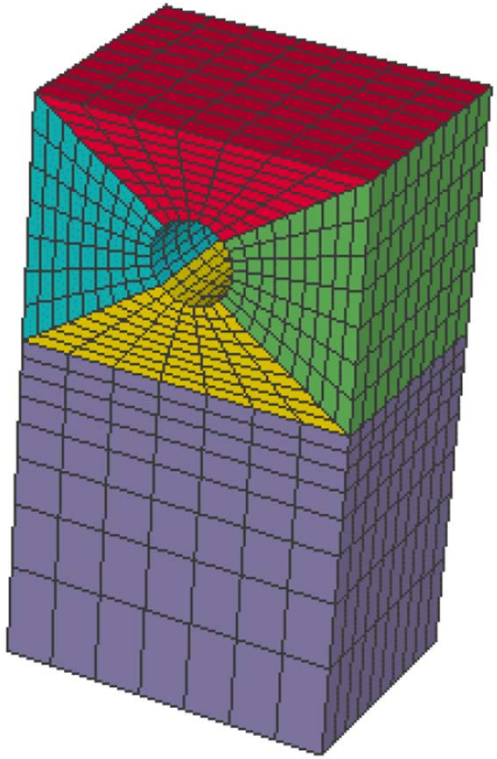
prism with
triangular base
(**wedge**)

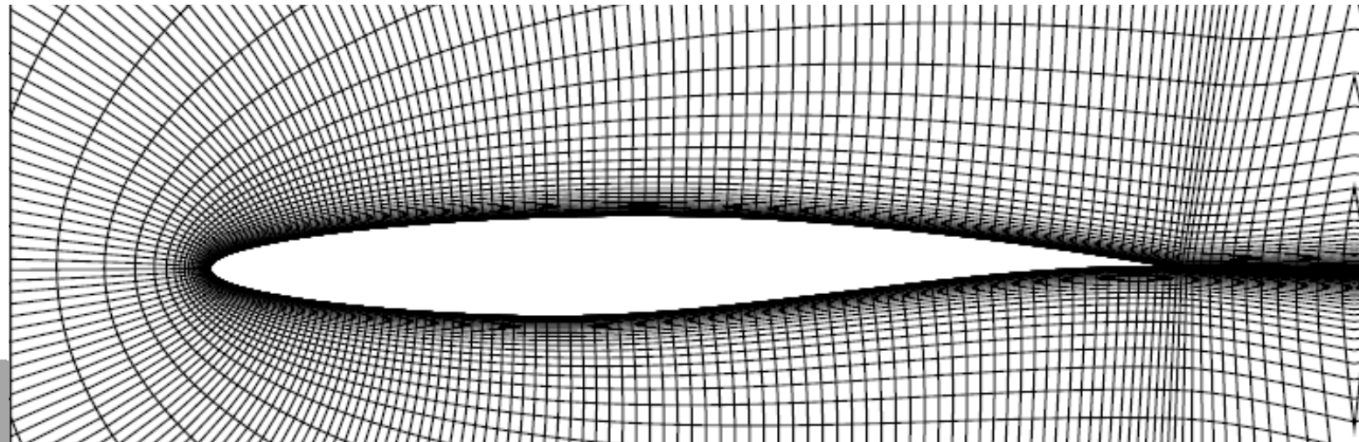
Body-fitted grids

- Grid lines follow the surfaces
- Geometry details can be captured
- Grid points easily clustered in viscous boundary layer
- Could be structured or unstructured or hybrid
- Most frequently used

Structured body-fitted grids

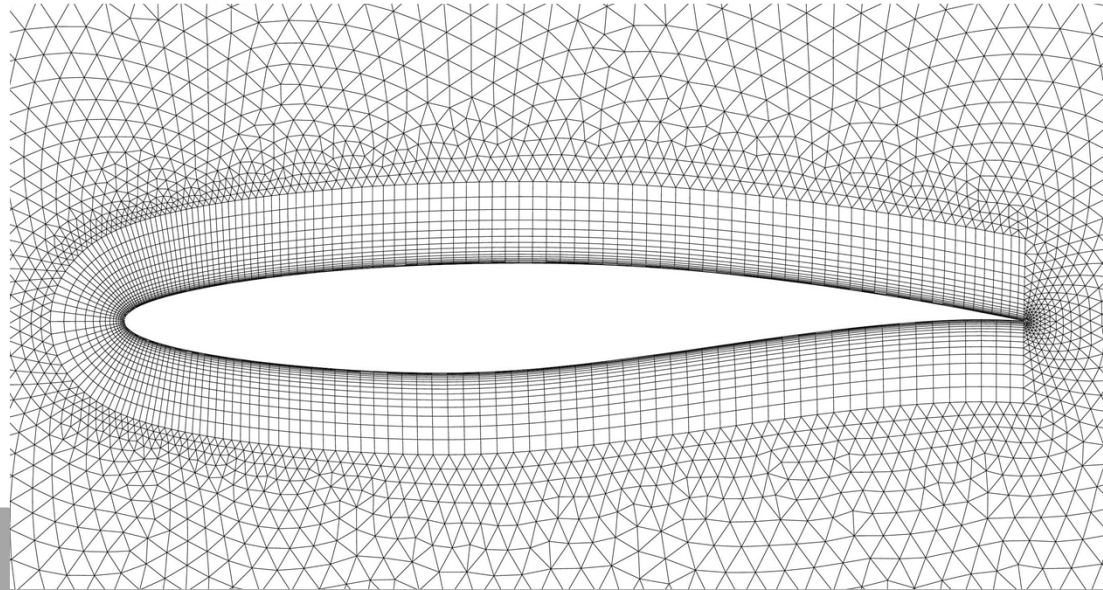
- Efficient solver algorithms
- Solution of high accuracy on well designed grids
- Multi-block approach for complex geometries
- No general automatic grid generation algorithm
- Grid generation a tedious “art” (complex grids can take months!)
- Grid points not easily located where they are needed





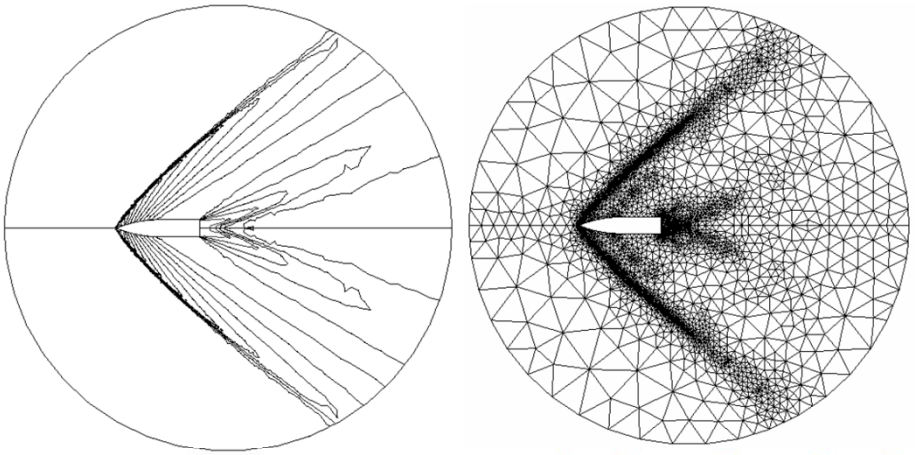
Unstructured body-fitted grids

- Most common in commercial CFD solvers today
- Grid cells of different types (tetrahedra, hexahedra, prisms and pyramids)
- Cell connectivity information -> less efficient solver algorithms
- Grid generation can be highly automized
- Grid points easily clustered without influencing the whole computational domain

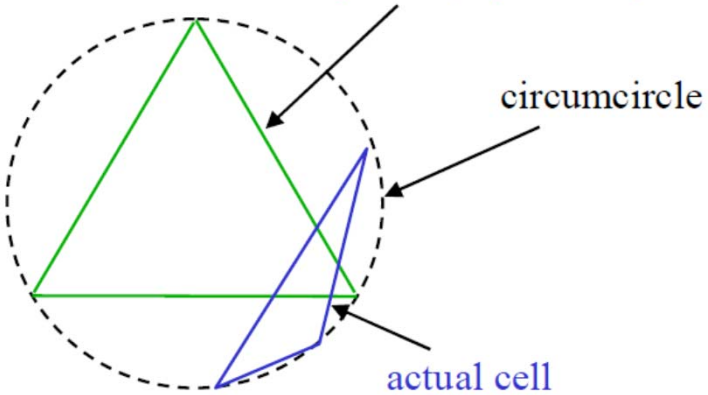


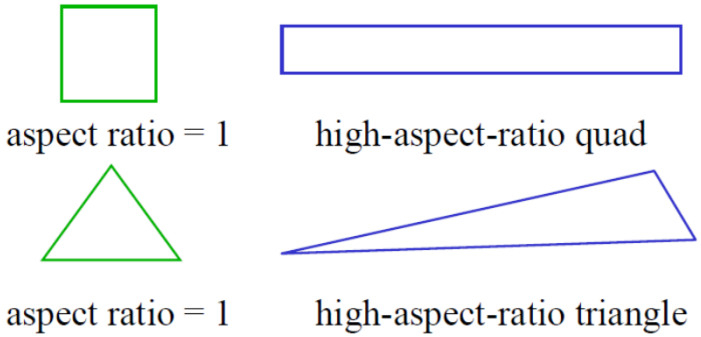
Grid quality

- Sufficiently fine grids
  - Gradients
  - Adaptation
- Shape of the cells
  - Skewness
  - Aspect ratio
    - usually no problem, 1000 in BL
- Orientation of cell faces
  - Normal to gradients
- Spatial distribution of cell sizes
  - Smooth change – max 20%

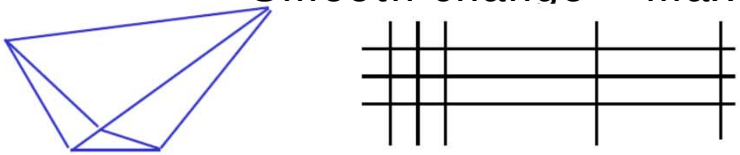


optimal (equilateral) cell





smooth change
in cell size



sudden change
in cell size — AVOID!

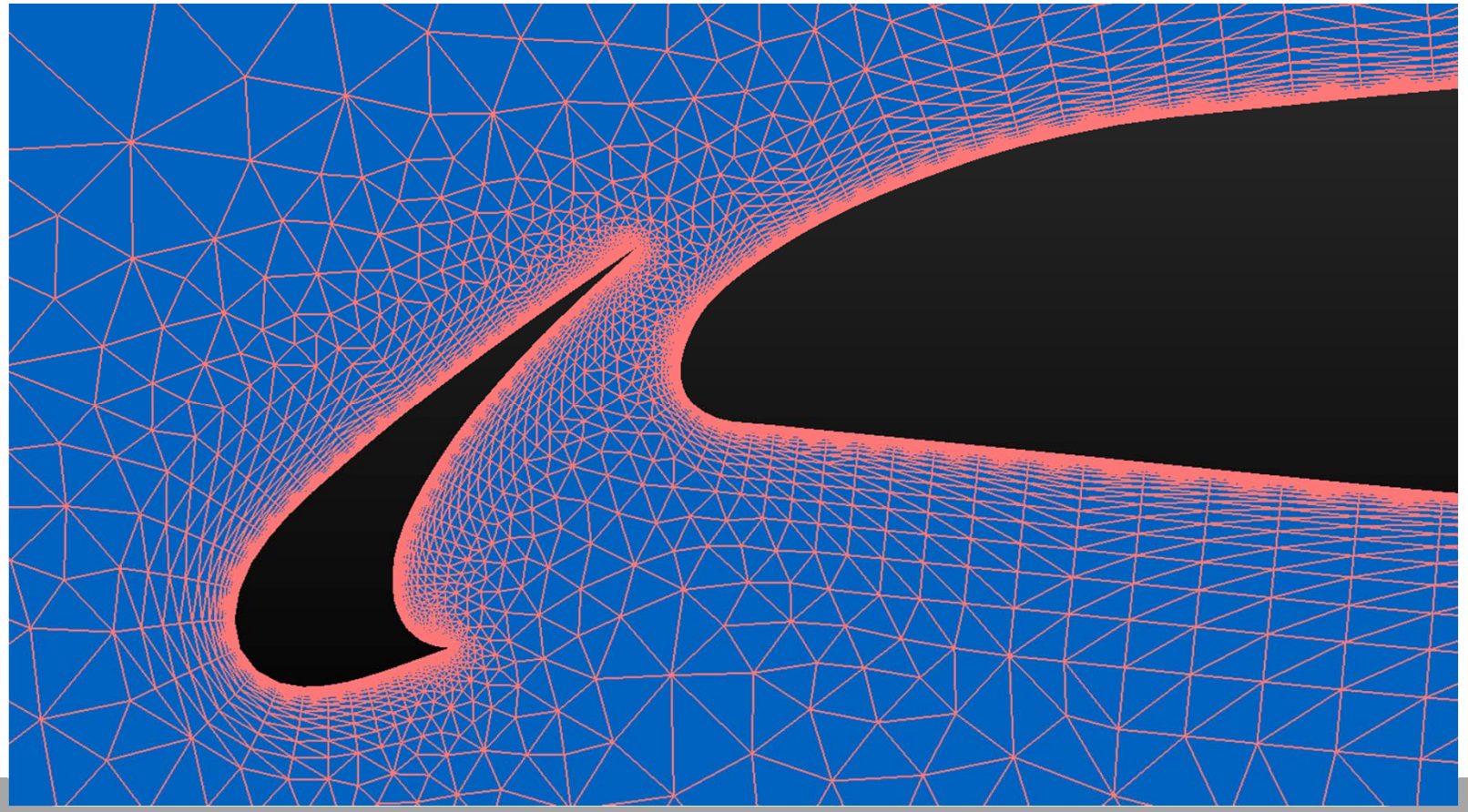
Grid quality …

- Grid quality is particularly important around large gradients
- Grid quality may influence both
  - accuracy and
  - numerical stability
- Grid topology
- “Prismatic layers” in boundary layers (unstructured grids)
  - “structured” near-wall grid
  - Improves grid quality
  - High *Re* boundary layers

Examples

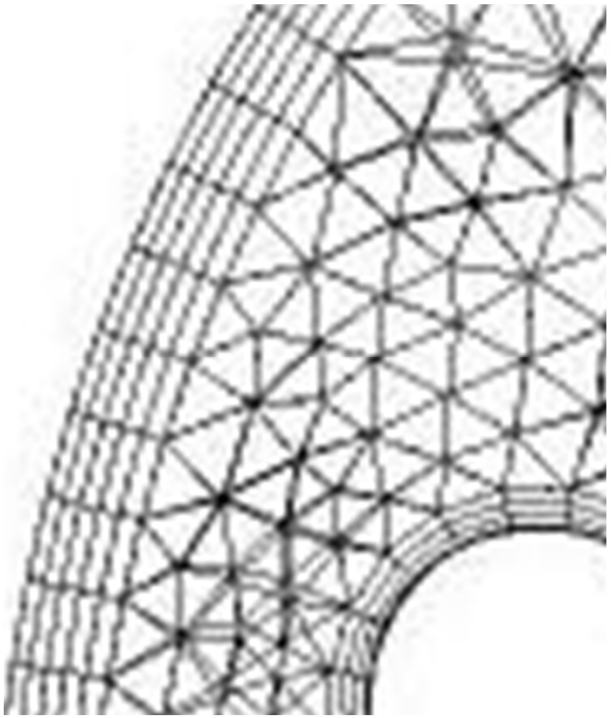
High-lift wing profile

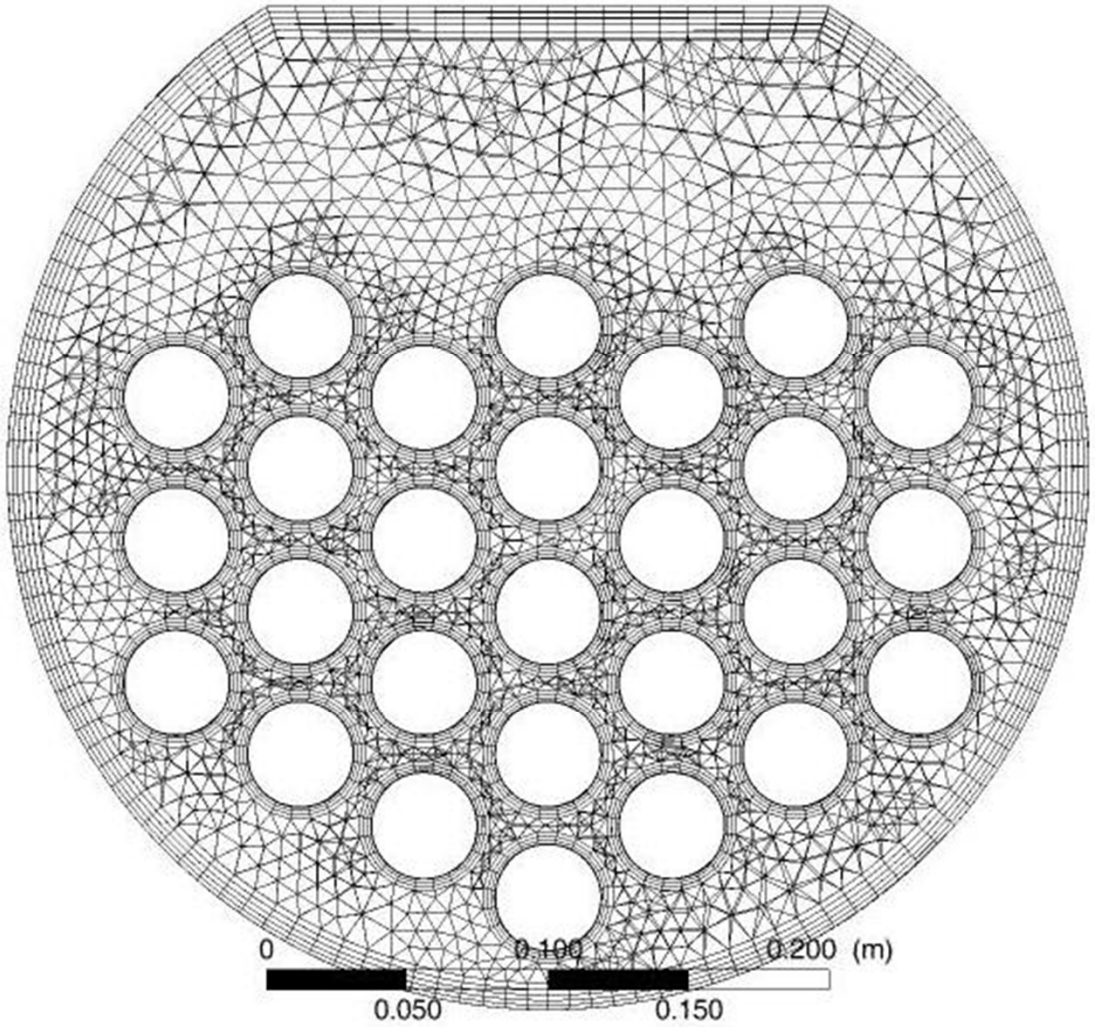
- Wake & shear layer not resolved
- BL mesh triangularized



Rod bundle

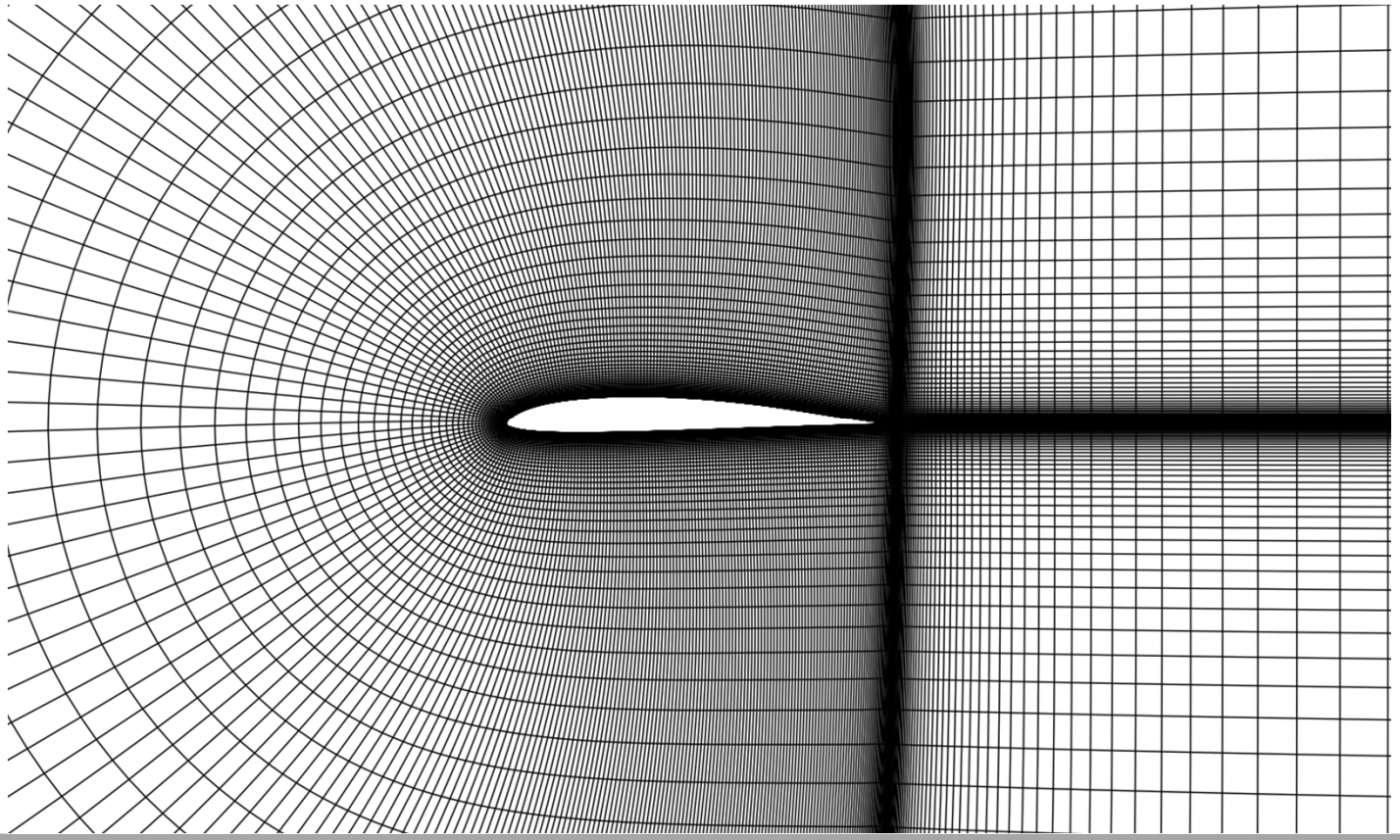
- Cell size jumps





Wing profile

- Grid topology - refined where not needed
  - To many points and convergence problems



Internal flow

- Grid topology – Skewed cells