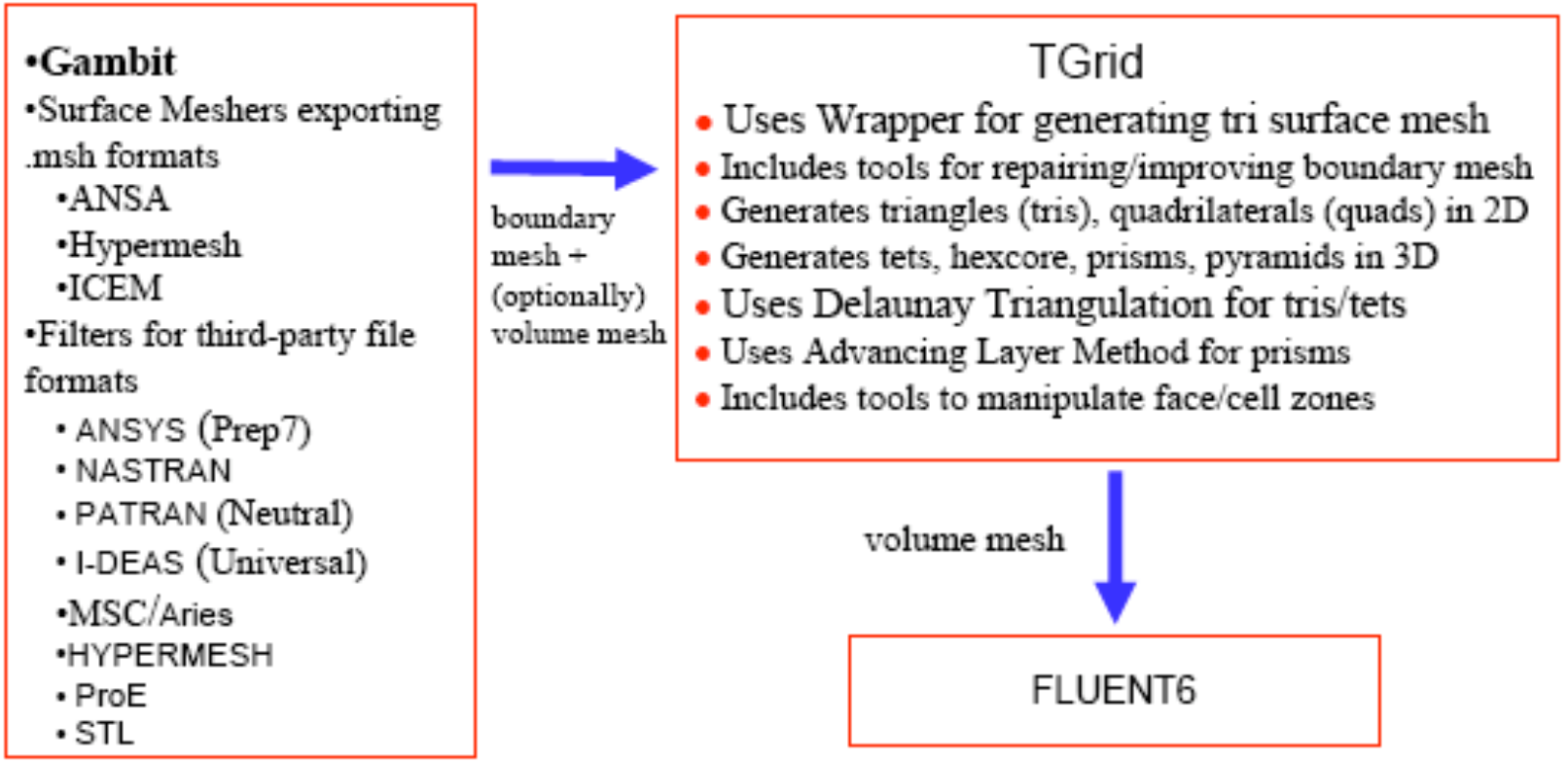
Grid Generation
TGrid

What is TGrid?

- A robust and highly automated unstructured volume mesh generator:



Gambit vs. TGrid

Gambit is a grid-generator and a geometry modeler

TGrid is a "pure" grid generator

Gambit is a general purpose grid generator for unstructured grids

TGrid is more focused on tet-based algorithms

Gambit-GUI is "more" user-friendly

TGrid-GUI is aligned with Fluent solver interface

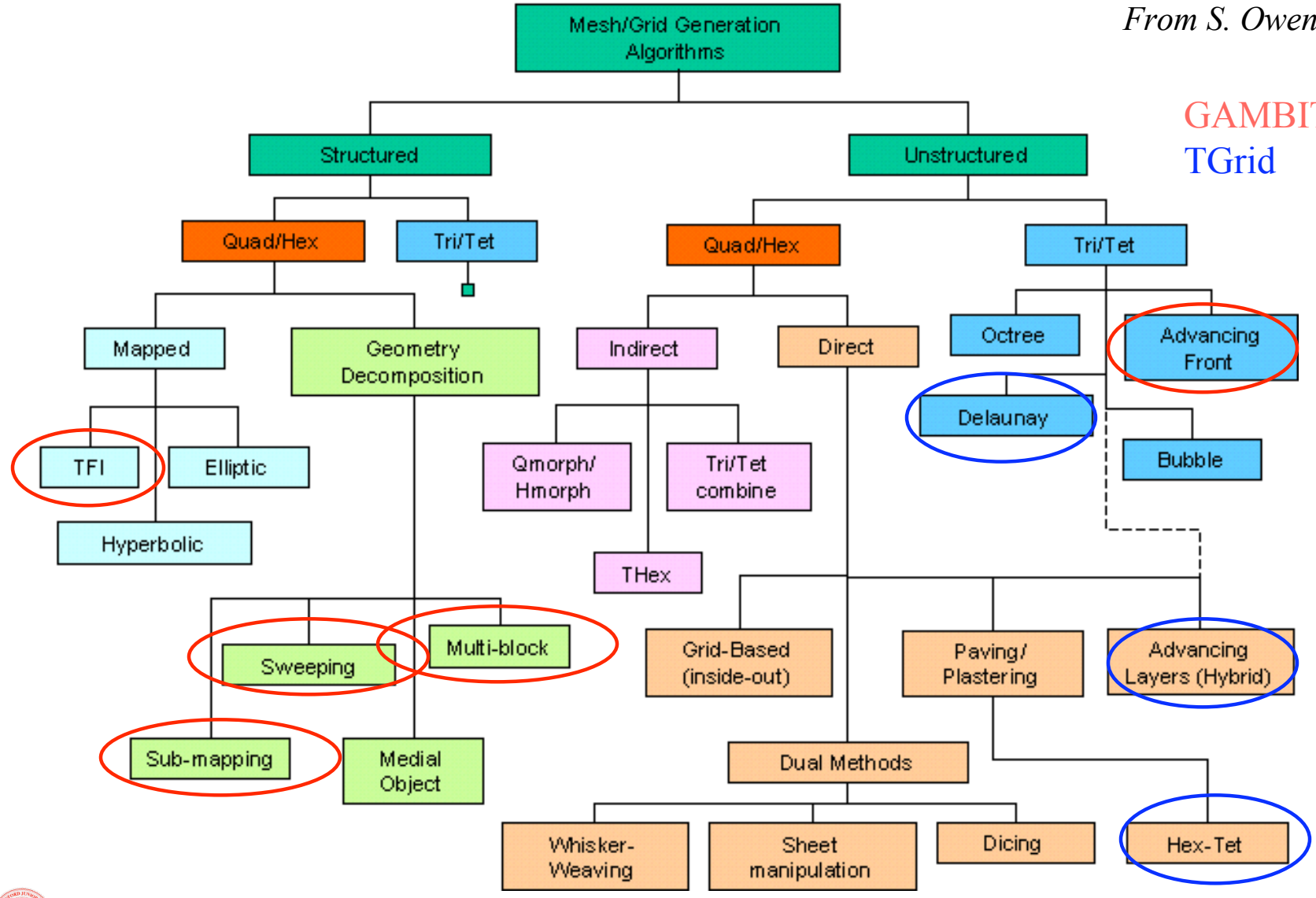
Gambit and TGrid

- TGRID has powerful boundary repair and mesh generation tools, which can be used to:
  - Repair and refine surface meshes
    - Improve mesh quality and remove disconnects
    - Refine mesh based on proximity, curvature or geometric features.
  - Generate surface wrapper mesh on highly complex and "dirty" geometry.
    - Easily handle small features, gaps and disconnects.
  - Grow prism boundary layers on complex geometry.
    - Robust prism growth capabilities.
  - Advanced control of volume meshing.
    - Pinpoint meshing problems and use mesh initialization/refinement controls.

Grid generation techniques

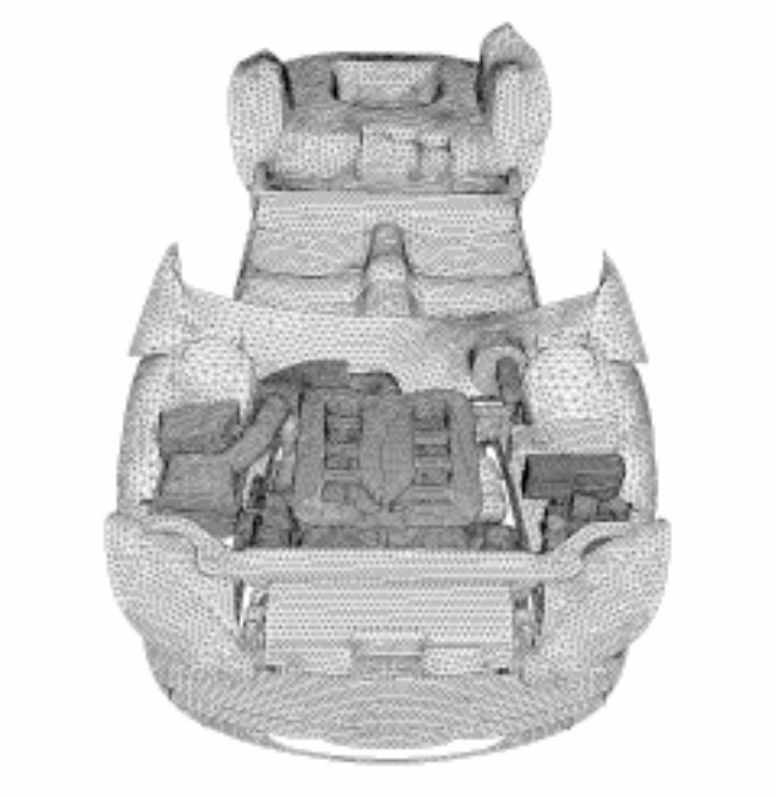
From S. Owen, 2005

GAMBIT
TGrid



Tetrahedral Meshes

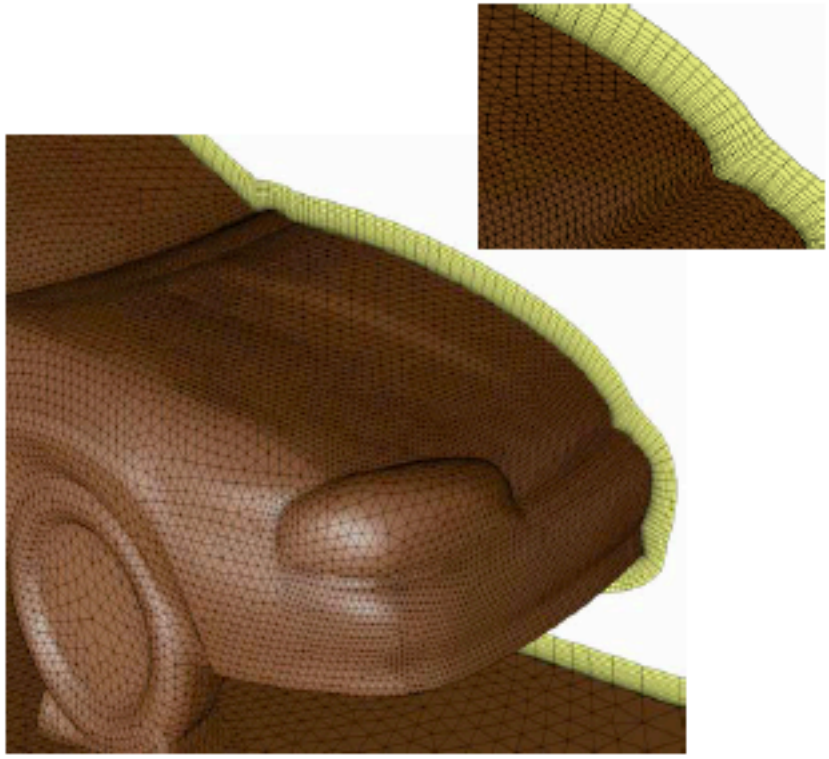
- Start from 3D boundary mesh containing only triangular faces.
- Generate mesh consisting of tetrahedra.
- Advanced control of volume meshing.
  - Set initialization and refinement controls
  - View unmeshed nodes to pinpoint problem areas.
  - Perform local refinement in a defined region.



Surface mesh for a grid containing only tetrahedra

Hybrid Meshes

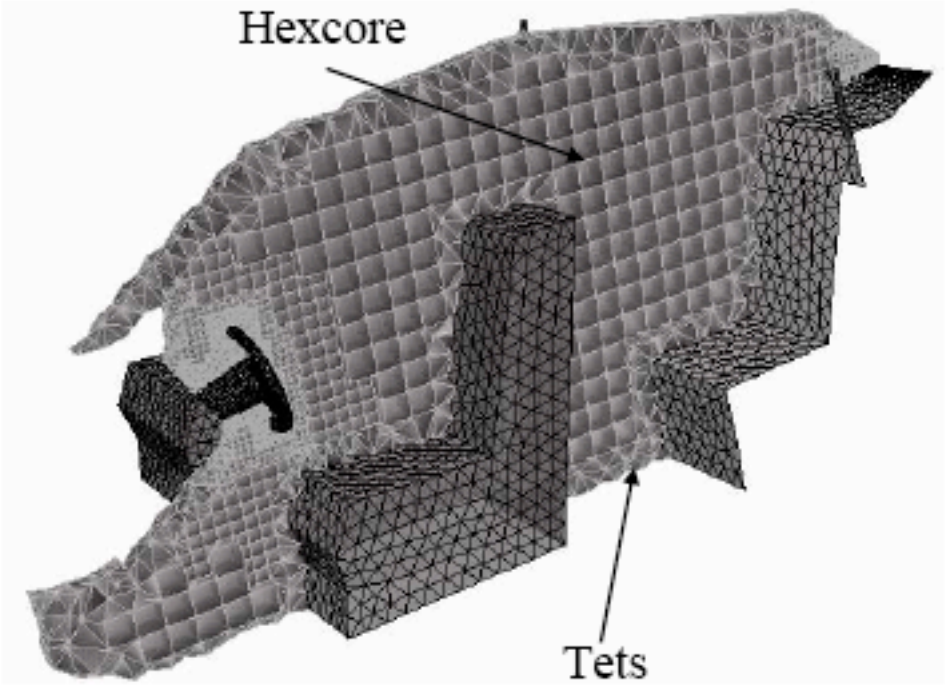
- Start from 3D boundary mesh containing triangular and/or quadrilateral faces.
- Obtain better quality/more efficient mesh using:
  - Prisms (wedges) for greater resolution in boundary layer
  - Tetrahedra ("tets") for rest of domain
- Robust Prism Growth capabilities:
  - Different prism layers can be grown on adjacent geometry.
  - Four different types of prism layers available.
  - Handle complex geometry, thin gaps and sharp corners.
  - Remesh adjacent mesh.



Grid with prisms in a boundary layer region

HexCore Meshes

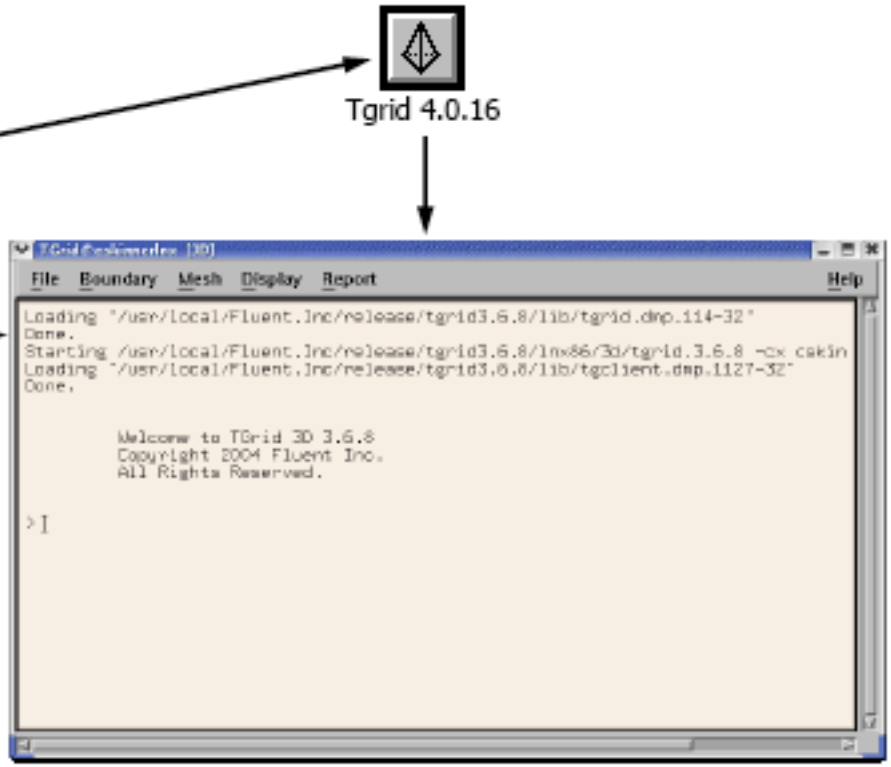
- Start from 3D boundary mesh containing only triangular faces
  - Automatic hexcore creation
- Suitable for curved/complex geometries with large open spaces
- Significantly smaller mesh size compared with purely tet cells
  - Fully compatible with boundary layer prism meshes



Hexcore mesh consists of two regions; an inner region of Cartesian hex cells and an outer region of tetrahedral cells

Starting Up

- To start TGrid
  - On a Windows system: click on the TGrid shortcut icon and then select 2d or 3d.
  - On a UNIX system: type `tgrid 2d` or `tgrid 3d`.
- Console window will appear.
- Text interface and complete graphical user interface (GUI)
- User interface similar in layout and operation to FLUENT6 interface.

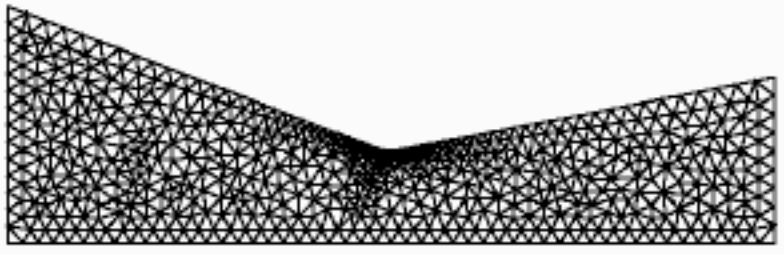


- Complete on-line help using hypertext format

Tri/Tet Mesh Generation

- Two phases:
  - **Initial mesh generation**: Create initial mesh of the volume. Coarse, highly skewed elements used as a starting point for the final volume mesh.
  - **Refinement on initial mesh**: Add nodes and cells to initial mesh trying to improve quality.

Boundary refinement

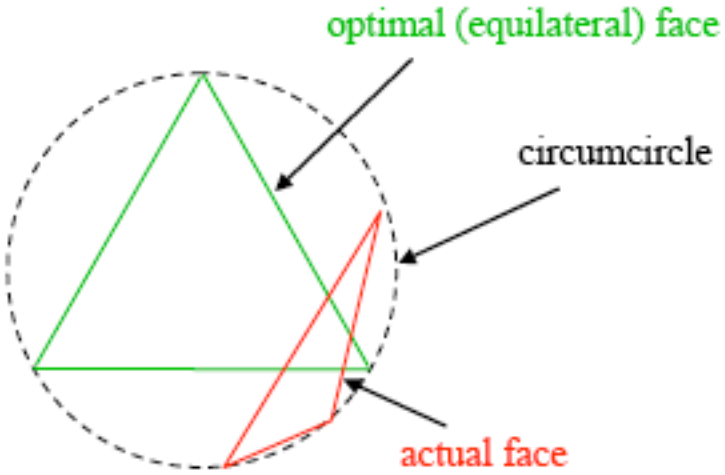


Cell zone refinement

- Initialisation and refinement can be automatic or manual.

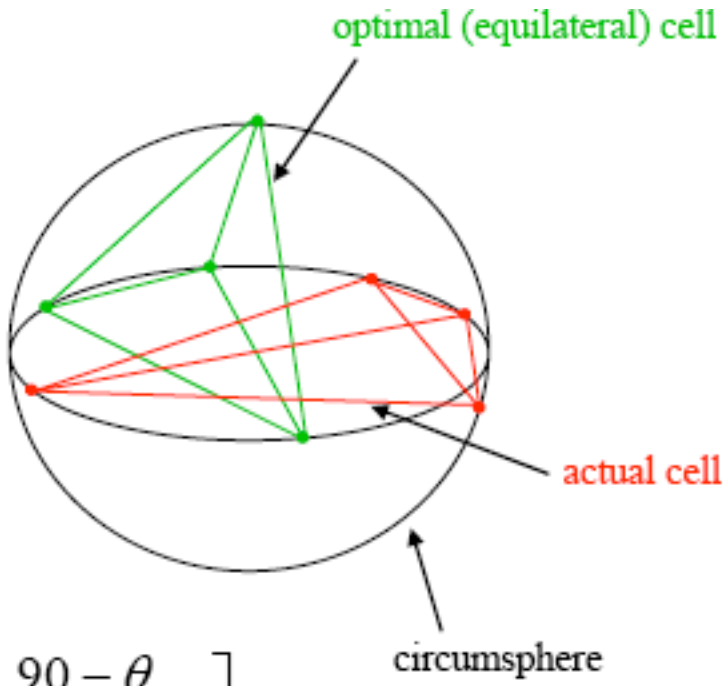
Tri/Tet Mesh Quality Measure

- The chief measure of mesh quality is the Tri/Tet Skewness Method
  - Equilateral Volume Deviation –Measures the degree of deviation of the area of the triangle from that of an ideal (equilateral) face or cell which would fit into it's circumcircle.
    - Skewness = $\frac{\text{Ideal face area} - \text{actual face area}}{\text{Ideal face area}}$
  - Normalized Equiangle Deviation – Measures the degree of deviation of the internal angles of the mesh face from an ideal face with equal internal angles.
- Skewness is plotted on a scale of 0 (good) to 1 (bad or degenerate element)
  - In TGrid, the scale from 0 to 1 divided into 100 equal divisions.



Tri/Tet Mesh Quality Measure

- Two methods for determining skewness:
  1. Based on the equilateral volume:
     - Skewness = $\dfrac{\text{optimal cell size} - \text{cell size}}{\text{optimal cell size}}$
     - Applies only to triangles and tetrahedra
     - Default method for tris and tets
  2. Based on the deviation from a normalized equilateral angle:
     - Skewness (for a quad) = $\max\left[\dfrac{\theta_{max} - 90}{90}, \dfrac{90 - \theta_{min}}{90}\right]$
     - Applies to all cell and face shapes
     - Always used for prisms and pyramids



Tri/Tet Mesh Quality Measure

- Change in size should be gradual (smooth).

smooth change in cell size

large jump in cell size

- Aspect ratio is ratio of longest edge length to shortest edge length.
  - Equal to 1 (ideal) for an equilateral triangle or a square.

aspect ratio = 1

high-aspect-ratio quad

aspect ratio = 1

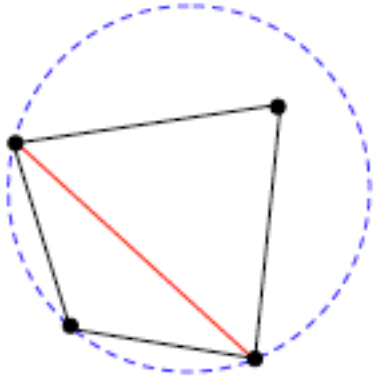
high-aspect-ratio triangle

Improving Quality

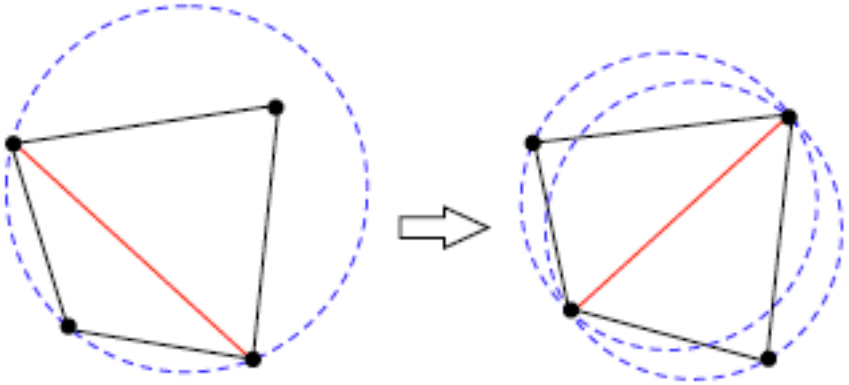
- A volume mesh is considered to be "bad" if it satisfies one or more the following conditions:
  - Very high skewness (skewness > 0.95)
  - Degenerate cells (skewness ~ 1)
  - High aspect ratio cells (Aspect ratios > 100)
  - Negative volumes
- Cell Quality can be improved by:
  - Improving surface mesh quality
  - Moving mesh nodes
  - Use CAD or other upstream preprocessors to fix geometric problems
  - Remove Boundary Slivers panel
  - Refine Boundary Slivers text command

Delaunay Violation

- A Delaunay violation occurs if a node of a triangle lies inside an adjacent triangle's circumcircle.
  - Eg: Long and thin triangles which have high skewness.



- Edge Swapping is typically used to remove the Delaunay violations.
  - Replace or "Swap" the diagonal of the quadrilateral formed by the two triangles with the other diagonal.



- Many tools in TGRID detect and remove Delaunay violations using edge swapping.