

Computational Aircraft Prototype Syntheses



Training Session 9 Meshing for Structures: EGADS ESP v1.18

Marshall Galbraith
galbramc@mit.edu

Massachusetts Institute of Technology

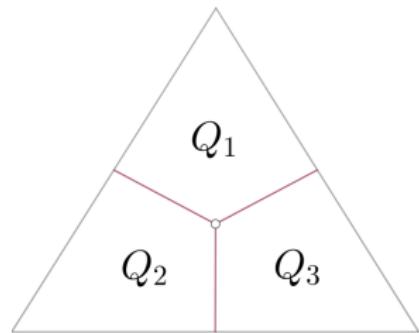
Bob Haimes
haimes@mit.edu

John F. Dannenhoffer, III
jfdannen@syr.edu
Syracuse University

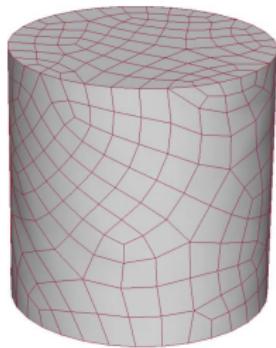
- EGADS tessellation for structural analysis
 - Regularized quad meshing
- Global EGADS tess parameters
 - Transfinite interpolation
- Local Mesh_Sizing parameters
 - Tess Parameters
 - Edge Point Count
- Suggested Exercises

- CAD surface mesh generator
- Originally targeted generating input tessellations for Cart3D
 - Goal – minimal counts that best represent the geometry
 - Produce a watertight discrete tessellation even when the BRep has large gaps
 - All vertices provide xyz and the appropriate geometric parameters
 - Useful for visualization
- No size gradation
 - Watertight is more important than meeting any meshing criteria
 - Can produce strongly anisotropic elements
 - Often not appropriate for tetrahedral meshers that use traditional Delaunay schemes

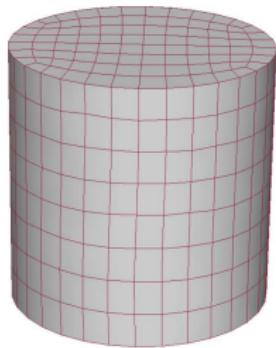
- Triangles split into 3 quads
- Basic: swapping, collapsing, splitting
- Advanced: Double Swap, Swap Collapse, Double Split
- EDGE tessellation fixed, and doubled
 - EDGE tessellation drives quading



Triangles split

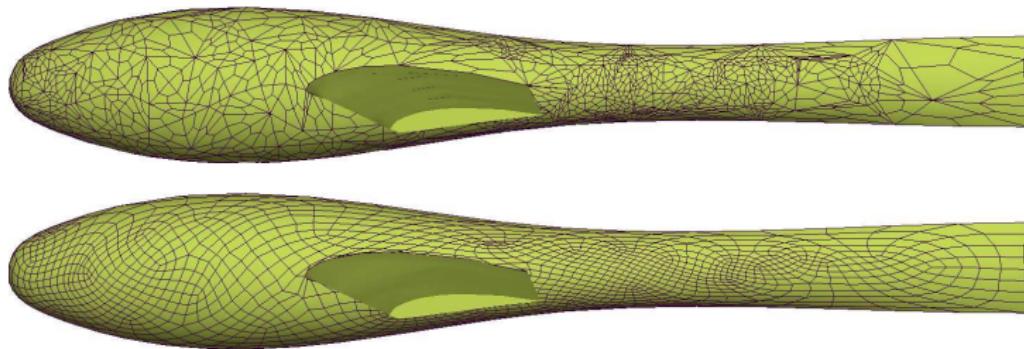
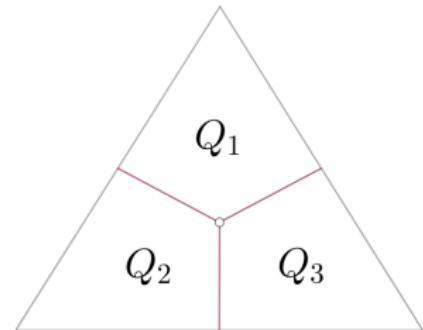


Basic operations



Advanced operations

- Triangles split into 3 quads
- Basic: swapping, collapsing, splitting
- Advanced: Double Swap, Swap Collapse, Double Split
- EDGE tessellation fixed, and doubled
 - EDGE tessellation drives quading





EGADS Tess AIM Documentation

- Full skin with spar and ribs structures
- Box structure with spars and ribs using `capsIgnore`

ESP/viewStructure.udc

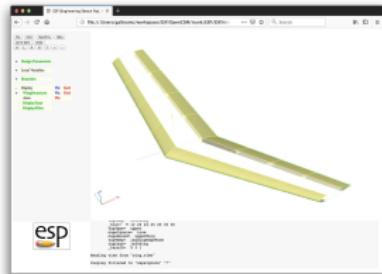
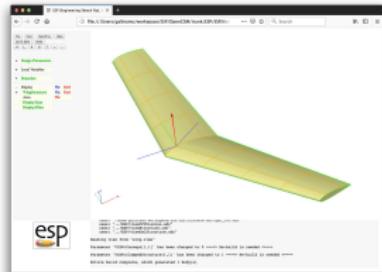
```
# Mark Faces near leadingEdge and trailingEdge
# so that they are not part of wing box
UDPRIM editAttr filename <<
    FACE ADJ2EDGE tagType=leadingEdge
    SET      capsIgnore=true

    FACE HAS      tagType=trailingEdge
    SET      capsIgnore=true

    FACE ADJ2FACE tagType=trailingEdge
    ANDNOT HAS   tagType=rib
    ANDNOT HAS   tagType=tip
    SET      capsIgnore=true

    FACE ADJ2EDGE tagType=trailingEdge
    SET      capsIgnore=true
```

>>

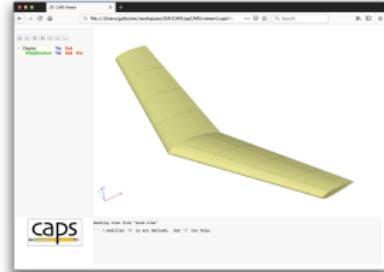


- Full skin with spar and ribs structures
- Box structure with spars and ribs using capsIgnore

session09/tess_1_Geom.py

```
# Enable the structural mode with the full skin
wing.setGeometryVal("VIEW:Concept"      , 0)
wing.setGeometryVal("VIEW:ClampedStructure", 1)
wing.setGeometryVal("VIEW:BoxStructure"    , 0)
```

```
# View the full geometry
wing.viewGeometry()
```



```
# Enable the structural mode for just the box
wing.setGeometryVal("VIEW:Concept"      , 0)
wing.setGeometryVal("VIEW:ClampedStructure", 1)
wing.setGeometryVal("VIEW:BoxStructure"    , 1)
```

```
# View the box geometry
wing.viewGeometry()
```

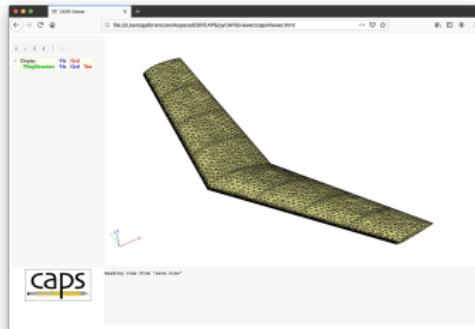
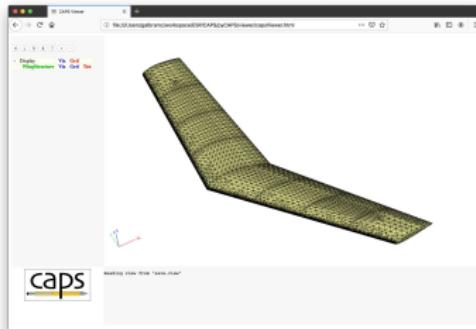


- EGADS tessellation for structural analysis
 - Regularized quad meshing
- Global EGADS tess parameters
 - Transfinite interpolation
- Local Mesh_Sizing parameters
 - Tess Parameters
 - Edge Point Count
- Suggested Exercises

- Attempts to Isolate 3 or 4 “sides”
 - Only single LOOPS
 - FACEs with more than 4 EDGEs are analyzed to see if multiple EDGEs can be treated as a single “side”

session09/tess_2_TFI_Templates.py

```
# Dissable TFI and Templates that generate "structured" triangular meshes
tess.setAnalysisVal("TFI_Templates", False)
```



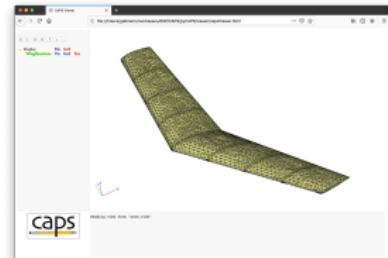
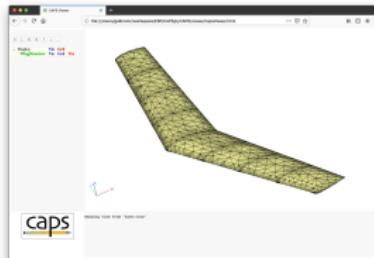
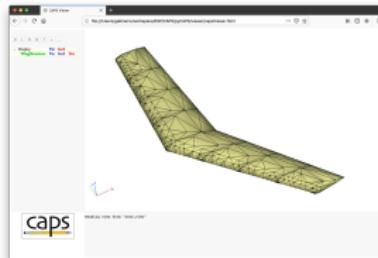
- maxLength and deviation scaled by capsMeshLength

session09/tess_3_Params.py

```
maxLength = 0.10 # bound on maximum segment length (0 - any length)
deviation = 0.01 # deviation from triangle centroid to geometry
dihedral  = 15   # maximum interior dihedral angle between triangle facets

# Set EGADS body tessellation parameters
tess.setAnalysisVal("Tess_Params", [maxLength, deviation, dihedral])

# Impact of chaning bound on the maximum segment
for maxLen in [0, 0.3, 0.1]:
    tess.setAnalysisVal("Tess_Params", [maxLen, 0.1, 30])
```



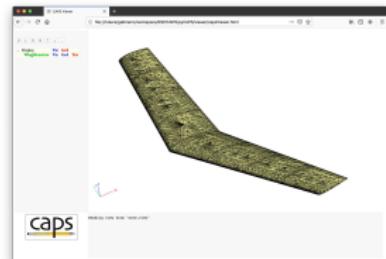
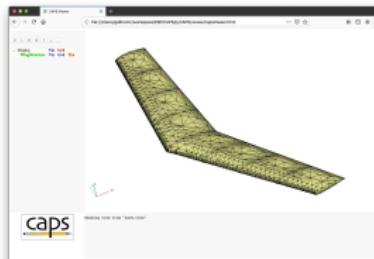
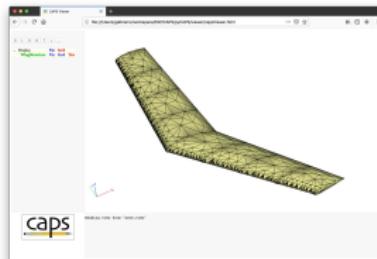
- maxLength and deviation scaled by capsMeshLength

session09/tess_4_Params.py

```
maxLength = 0.10 # bound on maximum segment length (0 - any length)
deviation = 0.01 # deviation from triangle centroid to geometry
dihedral  = 15   # maximum interior dihedral angle between triangle facets

# Set EGADS body tessellation parameters
tess.setAnalysisVal("Tess_Params", [maxLength, deviation, dihedral])

# Impact of chaning deviation
for dev in [0.01, 0.005, 0.001]:
    tess.setAnalysisVal("Tess_Params", [0, dev, 30])
```



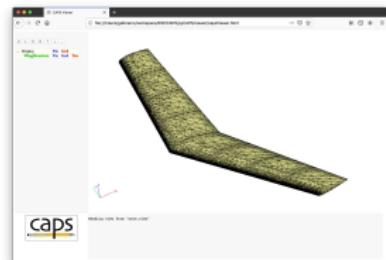
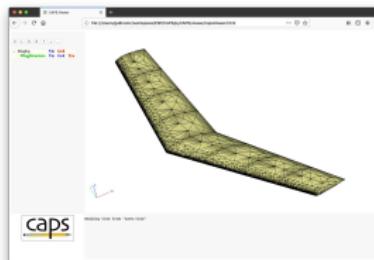
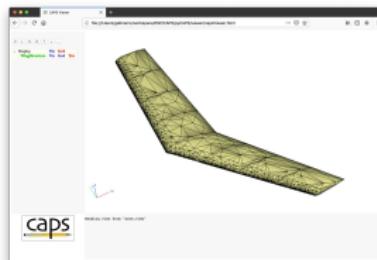
- maxLength and deviation scaled by capsMeshLength

session09/tess_5_Params.py

```
maxLength = 0.10 # bound on maximum segment length (0 - any length)
deviation = 0.01 # deviation from triangle centroid to geometry
dihedral  = 15   # maximum interior dihedral angle between triangle facets

# Set EGADS body tessellation parameters
tess.setAnalysisVal("Tess_Params", [maxLength, deviation, dihedral])

# Impact of chaning dihedral
for dihedral in [20, 10, 5]:
    tess.setAnalysisVal("Tess_Params", [0, 0.1, dihedral])
```

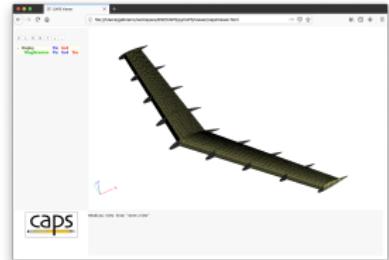
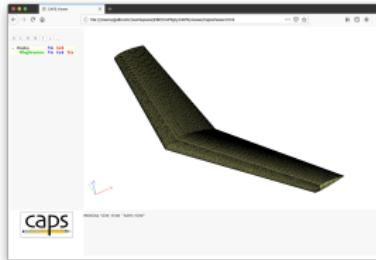
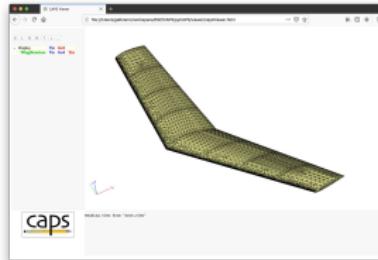


- Here, spanwise mesh spacing driven by leading edge spacing
- Meshing occurs prior to removing faces with capsIgnore

session09/tess_6_TriQuad.py

```
# Triangle tessellation  
tess.setAnalysisVal("Mesh_Elements", "Tri")
```

```
# Regularized quad tessellation  
tess.setAnalysisVal("Mesh_Elements", "Quad")
```



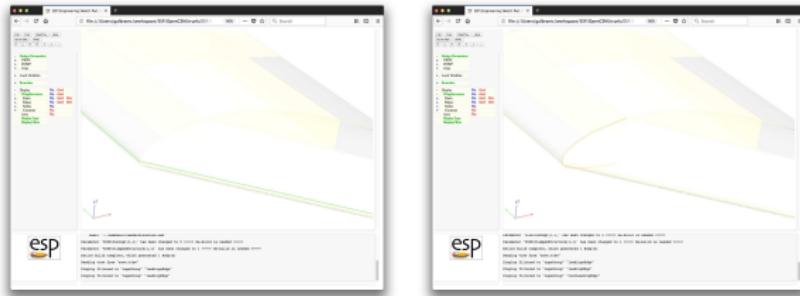
- EGADS tessellation for structural analysis
 - Regularized quad meshing
- Global EGADS tess parameters
 - Transfinite interpolation
- Local Mesh_Sizing parameters
 - Tess Parameters
 - Edge Point Count
- Suggested Exercises

- Modify leading edge spacing
- Set number of points on root rib EDGE by leading edge

session09/tess_7_MeshSizing.py

```
# Modify local mesh sizing parameters
Mesh_Sizing = [("leadingEdge"      , {"tessParams"     : [0, 0.2, 30]}),
               ("rootLeadingEdge", {"numEdgePoints" : 5})]

tess.setAnalysisVal("Mesh_Sizing", Mesh_Sizing)
```





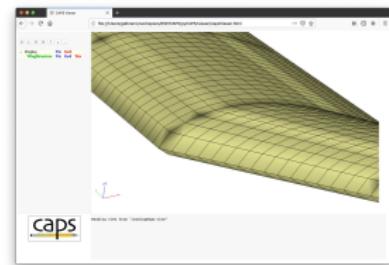
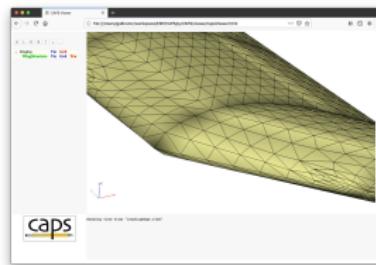
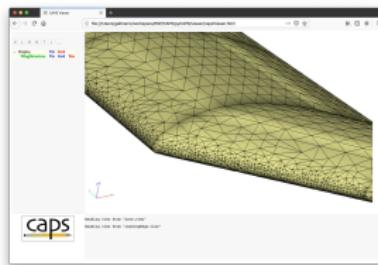
Mesh_Sizing Parameters

- Modify leading edge spacing
- Set number of points on root rib EDGE by leading edge

session09/tess_7_MeshSizing.py

```
# Modify local mesh sizing parameters
Mesh_Sizing = [("leadingEdge"      , {"tessParams"   : [0, 0.2, 30]}),
               ("rootLeadingEdge", {"numEdgePoints": 5})]

tess.setAnalysisVal("Mesh_Sizing", Mesh_Sizing)
```

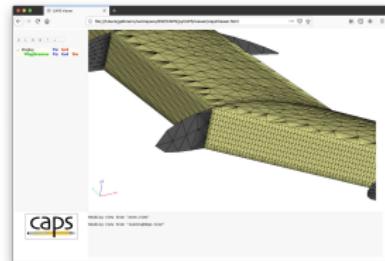
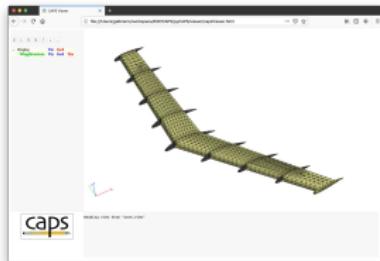


- Modify leading edge spacing
- Set number of points on root rib EDGE by leading edge
- Modify FACE parameters on wingSpar1 capsGroup

session09/tess_8_MeshSizing.py

```
# Modify local mesh sizing parameters
Mesh_Sizing = [("wingSpar1"      , {"tessParams"     : [0.02, 0.1, 30]}),
               ("leadingEdge"    , {"tessParams"     : [0, 0.2, 30]}),
               ("rootLeadingEdge", {"numEdgePoints" : 5})]

tess.setAnalysisVal("Mesh_Sizing", Mesh_Sizing)
```

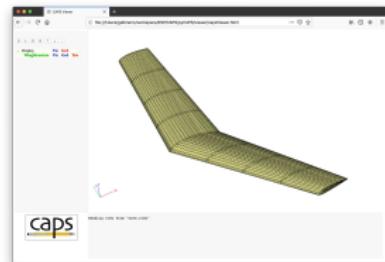
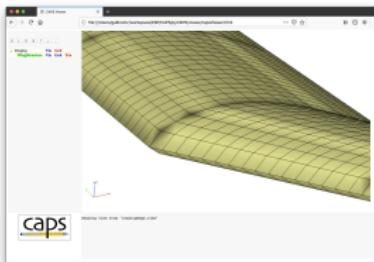
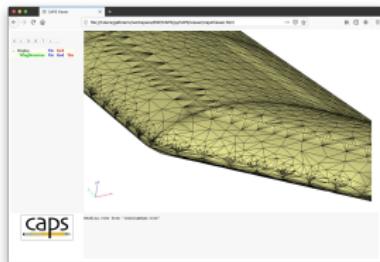


- Modify leading edge spacing
- Set number of points on root rib EDGE by leading edge
- Modify FACE parameters on wingSpar1 capsGroup

session09/tess_8_MeshSizing.py

```
# Modify local mesh sizing parameters
Mesh_Sizing = [("wingSpar1"      , {"tessParams"     : [0.02, 0.1, 30]}),
               ("leadingEdge"    , {"tessParams"     : [0, 0.2, 30]}),
               ("rootLeadingEdge", {"numEdgePoints" : 5})]

tess.setAnalysisVal("Mesh_Sizing", Mesh_Sizing)
```

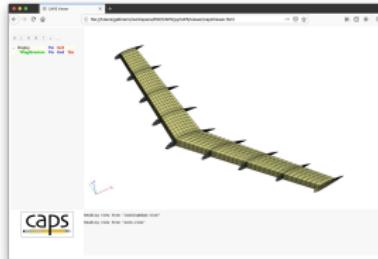
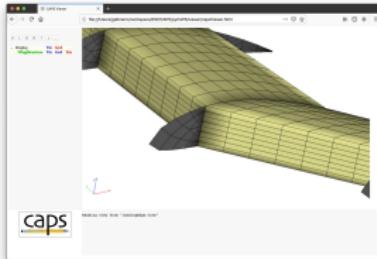


- Modify leading edge spacing
- Set number of points on root rib EDGE by leading edge
- Modify FACE parameters on wingSpar1 capsGroup

session09/tess_8_MeshSizing.py

```
# Modify local mesh sizing parameters
Mesh_Sizing = [("wingSpar1"      , {"tessParams"    : [0.02, 0.1, 30]}),
               ("leadingEdge"   , {"tessParams"    : [0, 0.2, 30]}),
               ("rootLeadingEdge", {"numEdgePoints": 5})]

tess.setAnalysisVal("Mesh_Sizing", Mesh_Sizing)
```



Tess_Params

- Modify Tess_Params for a different capsGroup

Minimal Quads

- Generate the smallest possible number of quad elements for

VIEW:Concept	0
VIEW:ClampedStructure	1
VIEW:BoxStructure	0

Specific Quads

- Generate quad meshes with approximately 2,000, 4,000, and 6,000 elements for

VIEW:Concept	0
VIEW:ClampedStructure	1
VIEW:BoxStructure	1

New capsGroup

- Add a capsGroup similar to rootLeadingEdge to the EDGEs on the root rib on the top and bottom of the spar.
- Use this to generate 2, 10, and 16 quads in the chordwise direction of the spar for

VIEW:Concept 0

VIEW:ClampedStructure 1

VIEW:BoxStructure 1

- Explore the impact of other AIM input parameters
- Create your own