

Computational Aircraft Prototype Syntheses



Training Session 9

Meshing for Structures: EGADS

ESP v1.19

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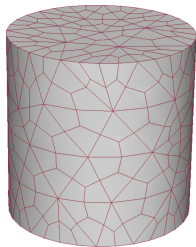
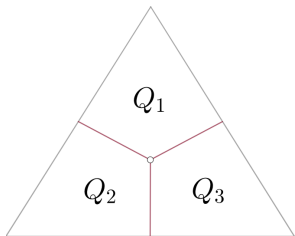
jfdannen@syr.edu

Syracuse University

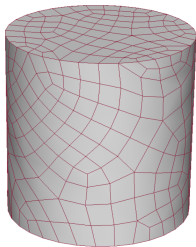
- EGADS tessellation for structural analysis
 - Regularized quad meshing
- Global EGADS tess parameters
 - Transfinite interpolation
- Local Mesh_Sizing parameters
 - Tess Parameters
 - Edge Point Count
- Suggested Exercises

- 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

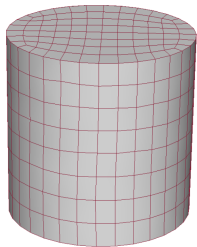
- Triangles split into 3 quads
- Basic: swapping, collapsing, splitting
- Advanced: Double Swap, Swap Collapse, Double Split
- **EDGE** tessellation fixed, and doubled
 - **EDGE** tessellation drives quading



Triangles split

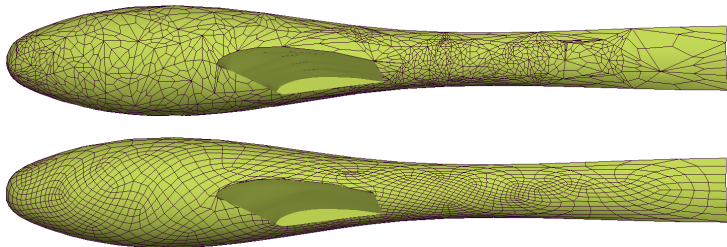
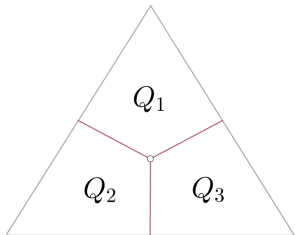


Basic operations



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` (use “keep” attribute to see what is retained)

ESP/viewStructure.udc

```
# Mark Faces near leadingEdge and trailingEdge
# so that they are not part of wing box
```

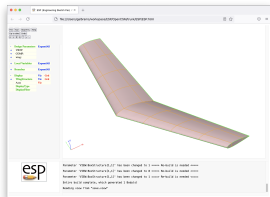
```
UDPRIM    editAttr filename <<
FACE ADJ2EDGE tagType=leadingEdge
SET       capsIgnore=true
```

```
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` (use “keep” attribute to see what is retained)

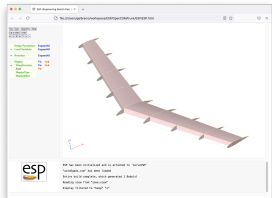
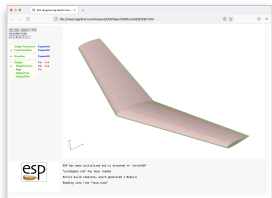
session09/tess_1_Geom.py

```
# Set geometry variables for structural IML/OML
wing.cfgpmtr.VIEW.Concept          = 0
wing.cfgpmtr.VIEW.ClampedStructure = 1
wing.cfgpmtr.VIEW.BoxStructure     = 0
```

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

```
# Enable the structural mode for just the box spar
wing.cfgpmtr.VIEW.Concept          = 0
wing.cfgpmtr.VIEW.ClampedStructure = 1
wing.cfgpmtr.VIEW.BoxStructure     = 1
```

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

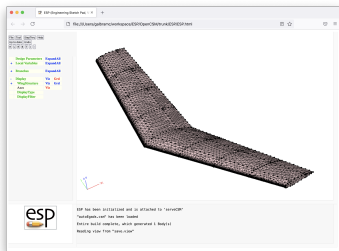
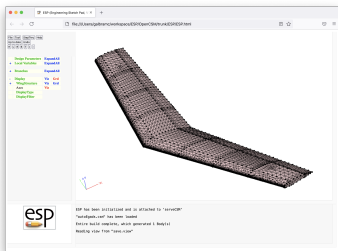


- EGADS tessellation for structural analysis
 - Regularized quad meshing
- Global **EGADS** tess parameters
 - Transfinite interpolation
- Local Mesh_Sizing parameters
 - Tess Parameters
 - Edge Point Count
- Suggested Exercises

- Attempts to Isolate 3 or 4 “sides”
 - Only single LOOP
 - **FACES** with more than 4 **EDGES** are analyzed to see if multiple **EDGES** can be treated as a single “side”
- Disable TFI to see impact of tessellation parameters

session09/tess_2_TFI_Templates.py

```
# Dissable TFI and Templates that generate "structured" triangular meshes
tess.input.TFI_Templates = False
```



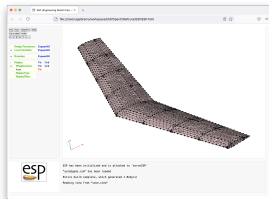
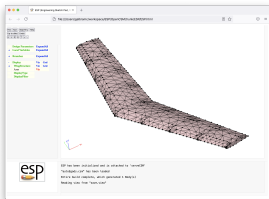
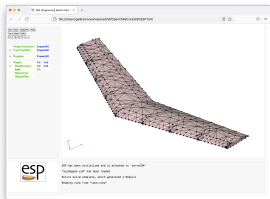
- maxLength and deviation scaled by capsMeshLength

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.input.Tess_Params = [maxLength, deviation, dihedral]
```

```
# Impact of changing bound on the maximum segment
for maxLength in [0, 0.3, 0.1]:
    tess.input.Tess_Params = [maxLength, 0.1, 30]
```



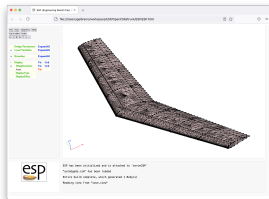
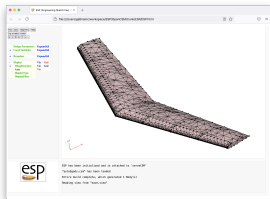
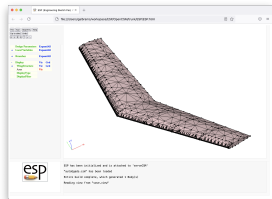
- maxLength and deviation scaled by capsMeshLength

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.input.Tess_Params = [maxLength, deviation, dihedral]
```

```
# Impact of changing deviation
for deviation in [0.01, 0.005, 0.001]:
    tess.input.Tess_Params = [0, deviation, 30]
```



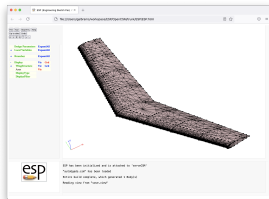
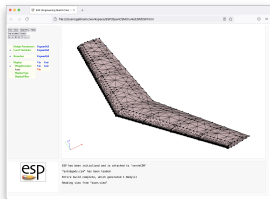
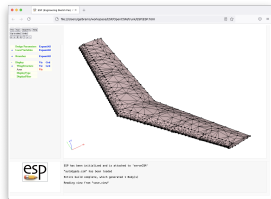
- maxLength and deviation scaled by capsMeshLength

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.input.Tess_Params = [maxLength, deviation, dihedral]
```

```
# Impact of changing dihedral
for dihedral in [20, 10, 5]:
    tess.input.Tess_Params = [0, 0.1, dihedral]
```

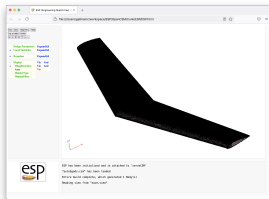
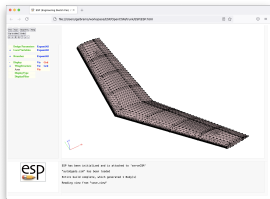


- Here, spanwise mesh spacing driven by leading edge spacing
- Meshes faces with `capsIgnore` (removed just in time)
- Only control over Quad tessellation is **EDGE** tessellation
 - Tessellation parameters set global **EDGE** tessellation
 - `Mesh_Sizing` parameters set local **EDGE** tessellation

session09/tess_6_TriQuad.py

```
# Triangle tessellation
tess.input.Mesh_Elements = "Tri"
```

```
# Regularized quad tessellation
tess.input.Mesh_Elements = "Quad"
```



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- `numEdgePoints`: Specific number of points on EDGE (min 2)
- `edgeDistribution`: Even or Tanh
- `initalNodeSpacing`: Spacing at beginning and end of EDGE
- `tessParams`: Local tessellation parameters on EDGES or FACES [Max length, deviation, dihedral angle]

Regularized Quads

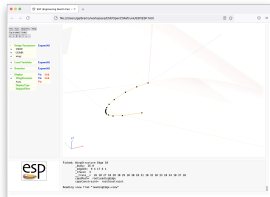
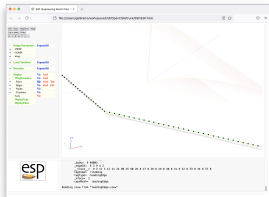
- EDGE points always adjusted to maximize TFI
- Choosing EDGE point count follows:
 - 1. Finest specified point count set via EDGE Mesh_Sizing
 - 2. Mesh_Sizing point count retained over higher unspecified point count
 - 3. Finest unspecified point count

- Modify leading edge spacing
 - `leadingEdge` and `rootLeadingEdge` `capsMesh` attributes
- 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" : 2}}
```

tess.input.Mesh_Sizing = Mesh_Sizing



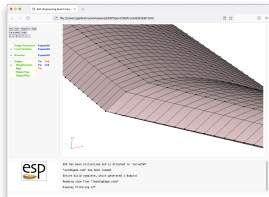
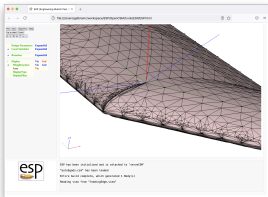
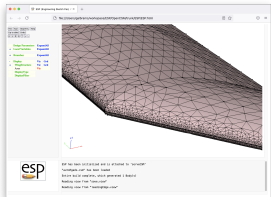
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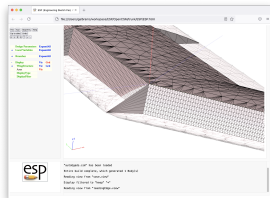
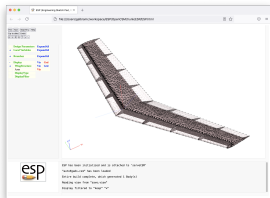
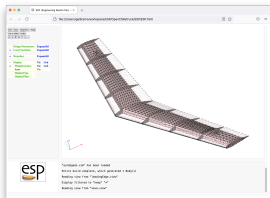


- Modify leading edge spacing
- Set number of points on root rib EDGE by leading edge
- Modify parameters on FACES with capsMesh **wingSpar1**

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": 2}}
```

tess.input.Mesh_Sizing = Mesh_Sizing



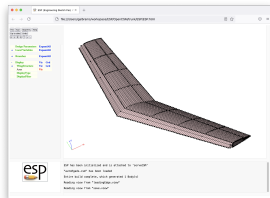
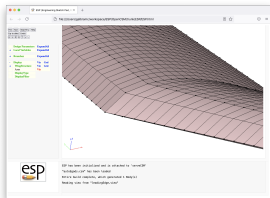
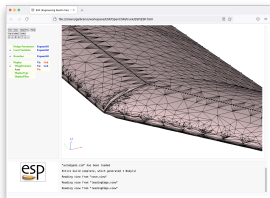
- Modify leading edge spacing
- Set number of points on root rib EDGE by leading edge
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session09/tess_8_MeshSizing.py

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```

```
tess.input.Mesh_Sizing = Mesh_Sizing
```

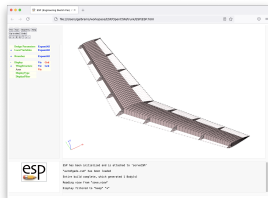
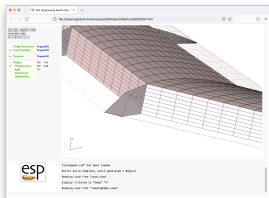


- Modify leading edge spacing
- Set number of points on root rib **EDGE** by leading edge
- Modify parameters on **FACES** with capsMesh **wingSpar1**

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Mesh_Sizing = {"wingSpar1"      : {"tessParams"   : [0.02, 0.1, 30]},
               "leadingEdge"    : {"tessParams"   : [0, 0.2, 30]},
               "rootLeadingEdge": {"numEdgePoints": 2}}
```

tess.input.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 `EDGE s` 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

<code>VIEW:Concept</code>	0
<code>VIEW:ClampedStructure</code>	1
<code>VIEW:BoxStructure</code>	1

- Explore the impact of other AIM input parameters
- Create your own (optionally share it galbramc@mit.edu)