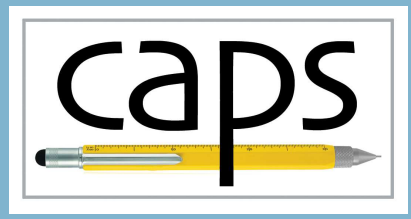
Computational Aircraft Prototype Syntheses



Training Session 5.1
Meshing for Structures: EGADS

Corrected for ESP Release 1.17

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Overview

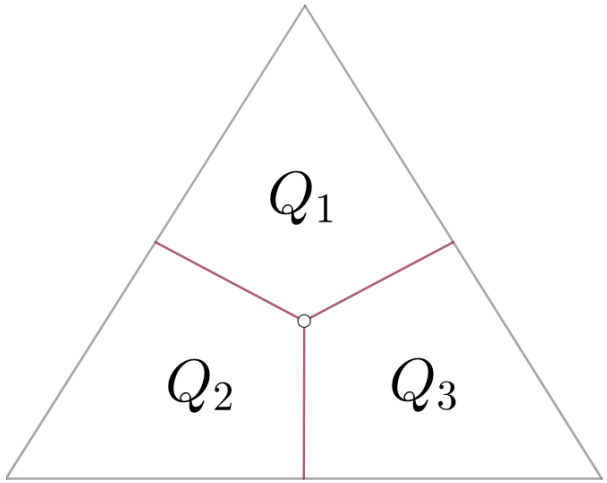
- EGADS tessellation for structural analysis
  - Regularized quad meshing
- Global EGADS tess parameters
  - Transfinite interpolation
- Local Mesh_Sizing parameters
  - Tess Parameters
  - Edge Point Count
- Suggested Exercises

EGADS tessellation Overview

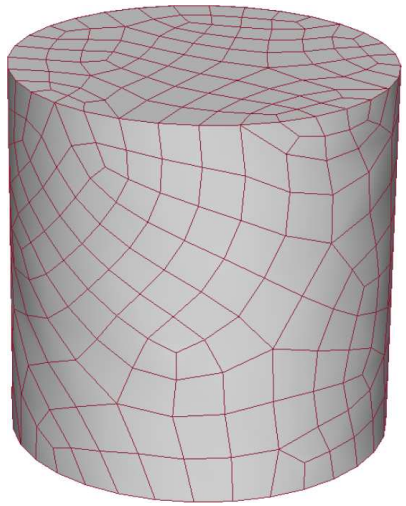
- CAD surface mesh generator
- Originally targeted generating input tessellations for Cart3D
  - Goal – minimal counts that best represent the geometry
  - Produce a watertight discrete tessellation even when the BRep has large gaps
  - All vertices provide xyz and the appropriate geometric parameters
  - 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

EGADS Regularized Quad Meshing

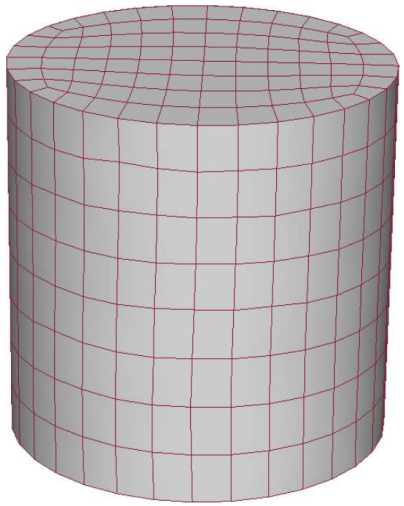
- Triangles split into 3 quads
- Basic: swapping, collapsing, splitting
- Advanced: Double Swap, Swap Collapse, Double Split
- `EDGE` tessellation fixed, and doubled
  - `EDGE` tessellation drives quading



Triangles split



Basic operations



Advanced operations

EGADS Regularized Quad Meshing

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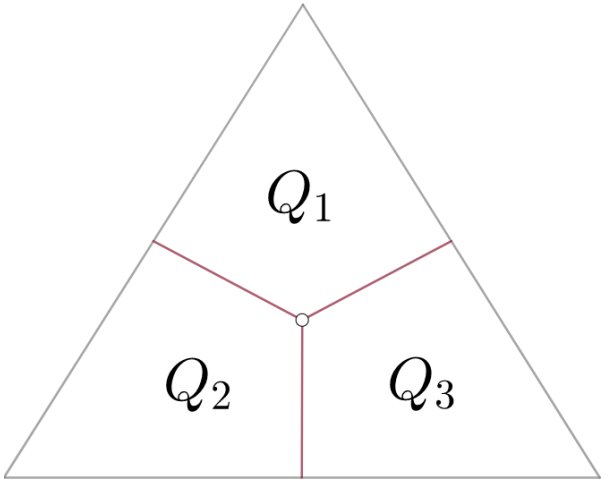
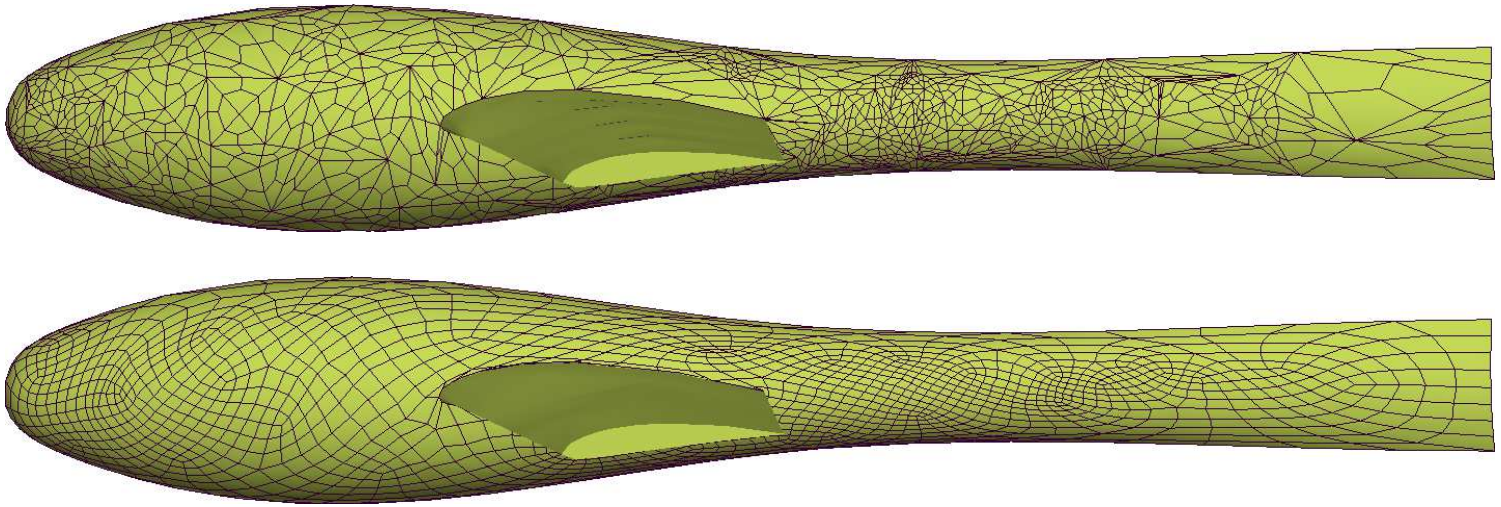
  - `EDGE` tessellation drives quading





EGADS Tess AIM Documentation

wing3.csm Geometry

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

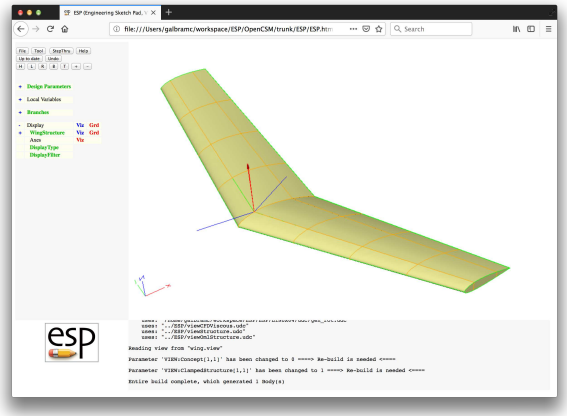
ESP/viewStructure.udc

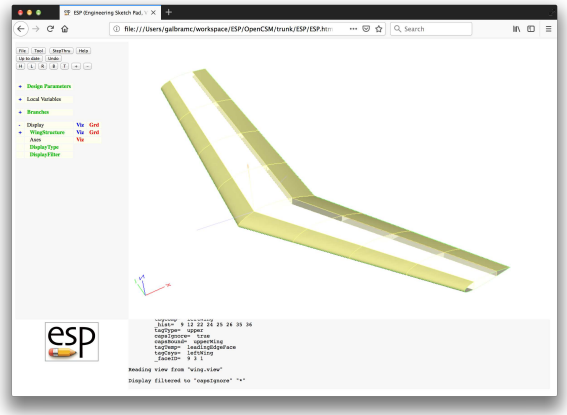
```
        # Mark Faces near leadingEdge and trailingEdge
        # so that they are not part of wing box
        UDPRIM    editAttr  filename  <<
            FACE ADJ2EDGE tagType=leadingEdge
            SET           capsIgnore=true

            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
>>
```





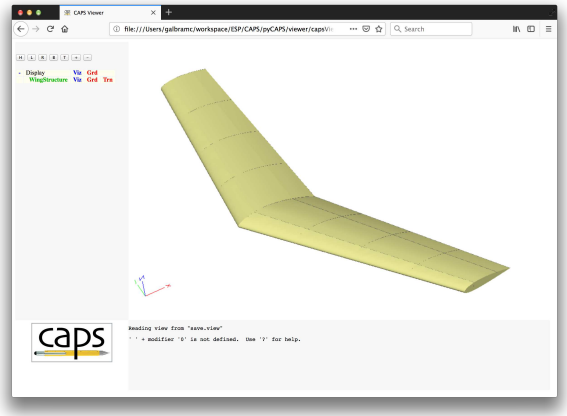
wing3.csm Geometry

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

session5.1/tess_1_Geom.py

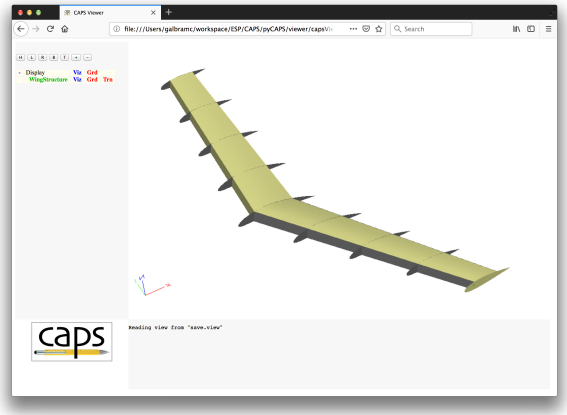
```
# Enable the structural mode with the full skin
wing.setGeometryVal("VIEW:Concept"          , 0)
wing.setGeometryVal("VIEW:ClampedStructure", 1)
wing.setGeometryVal("VIEW:BoxStructure"     , 0)

# 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()
```



Overview

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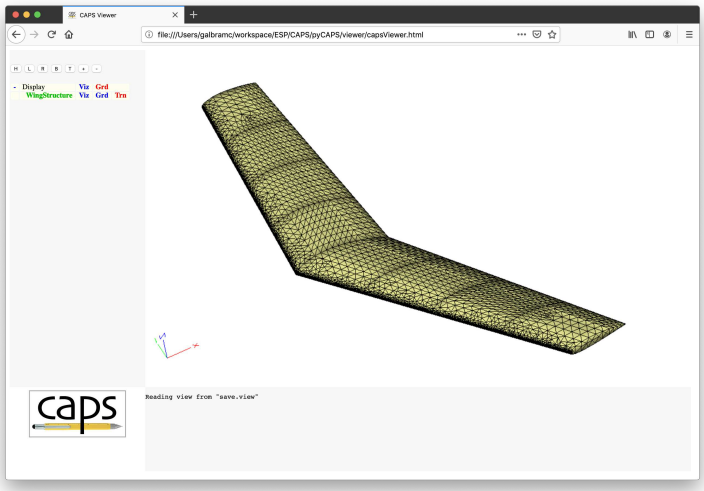
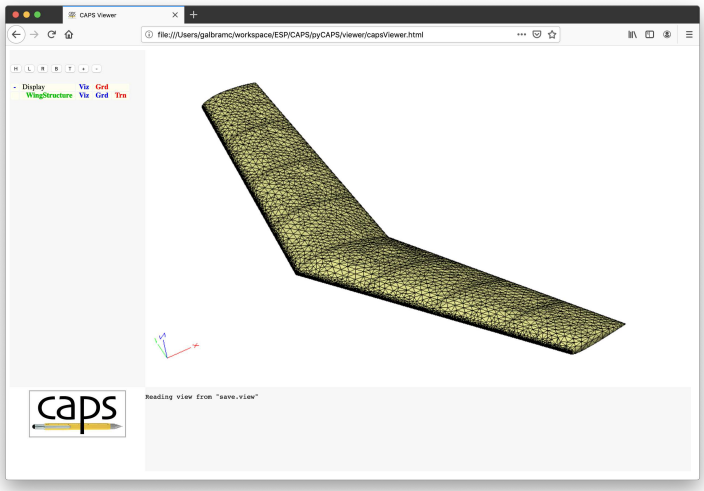
Transfinite Interpolation and Templates

- 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”

session5.1/tess_2_TFI_Templates.py

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





EGADS Tess Parameters

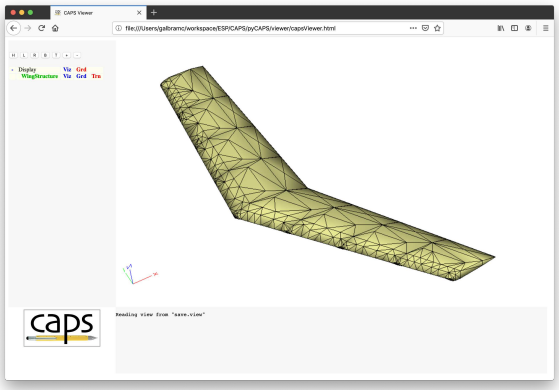
- maxLength and deviation scaled by `capsMeshLength`

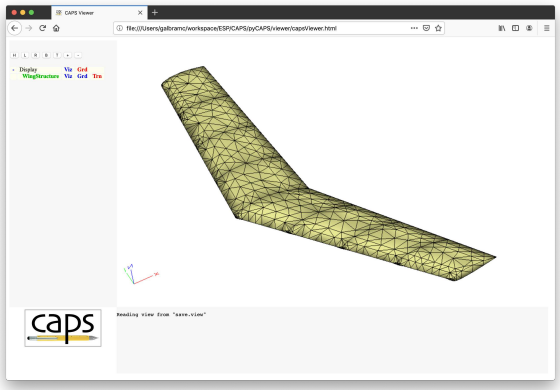
session5.1/tess_3_Params.py

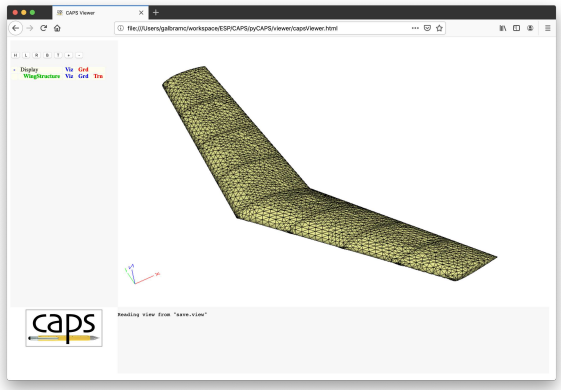
```
maxLength = 0.10 # bound on maximum segment length (0 - any length)
deviation = 0.01 # deviation from triangle centroid to geometry
dihedral  = 15   # maximum interior dihedral angle between triangle facets

# 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])
```







EGADS Tess Parameters

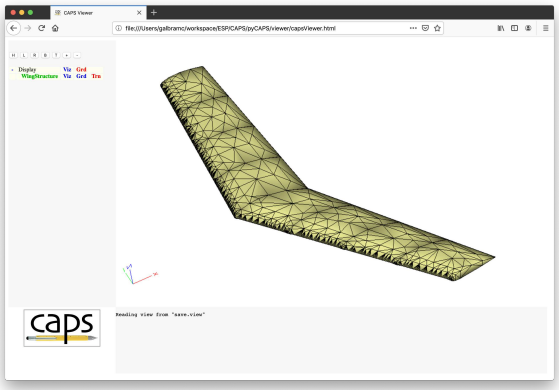
- maxLength and deviation scaled by `capsMeshLength`

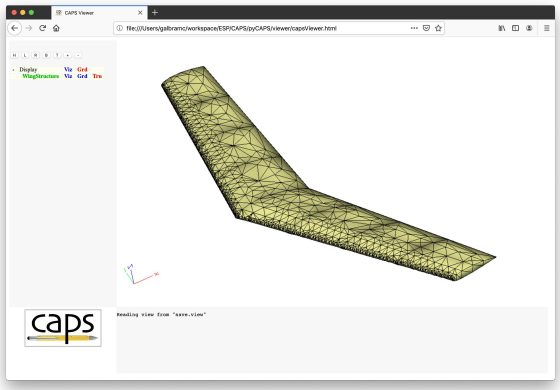
session5.1/tess_4_Params.py

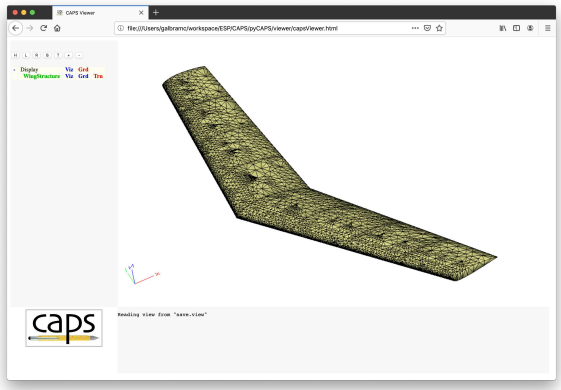
```
maxLength = 0.10 # bound on maximum segment length (0 - any length)
deviation = 0.01 # deviation from triangle centroid to geometry
dihedral  = 15   # maximum interior dihedral angle between triangle facets

# 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])
```







EGADS Tess Parameters

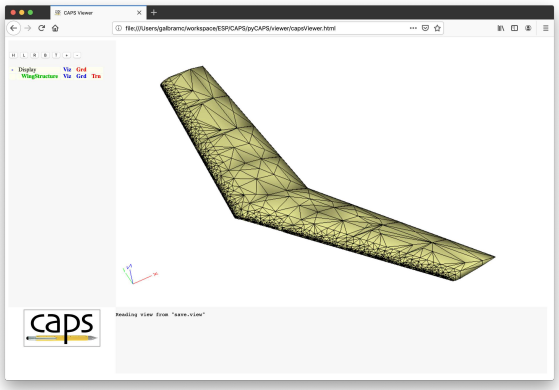
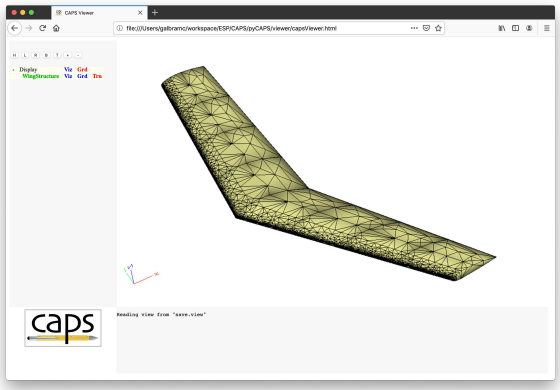
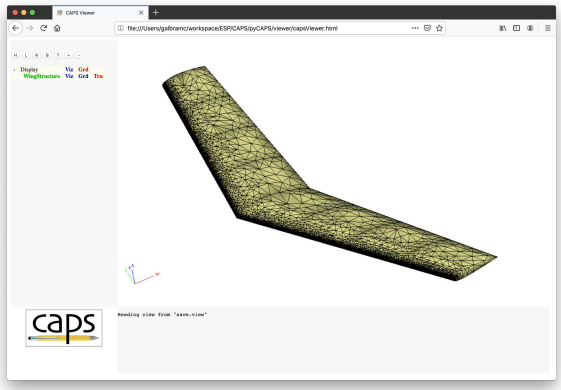
- maxLength and deviation scaled by `capsMeshLength`

session5.1/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])
```

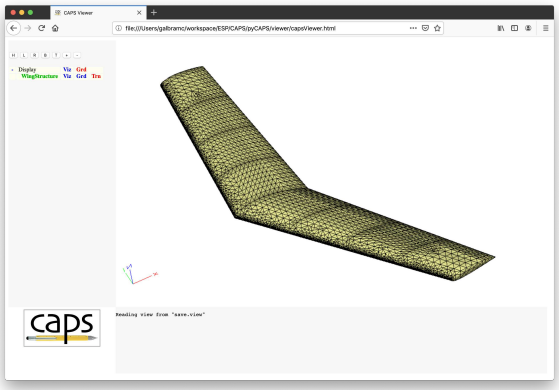
Regularized Quads

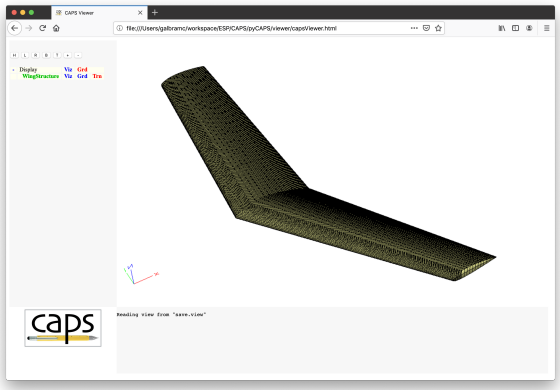
- Here, spanwise mesh spacing driven by leading edge spacing
- Meshing occurs prior to removing faces with `capsIgnore`

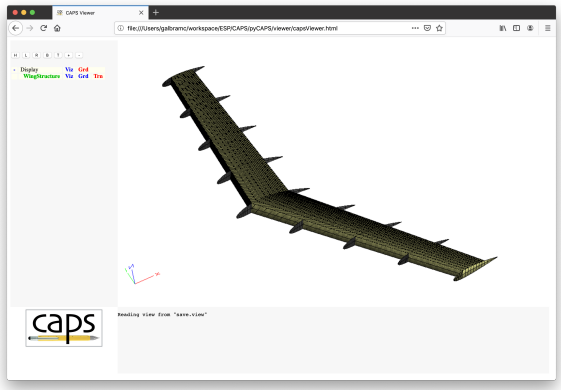
session5.1/tess_6_TriQuad.py

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

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







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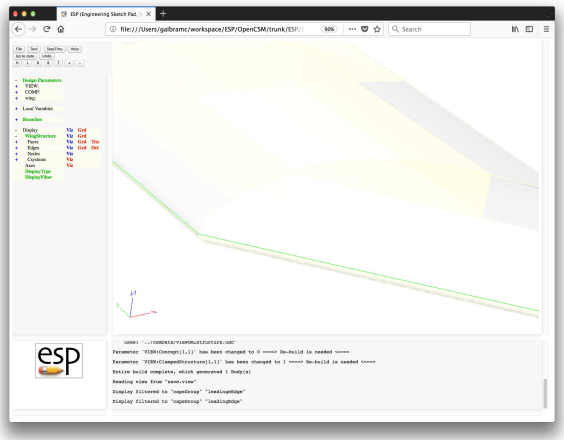
Mesh_Sizing Parameters

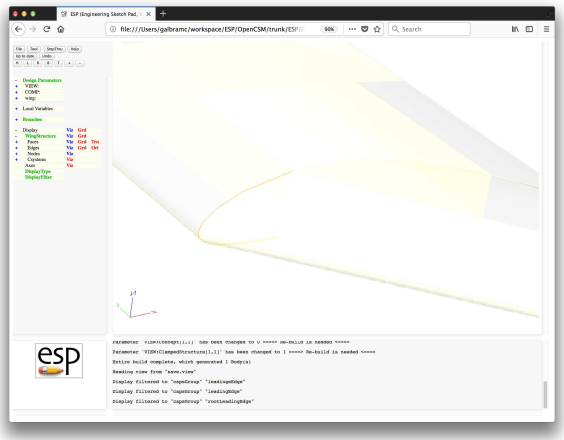
- Modify leading edge spacing
- Set number of points on root rib `EDGE` by leading edge

session5.1/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)
```





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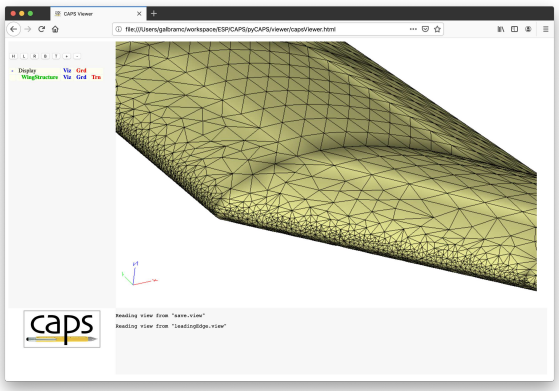
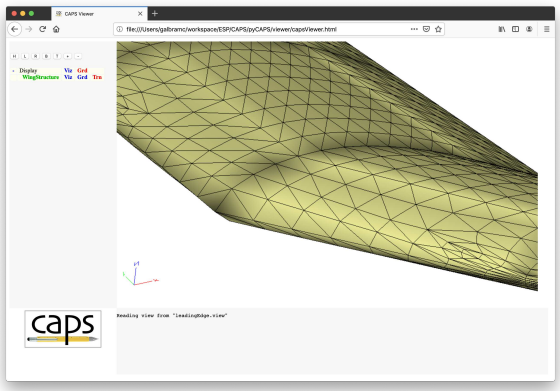
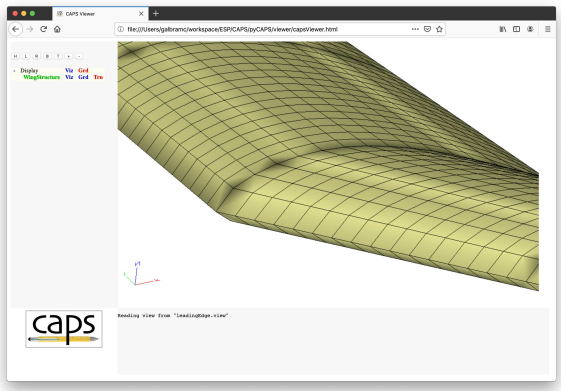






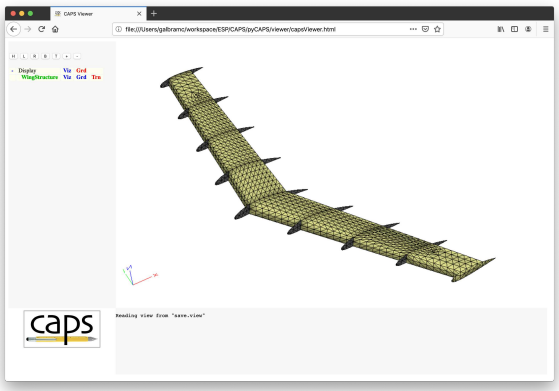
Mesh_Sizing Parameters Cont.

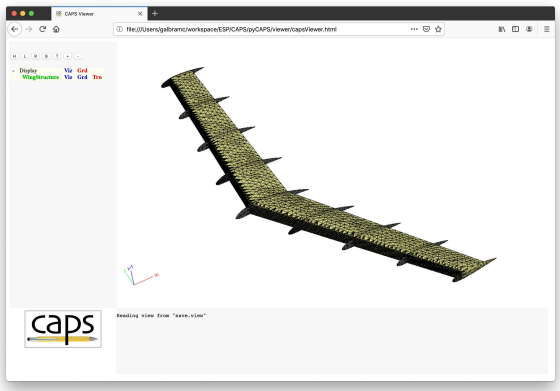
- Modify leading edge spacing
- Set number of points on root rib `EDGE` by leading edge
- Modify `FACE` parameters on wingSpar1 `capsGroup`

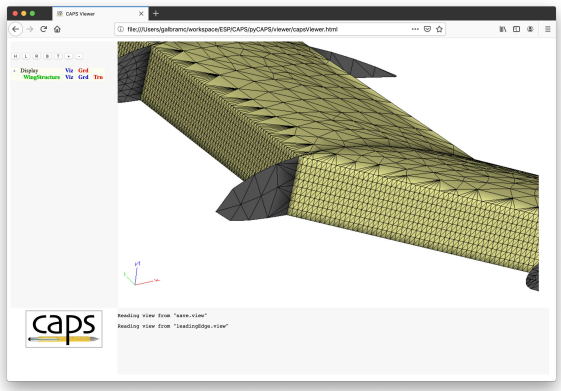
session5.1/tess_8_MeshSizing.py

```
# 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)
```







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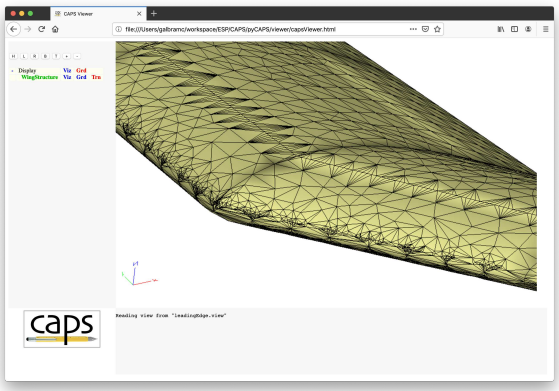

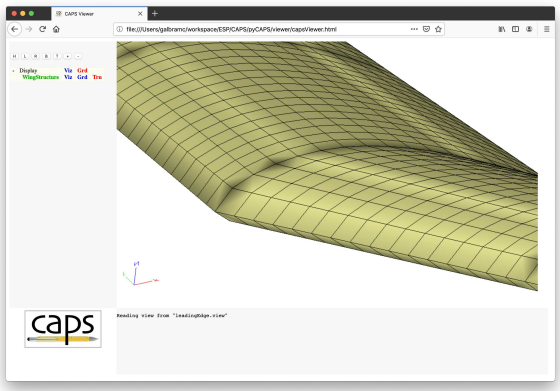

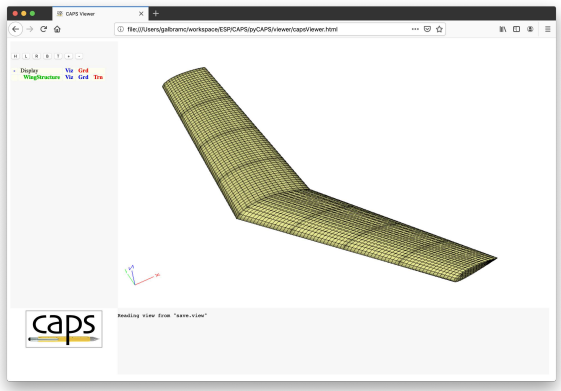

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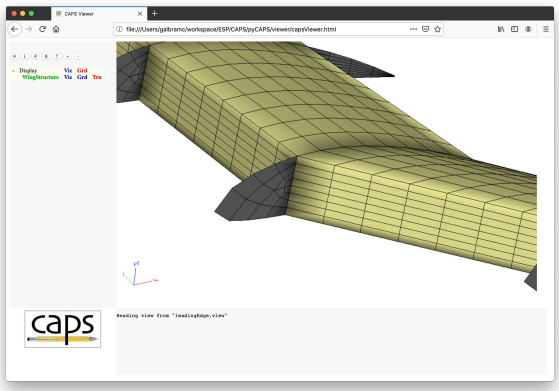
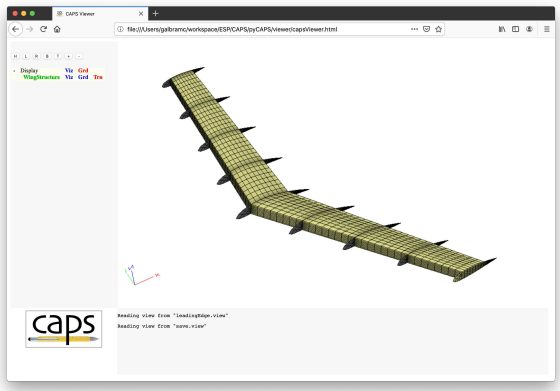
               ("rootLeadingEdge", {"numEdgePoints" : 5})]

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





Suggested Exercises

Tess_Params

- Modify Tess_Params for a different `capsGroups`
- Explore the impact of other AIM input parameters
- Create your own