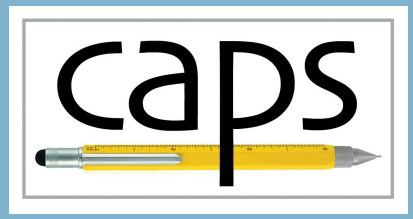
Computational Aircraft Prototype Syntheses



Training Session 7
Meshing for CFD II: Pointwise

ESP v1.18

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Overview

- Pointwise and GeomToMesh.glf
- Pointwise invsicid meshing
  - Suggested parameters
  - Proximity detection
- Pointwise viscous meshing
  - Suggested parameters
  - Viscous boundary layer mesh generation
- Suggested Exercises

Pointwise Overview

- Pointwise: commercial software available for Windows, Linux, and Mac.
- General purpose mesh generator for high quality structured, unstructured, and hybrid meshes
- T-Rex extrusion for generation of boundary layer resolving hybrid meshes.
- Glyph: a TCL/TK based scripting language to automate repetitive tasks.

GeomToMesh.glf Overview

- GeomToMesh.glf: glyph script for creating unstructured volume meshes given a clean EGADS geometry file.
- Vision: script to automatically generate a valid, high quality unstructured mesh given clean, closed geometry.
- Using geometry attributions, the scripts will attempt to create a mesh that matches the user's intent.
- Source Box for increased viscous off body resolution
- Elevate on Export generates higher-order curved meshes (not yet in CAPS)

Pointwise AIM Inputs and Outputs

Pointwise AIM Documentation

Transport Geometry EGADS Files

- Use **pyCAPS** to export geometry to EGADS files
- Explore meshing parameters without rebuilding geometry
- DANGER: Decouples geometric and analysis parameters
  - getGeometryVal and getGeometryOutVal are read only

Execute: EGADS/egadsCFD.py

```
# Change to Inviscid CFD view
transport.setGeometryVal("VIEW:Concept"    , 0)
transport.setGeometryVal("VIEW:CFDInviscid", 1)
transport.setGeometryVal("VIEW:CFDViscous" , 0)

# Enable just wing
transport.setGeometryVal("COMP:Wing"   , 1)
transport.setGeometryVal("COMP:Fuse"   , 0)
transport.setGeometryVal("COMP:Htail"  , 0)
transport.setGeometryVal("COMP:Vtail"  , 0)
transport.setGeometryVal("COMP:Pod"    , 0)
transport.setGeometryVal("COMP:Control", 0)

# Save egads file of the geometry
print("==> Generating CFDInviscid_Wing")
transport.saveGeometry("CFDInviscid_Wing.egads")
```

CFDInviscid_Wing.egads
CFDInviscid_WingPod.egads
CFDInviscid_Transport.egads
CFDViscous_Wing.egads
CFDViscous_WingPod.egads
CFDViscous_Transport.egads

Pointwise Execution

- Pointwise GeomToMesh.glf script available via $CAPS_GLYPH environment variable
- Windows: also uses PW_HOME environment variable

session07/pointwise_01_Defaults.py

```
####### Run pointwise #################
currentDirectory = os.getcwd()   # Get current working directory
os.chdir(pointwise.analysisDir)  # Move into test directory

CAPS_GLYPH = os.environ["CAPS_GLYPH"]
for i in range(60):
    if "Windows" in platform.system():
        PW_HOME = os.environ["PW_HOME"]
        os.system('"' + PW_HOME + '\\win64\\bin\\tclsh.exe ' + CAPS_GLYPH + \
                  '\\GeomToMesh.glf" caps.egads capsUserDefaults.glf')
    else:
        os.system("pointwise -b " + CAPS_GLYPH + "/GeomToMesh.glf caps.egads capsUserDefaults.glf")

    time.sleep(1) # let the harddrive breathe
    if os.path.isfile('caps.GeomToMesh.gma') and os.path.isfile('caps.GeomToMesh.ugrid'): break
    time.sleep(20) # wait and try again

os.chdir(currentDirectory)       # Move back to top directory
#######################################
```

GeomToMesh.glf Default Values

- GeomToMeshDefaults.glf contains meshing parameters that control the mesh characteristics
- The default parameter settings mirror values in Pointwise interactive mode
- GeomToMesh.glf input: CAD file (egads for instance) and optional "UserDefault.glf"
- The parameters in the "UserDefaults.glf" file will override the settings in the GeomToMeshDefaults.glf

Execute: session07/pointwise_01_Defaults.py

GeomToMesh.glf Suggested Inviscid Values

- Steve Karman: "The values discussed in the following slides are, to some extent, personal preferences evolved over years of experience."
- These parameters resolve geometry curvature and create high quality surface meshes
- The volume mesh exhibits smooth gradation of element size

session07/pointwise_02_InviscidWing.py

```
# Connector level
pointwise.setAnalysisVal("Connector_Turn_Angle"    , 10)
pointwise.setAnalysisVal("Connector_Source_Spacing", True)

# Domain level
pointwise.setAnalysisVal("Domain_Algorithm"   , "AdvancingFront")
pointwise.setAnalysisVal("Domain_Max_Layers"  , 15)
pointwise.setAnalysisVal("Domain_TRex_ARLimit", 20.0)
pointwise.setAnalysisVal("Domain_Decay"       , 0.8)

# Block level
pointwise.setAnalysisVal("Block_Boundary_Decay"      , 0.8)
pointwise.setAnalysisVal("Block_Edge_Max_Growth_Rate", 1.5)
```

GeomToMesh.glf Suggested Inviscid Values

- Connector attributes control the mesh operations on `EDGE`s
- Geometry curve length and curvature can influence the mesh resolution and distribution
- Source Spacing enables proximity checking between connectors

session07/pointwise_02_InviscidWing.py

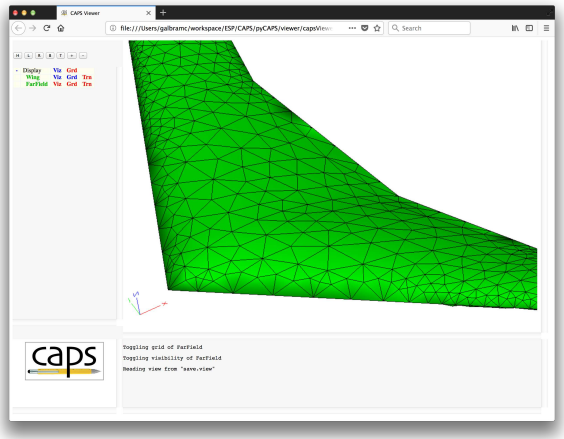
```
# Connector level
pointwise.setAnalysisVal("Connector_Turn_Angle"    , 10)
pointwise.setAnalysisVal("Connector_Source_Spacing", True)
```

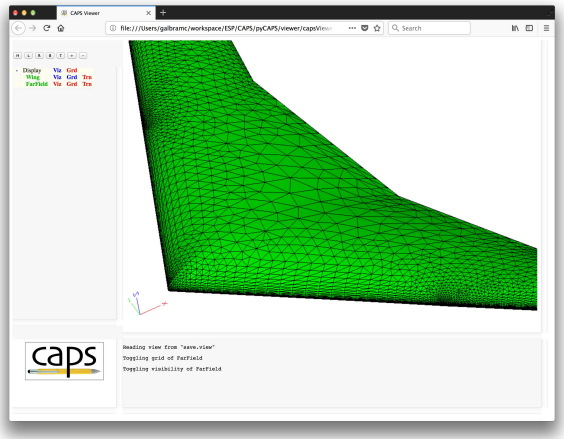
GeomToMesh.glf Suggested Inviscid Values

- Domain attributes control the mesh operations on `FACE`s
- Max Layers enables T-Rex surface boundary layer
  - Clustering to high curvature and sharp regions of the geometry

session07/pointwise_02_InviscidWing.py

```
# Domain level
pointwise.setAnalysisVal("Domain_Algorithm"    , "AdvancingFront")
pointwise.setAnalysisVal("Domain_Max_Layers"   , 15)
pointwise.setAnalysisVal("Domain_TRex_ARLimit", 20.0)
pointwise.setAnalysisVal("Domain_Decay"        , 0.8)
```





GeomToMesh.glf Suggested Inviscid Values

- Block attributes control the mesh operation in the volume, including the extruded viscous mesh portion

session07/pointwise_02_InviscidWing.py

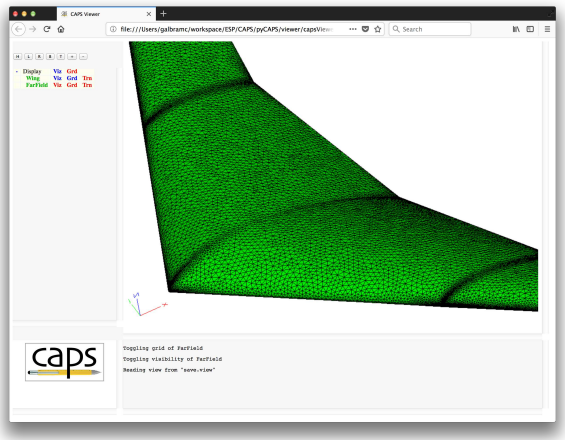
```
# Block level
pointwise.setAnalysisVal("Block_Boundary_Decay"      , 0.8)
pointwise.setAnalysisVal("Block_Edge_Max_Growth_Rate", 1.5)
```

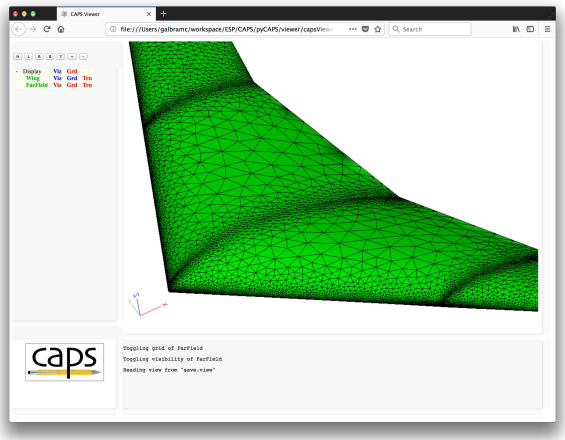
Impact of Connector_Turn_Angle

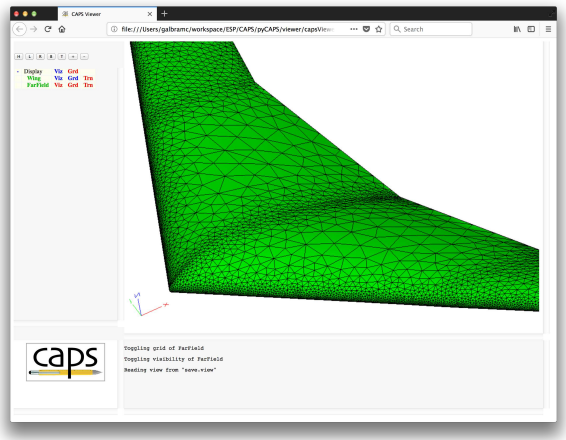
- Turning Angle resolves the surface mesh EDGEs in increments to match the degree specified
- The default value for the Turning Angle Hard (70.0) will identify sharp corners in the geometry not flagged by turning angle

session07/pointwise_03_TurnAngle.py

```
# Demonstrate the impact of Connector_Turn_Angle
for conTurnAngle in [1, 10, 50]:
    # Modify the turn angle
    pointwise.setAnalysisVal("Connector_Turn_Angle", conTurnAngle)
```





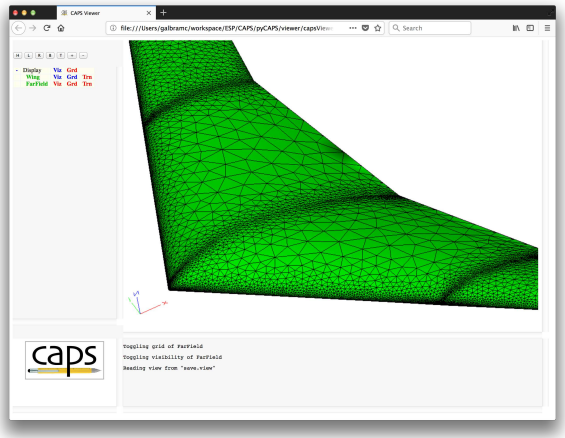
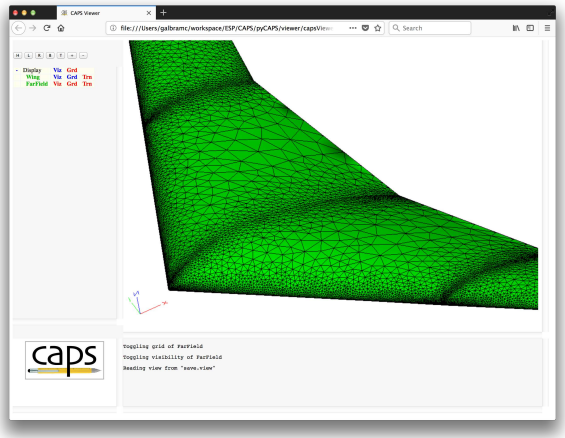
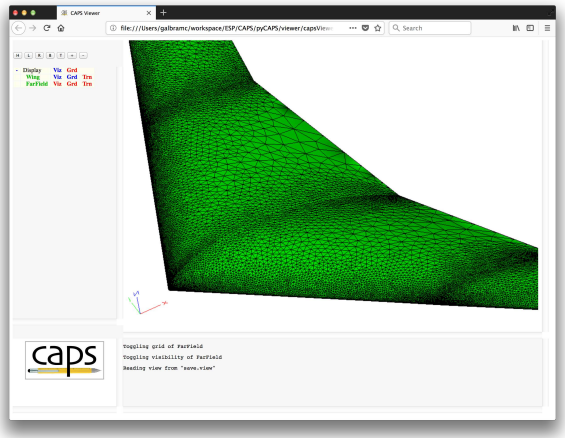


Impact of Domain_Decay

- Domain decay controls gradation of edge lengths away from the EDGEs a surface mesh patch.
- Values near 1.0 give gradual increase in edge length.
- Values (0.5 or less) gives rapid increase is edge length.

session07/pointwise_04_DomainDecay.py

```
# Demonstrate the impact of Domain_Decay
for domDecay in [0.1, 0.75, 0.95]:
    # Modify the domain decay
    pointwise.setAnalysisVal("Domain_Decay", domDecay)
```

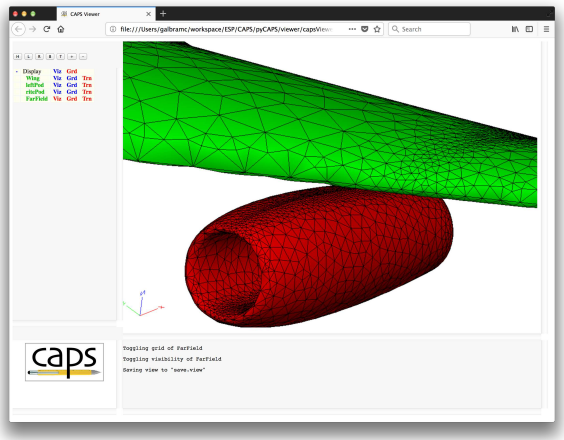




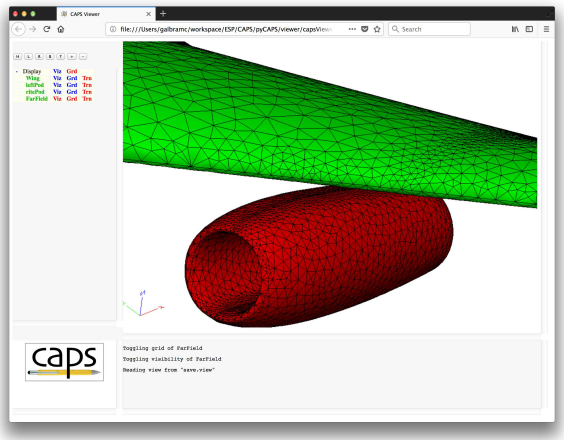
Proximity Detection

- Pod includes `EDGE` geometry close to the wing leading edge
- Source Spacing enables connectors-to-connector proximity detection
- The proximity test also uses Block level parameters

session07/pointwise_05_Proximity.py

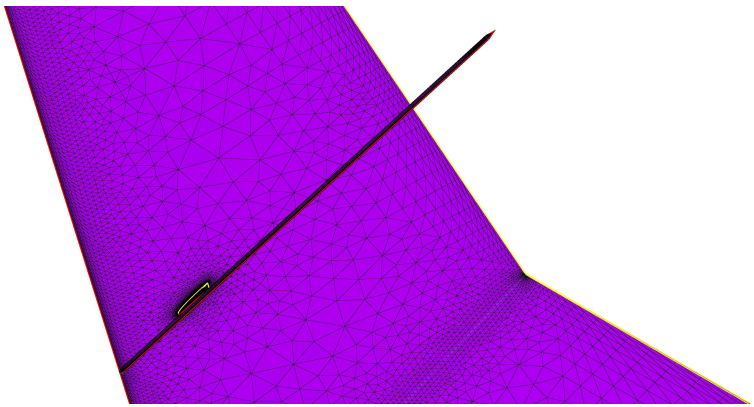
```
# Demonstrate the impact of Connector_Source_Spacing
for conSourceSpace in [False, True]:
    # Modify the source spacing
    pointwise.setAnalysisVal("Connector_Source_Spacing", conSourceSpace)
```

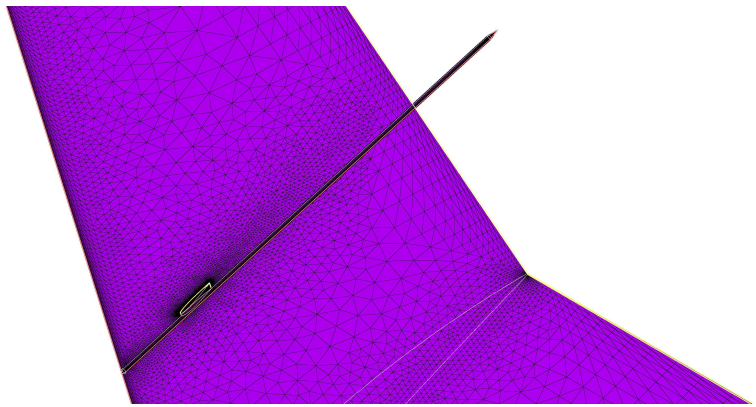




Proximity Detection

- Domain-to-domain proximity detection enabled with
  Connector_Adapt_Sources
  Domain_Adapt

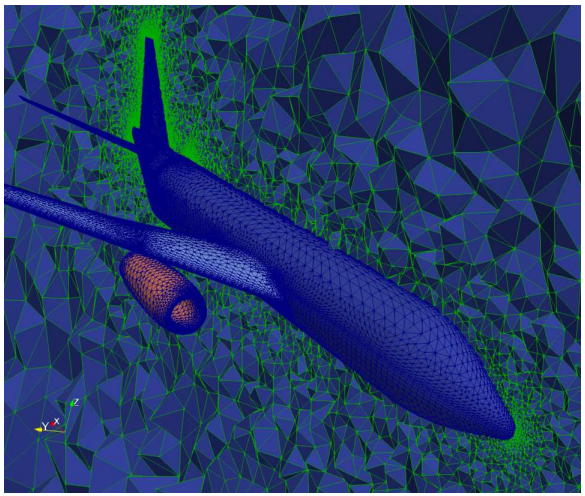
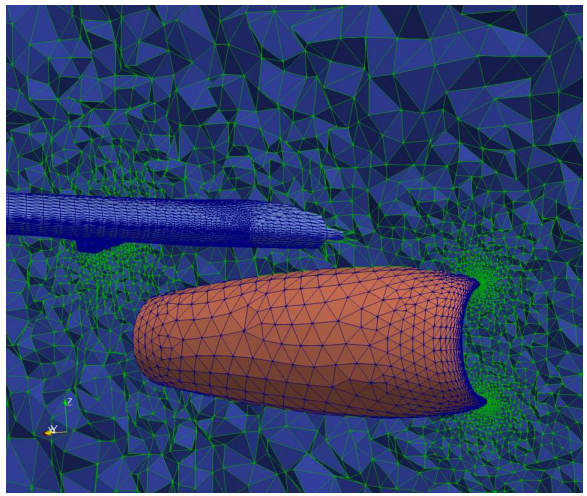
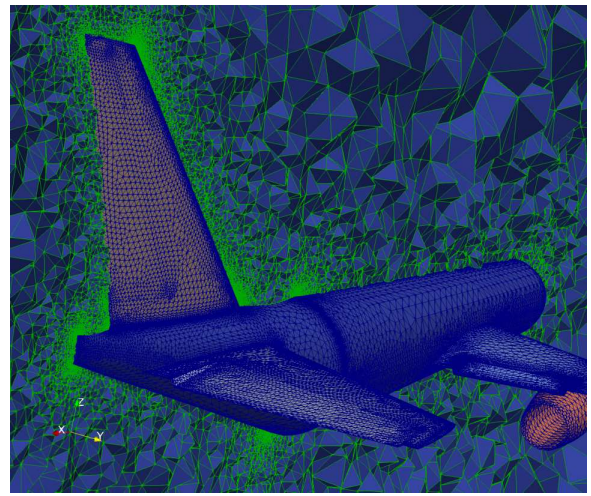




Full Inviscid Transport Example

- Inviscid surface mesh for the full transport configuration using suggested parameters
  - $\sim$ 5 min
  - 600k Nodes
  - 4M Elements

session07/pointwise_06_InviscidTransport.py

Overview

- Pointwise and GeomToMesh.glf
- Pointwise invsicid meshing
  - Suggested parameters
  - Proximity detection
- Pointwise viscous meshing
  - Suggested parameters
  - Viscous boundary layer mesh generation
- Suggested Exercises

GeomToMesh.glf Suggested Viscous Values

- Recommended viscous values are similar to the inviscid
- Block level parameters to control boundary layer meshing

session07/pointwise_07_ViscousWing.py

```
# Connector level
pointwise.setAnalysisVal("Connector_Turn_Angle"      , 10)
pointwise.setAnalysisVal("Connector_Prox_Growth_Rate", 1.2)
pointwise.setAnalysisVal("Connector_Source_Spacing"  , True)

# Domain level
pointwise.setAnalysisVal("Domain_Algorithm"   , "AdvancingFront")
pointwise.setAnalysisVal("Domain_Max_Layers"  , 15)
pointwise.setAnalysisVal("Domain_Growth_Rate" , 1.2)
pointwise.setAnalysisVal("Domain_TRex_ARLimit", 20.0)
pointwise.setAnalysisVal("Domain_Decay"       , 0.8)

# Block level
pointwise.setAnalysisVal("Block_Boundary_Decay"      , 0.8)
pointwise.setAnalysisVal("Block_Collision_Buffer"    , 1.0)
pointwise.setAnalysisVal("Block_Max_Skew_Angle"      , 160.0)
pointwise.setAnalysisVal("Block_Edge_Max_Growth_Rate", 1.5)
pointwise.setAnalysisVal("Block_Full_Layers"         , 1)
pointwise.setAnalysisVal("Block_Max_Layers"          , 100)

# Set wall spacing for capsGroup = Wing
viscousWall  = {"boundaryLayerSpacing" : 0.001}
pointwise.setAnalysisVal("Mesh_Sizing", ("Wing", viscousWall))
```

GeomToMesh.glf Suggested Viscous Values

- The suggested connector attributes very similar to inviscid values.
- Proximity growth rate has been slightly reduced.

session07/pointwise_07_ViscousWing.py

```
# Connector level
pointwise.setAnalysisVal("Connector_Turn_Angle"      , 10)
pointwise.setAnalysisVal("Connector_Prox_Growth_Rate", 1.2)
pointwise.setAnalysisVal("Connector_Source_Spacing"  , True)
```

GeomToMesh.glf Suggested Viscous Values

- The suggested domain attributes also similar to inviscid values.
- The growth rate has been slightly reduced.

session07/pointwise_07_ViscousWing.py

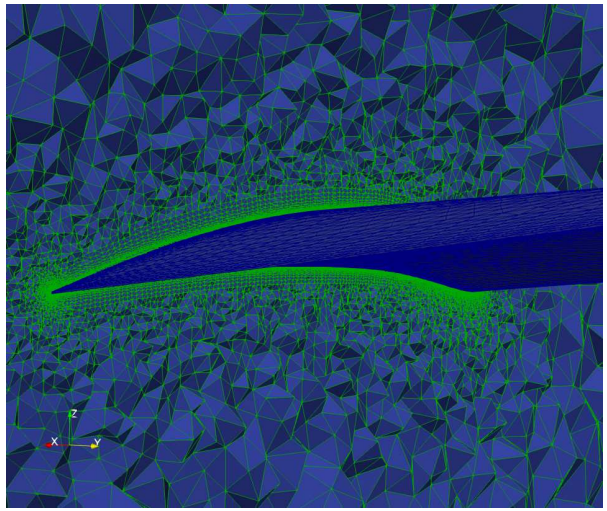
```
# Domain level
pointwise.setAnalysisVal("Domain_Algorithm"    , "AdvancingFront")
pointwise.setAnalysisVal("Domain_Max_Layers"   , 15)
pointwise.setAnalysisVal("Domain_Growth_Rate" , 1.2)
pointwise.setAnalysisVal("Domain_TRex_ARLimit", 20.0)
pointwise.setAnalysisVal("Domain_Decay"        , 0.8)
```

GeomToMesh.glf Suggested Viscous Values

- Increased collision buffer to allow gap between fronts
- Skew angle stops T-Rex locally when elements exceed
- Full_Layers is the desired number of full viscous layers
- Max Layer is upper bounds on the number of layers
- T-Rex automatically halts locally when elements approach isotropy

session07/pointwise_07_ViscousWing.py

```
# Block level
pointwise.setAnalysisVal("Block_Boundary_Decay"      , 0.8)
pointwise.setAnalysisVal("Block_Collision_Buffer"    , 1.0)
pointwise.setAnalysisVal("Block_Max_Skew_Angle"      , 160.0)
pointwise.setAnalysisVal("Block_Edge_Max_Growth_Rate", 1.5)
pointwise.setAnalysisVal("Block_Full_Layers"         , 1)
pointwise.setAnalysisVal("Block_Max_Layers"          , 100)
```

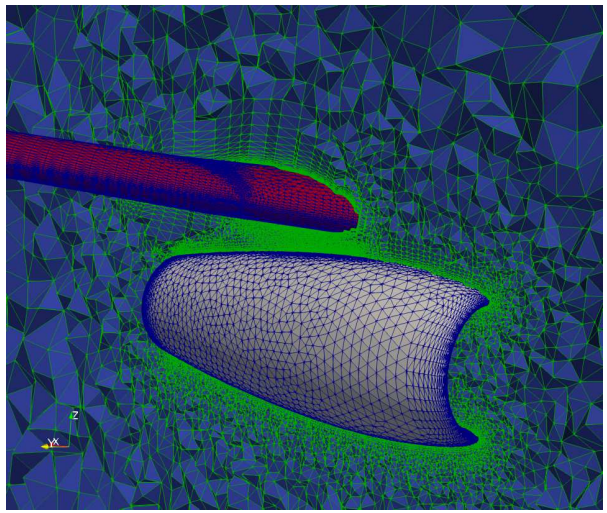


Colliding Boundary Layers

- Viscous extrusion when "PW:WallSpacing" attribute on `FACE`s
  - Set with Mesh_Sizing `boundaryLayerSpacing` using `capsGroup`
  - `boundaryLayerSpacing` scaled by `capsMeshLength`
- Boundary layer wall spacings can differ between `capsGroup`

session07/pointwise_08_ViscousWingPod.py

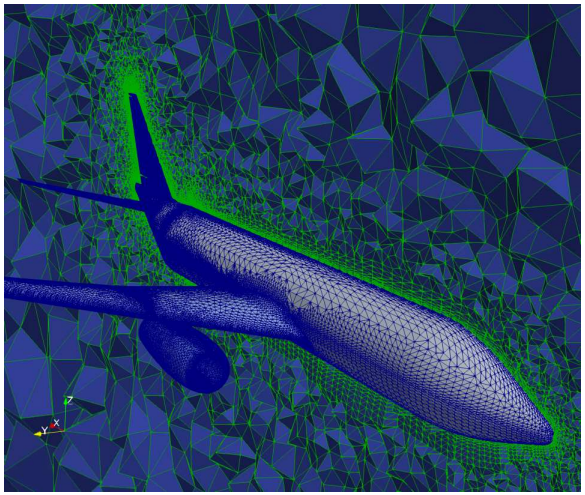
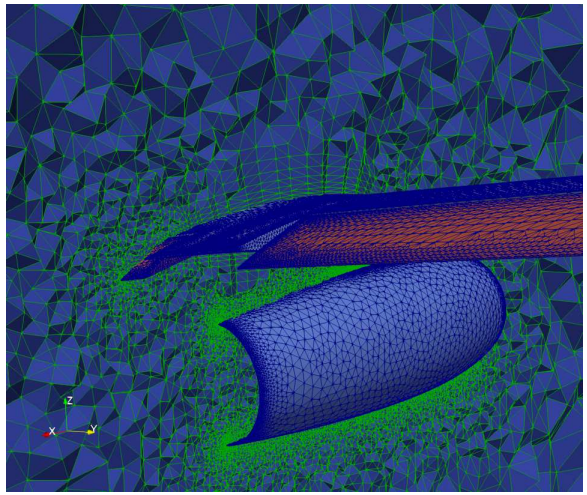
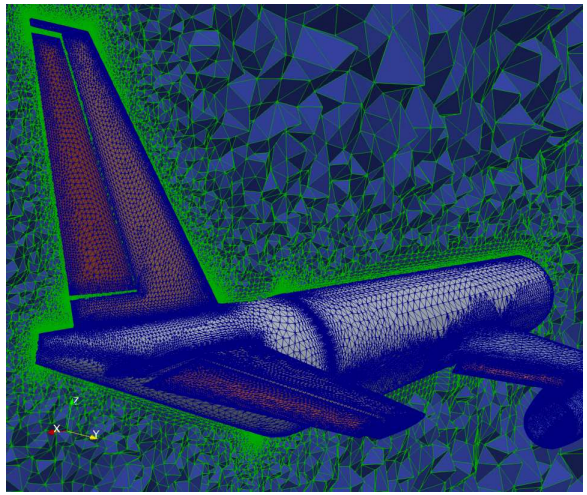
```
# Set wall spacing for capsGroup = Wing and capsGroup = Pod
wingWall = {"boundaryLayerSpacing" : 0.001}
podWall  = {"boundaryLayerSpacing" : 0.003}
pointwise.setAnalysisVal("Mesh_Sizing", [("Wing", wingWall),
                                         ("Pod", podWall)])
```



Full Transport Example

- Viscous surface mesh for the full transport configuration using suggested parameters[1]
  - $\sim$ 15 min
  - 1.8M Nodes
  - 10.2M Elements

session07/pointwise_09_ViscousTransport.py

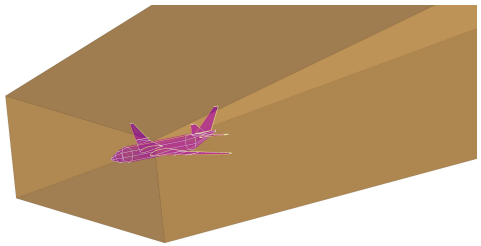
[1]NOTE: Unreasonably coarse boundary layers in examples

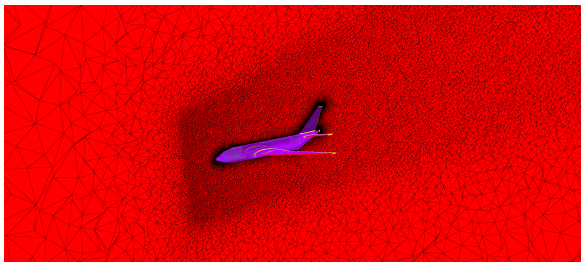
Source Box

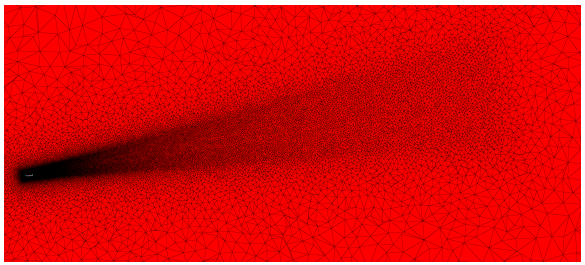
- Box keys off of all viscous surfaces
- Creates an elongated box the direction of the vector
- Widens using the Angle parameter
- Scalar size field grows from surface size along the box

session07/pointwise_10_SourceBox.py

```
# General source box parameters
pointwise.setAnalysisVal("Gen_Source_Box_Length_Scale", 40.0)
pointwise.setAnalysisVal("Gen_Source_Box_Direction"   , [ 0.9848077, 0, 0.1736482 ])
pointwise.setAnalysisVal("Gen_Source_Box_Angle"       , 10.0)
pointwise.setAnalysisVal("Gen_Source_Growth_Factor"   , 40.0)
```







Suggested Exercises

Domain Proximity

- Enable domain-to-domain proximity detection for the wing with pods
  - Connector_Adapt_Sources and Domain_Adapt

Other AIM Inputs

- Explore the impact of Pointwise AIM input parameters
  - Connector, Domain, Block inputs

Suggested Exercises Cont.

Inviscid Mesh Sequence

- For the InviscidTransport, generate surface meshes with approximate element counts of:
  - 150,000
  - 250,000
  - 300,000

- Create your own