CHIMERA GRID TOOLS TUTORIAL: PART 2
AUTO-MESHING MODULES

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15th Symposium on Overset Composite Grids and Solution Technology,
Suffolk, Virginia, November 1-3, 2022

OUTLINE

- Introduction
- Geometry input and best practices
- EGADS2SRF
- POGS (Pre-Processor for Overset Grid Simulations)

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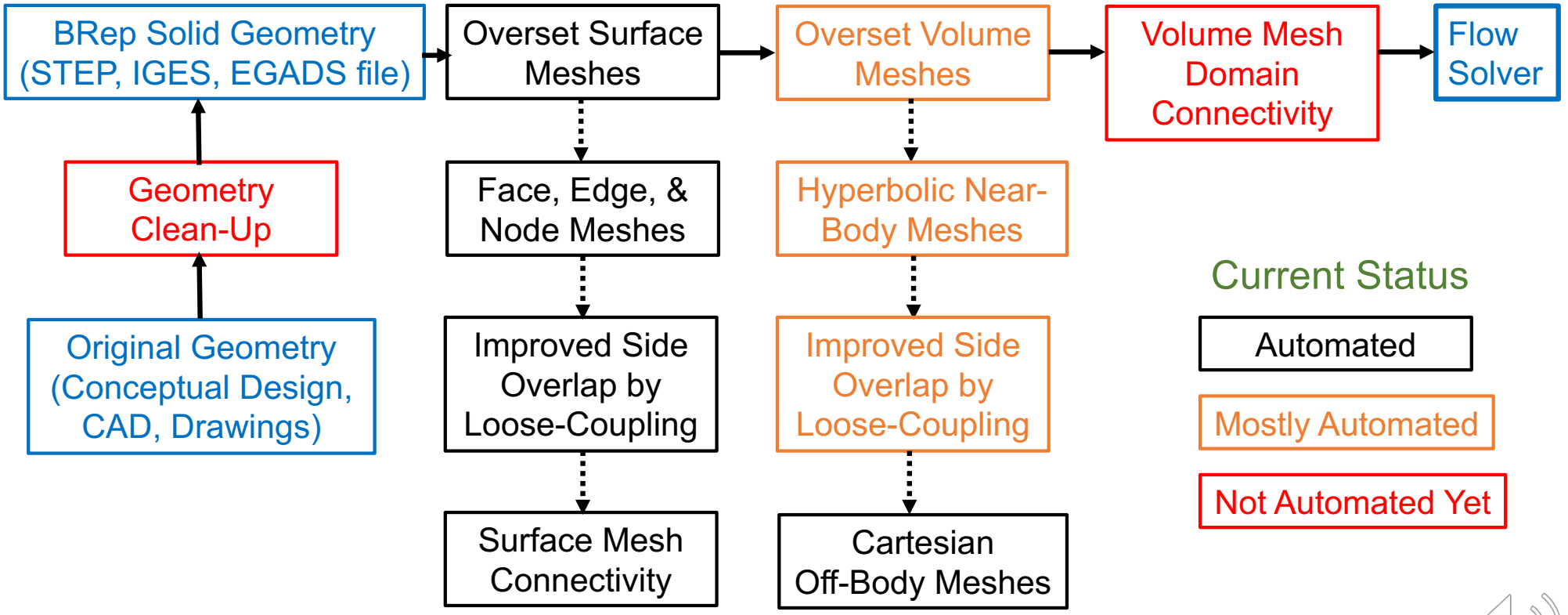
OVERSET MESH GENERATION AUTOMATION FLOW CHART



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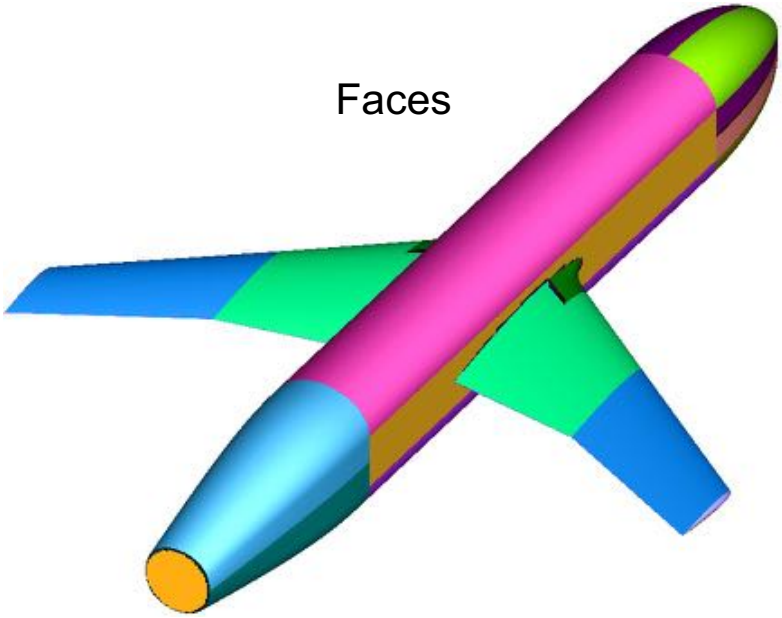
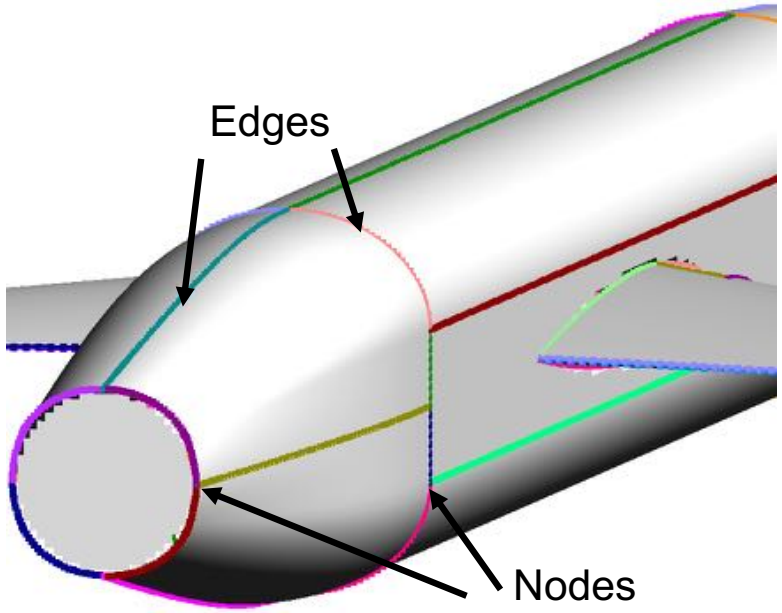
GEOMETRY INPUT

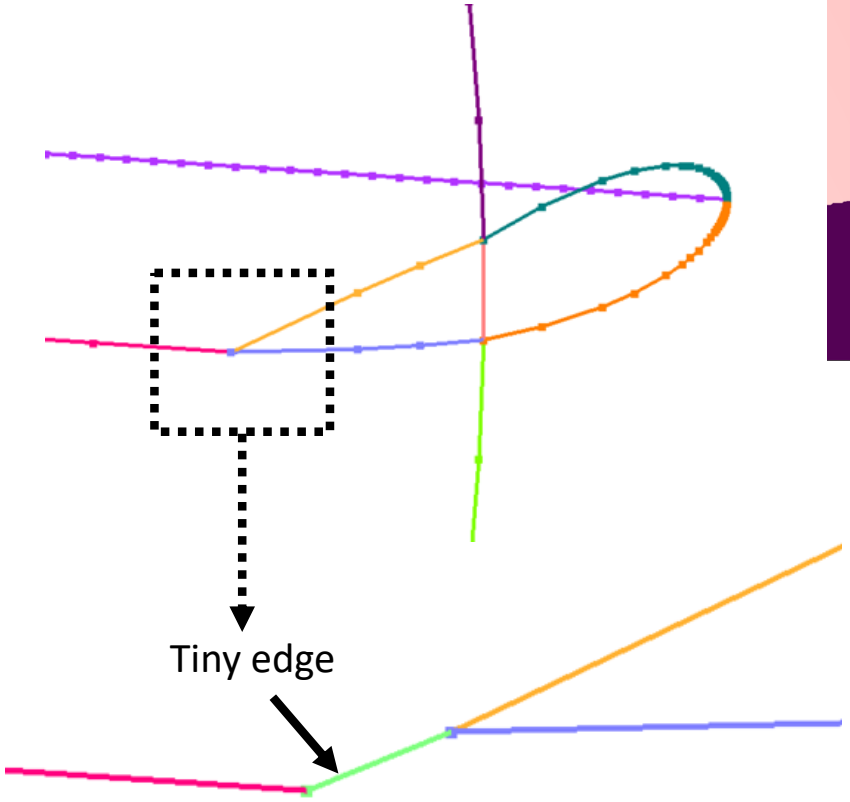
- Boundary Representation (BRep) solid (STEP, IGES, EGADS)
- Topological relationship: Faces (F), Edges (E), Nodes (N)
- Construct meshes based on F, E, N
- Total # of grids ~ (# F + # E + # N)

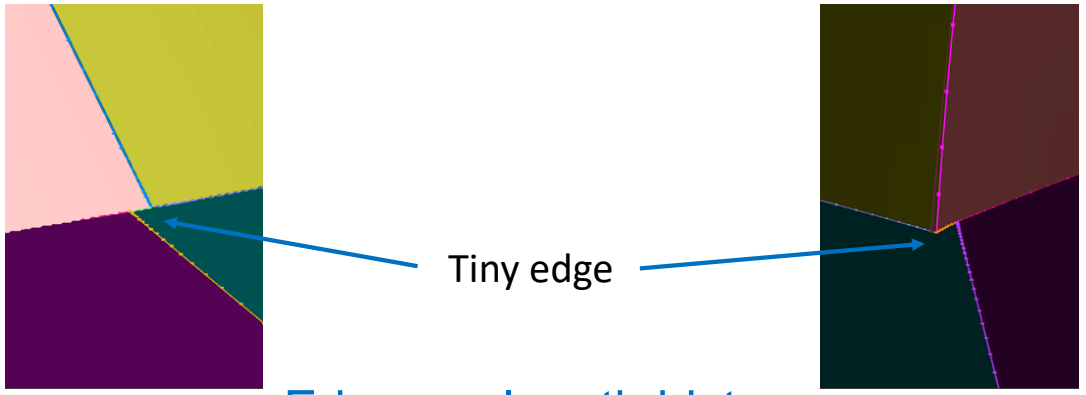




GEOMETRY BEST PRACTICES (1)

Make sure tolerances << smallest geometric feature size





Edge arc length histogram

	# edges
E <= 1.0E-6 * diag	2
1.0E-6 * diag < E <= 1.0E-5 * diag	0
1.0E-5 * diag < E <= 1.0E-4 * diag	0
1.0E-4 * diag < E <= 1.0E-3 * diag	0
1.0E-3 * diag < E <= 1.0E-2 * diag	14
1.0E-2 * diag < E <= 1.0E-1 * diag	136
1.0E-1 * diag < E <= 1.0 * diag	21
1.0 * diag < E	0

min edge length = 0.00003 at edge 103
max edge length = 28.08451 at edge 10

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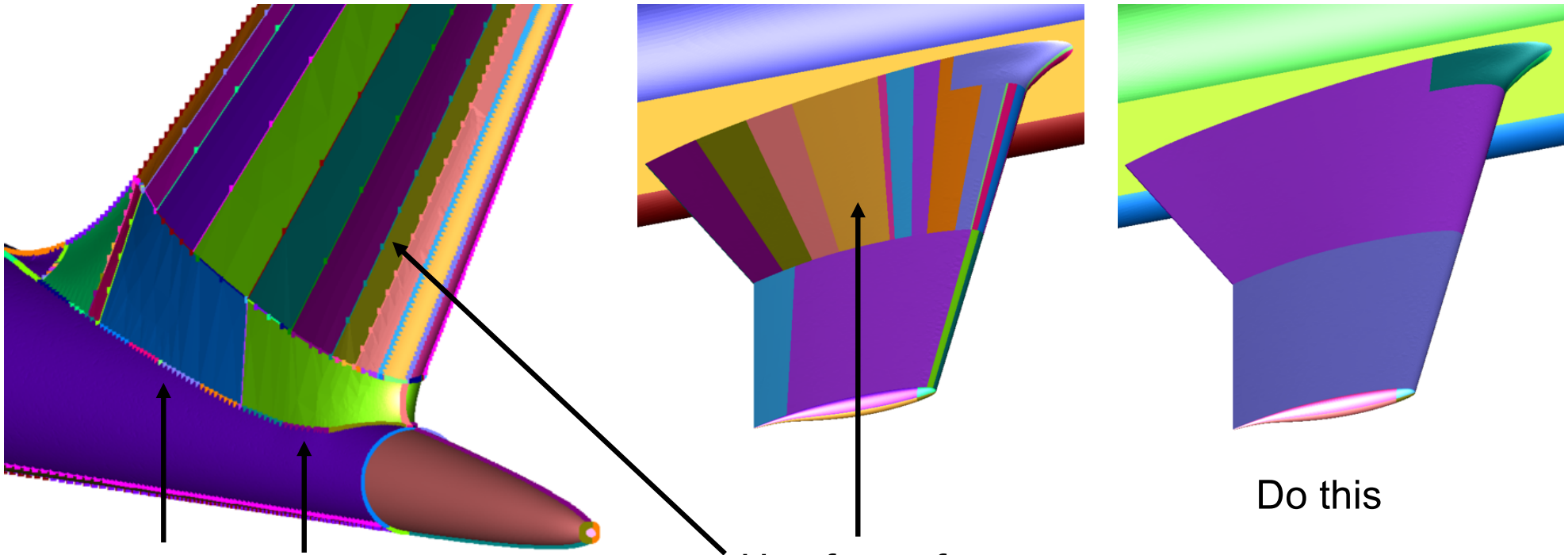
GEOMETRY BEST PRACTICES (2)

Use as few edges and faces as possible to represent the geometry

Use lowest order analytic curves and surfaces possible to describe geometry



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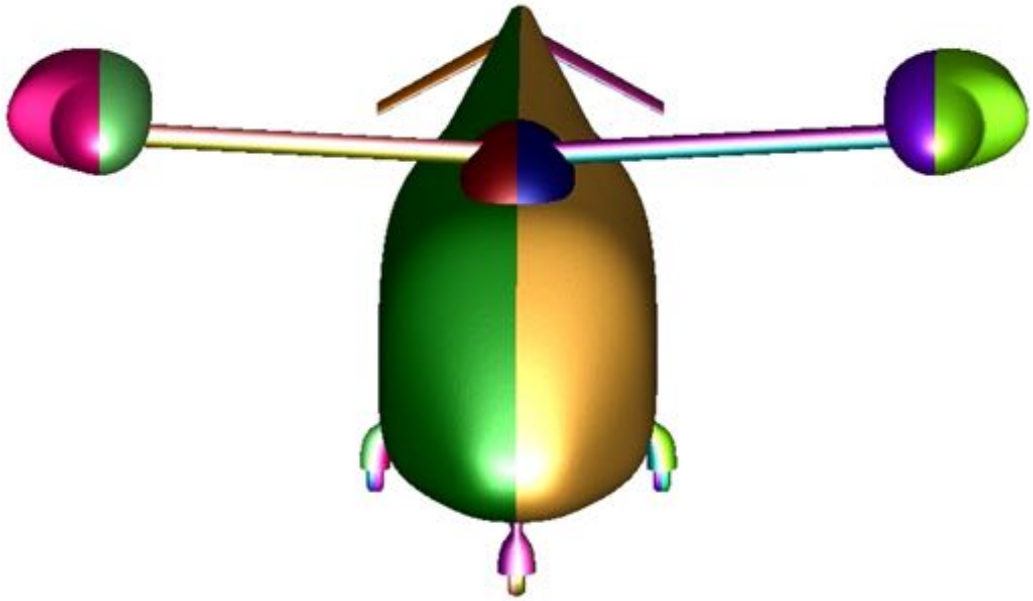
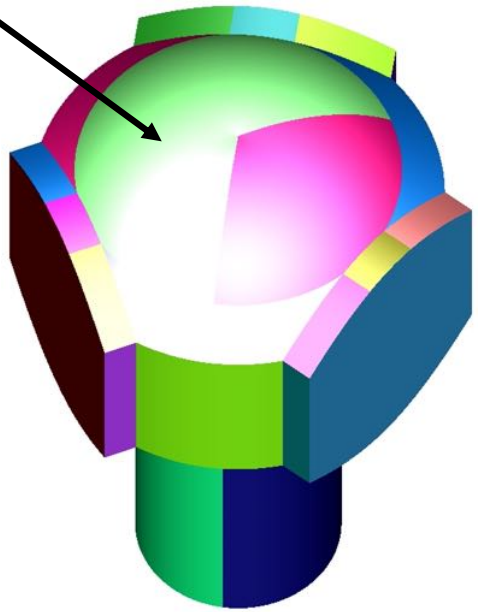
GEOMETRY BEST PRACTICES (3)

Faces, edges and nodes should be symmetric relative to the lines of symmetry



Symmetric vehicle – use same number of faces, edges and nodes on left and right sides

Should be 120 degree wedge



Should have 3-fold symmetry

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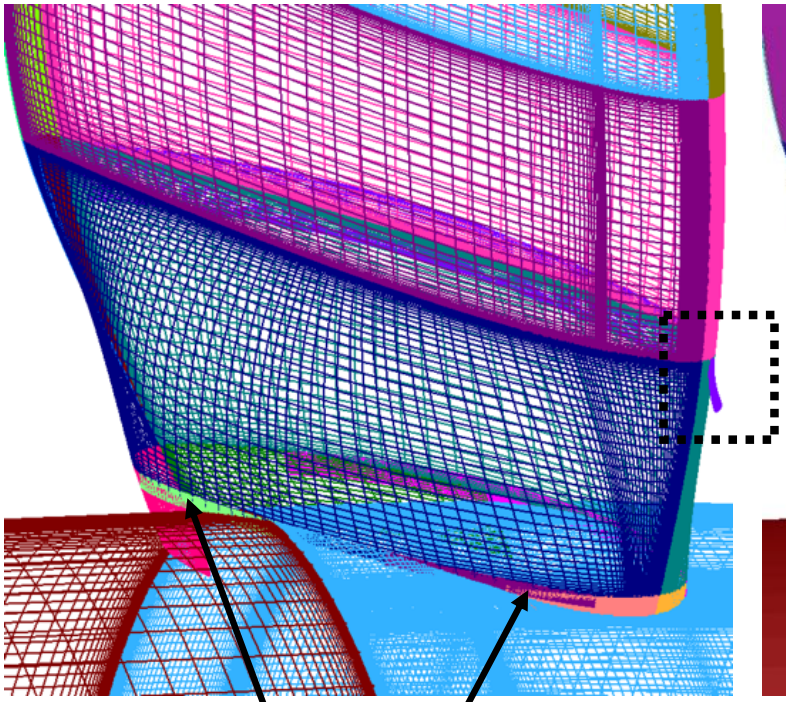
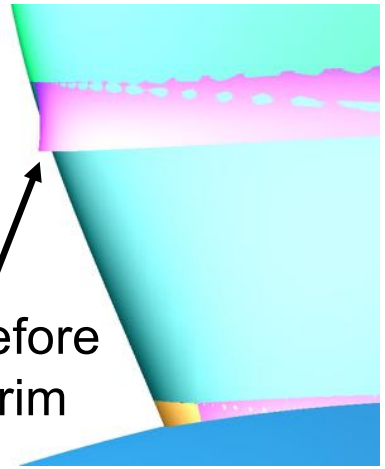
GEOMETRY BEST PRACTICES (4)

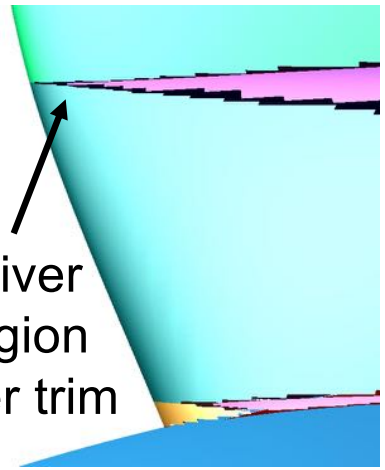
Avoid sliver and tiny faces



Complete untrimmed small faces

Tiny sliver faces after trim





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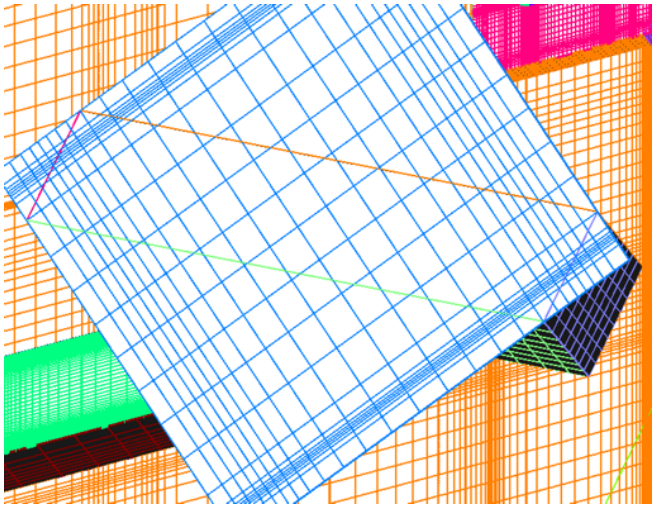
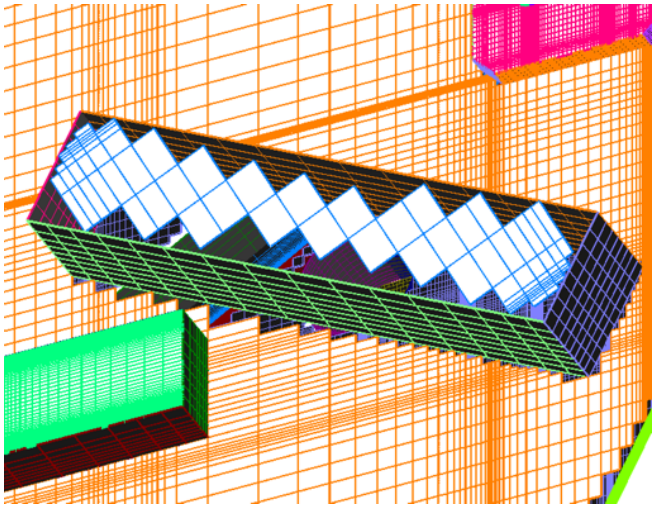
GEOMETRY BEST PRACTICES (5)

Avoid creation of faces with excessive trim

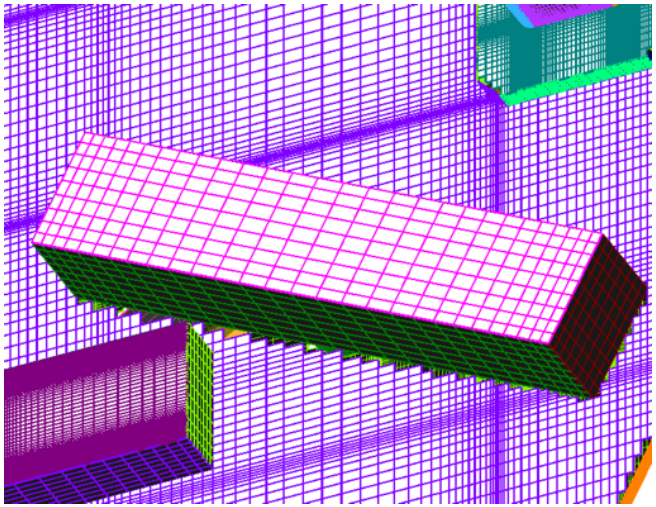
Align isoparameter (u,v) lines with face boundaries



Untrimmed face with misaligned u,v



Trimmed face with misaligned u,v



Trimmed face with aligned u,v

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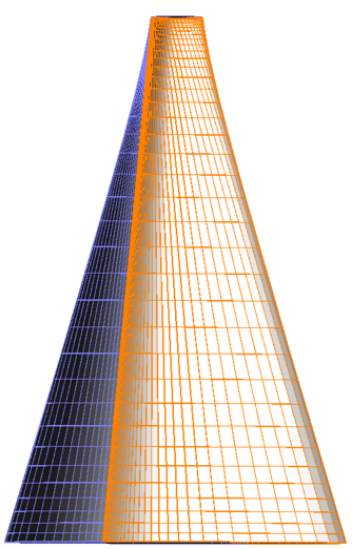
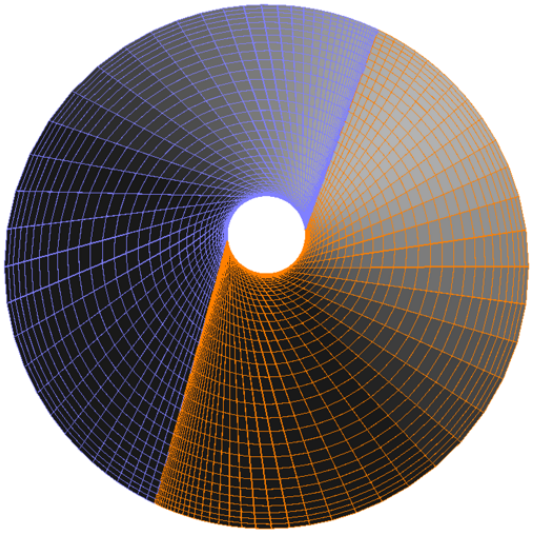
GEOMETRY BEST PRACTICES (6)

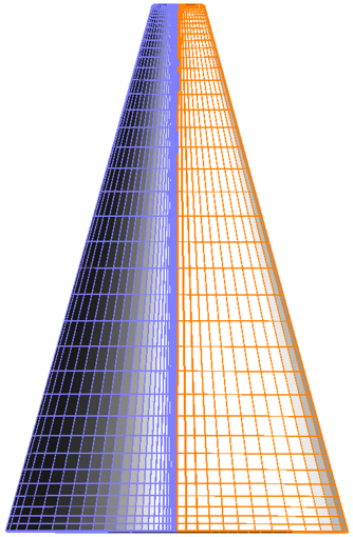
Align isoparameter lines of face to surface curvature

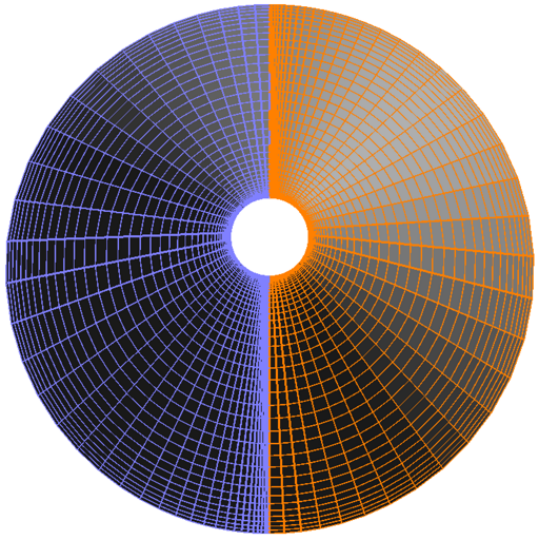
Axisymmetric bodies should be created by revolving a profile curve





Isoparameter lines not aligned with surface curvature

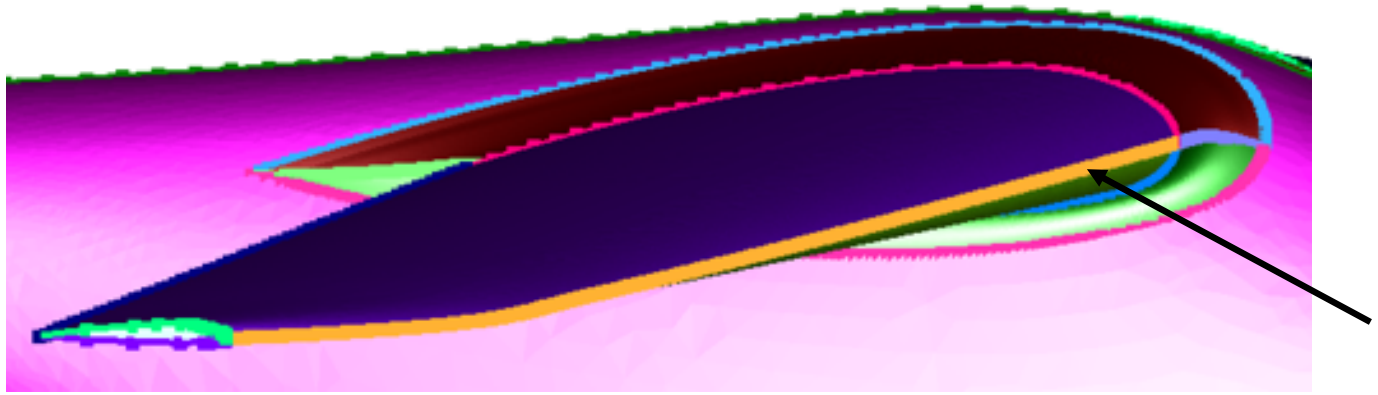




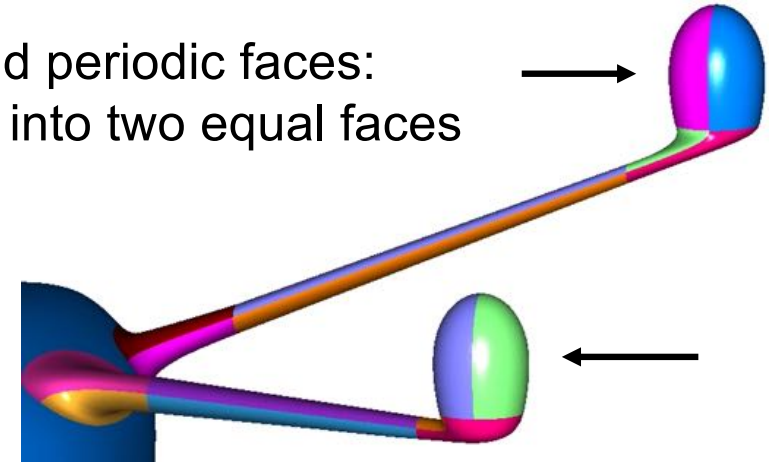
Isoparameter lines aligned with surface curvature

GEOMETRY BEST PRACTICES (7)

Airfoil shapes: define a BRep edge at leading edge



Avoid periodic faces:
split into two equal faces



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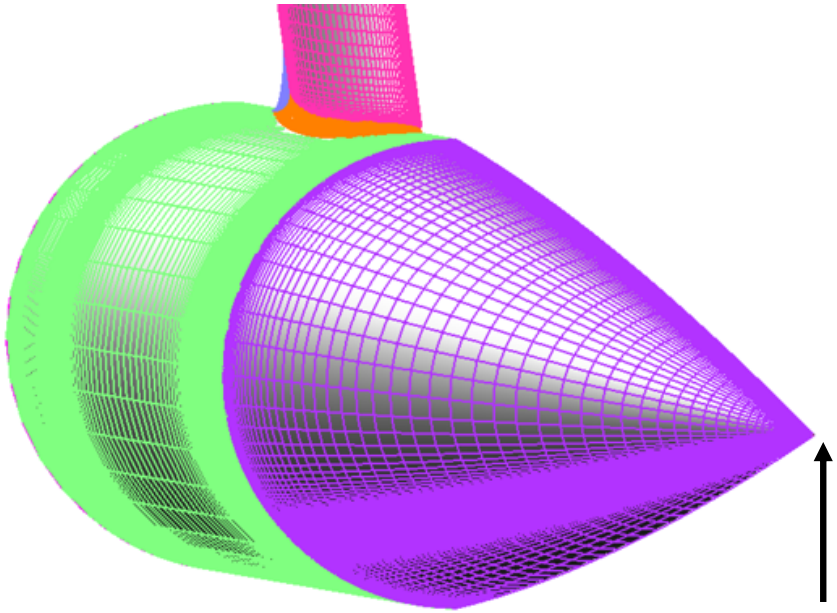
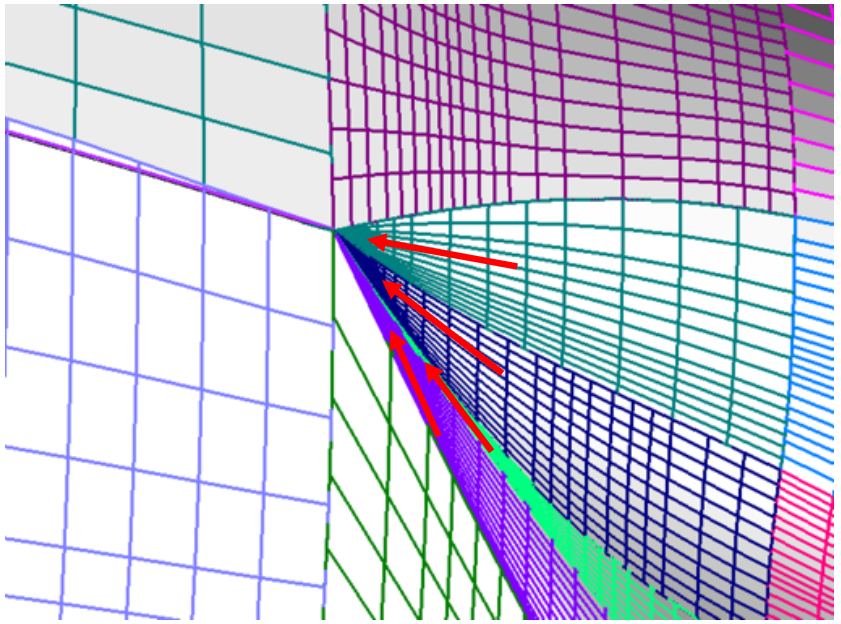
GEOMETRY BEST PRACTICES (8)

Avoid collapsed edges on a face unless dictated by geometry



Collapsed edge required at apex of cone



Avoid collapsed edge on smooth surface

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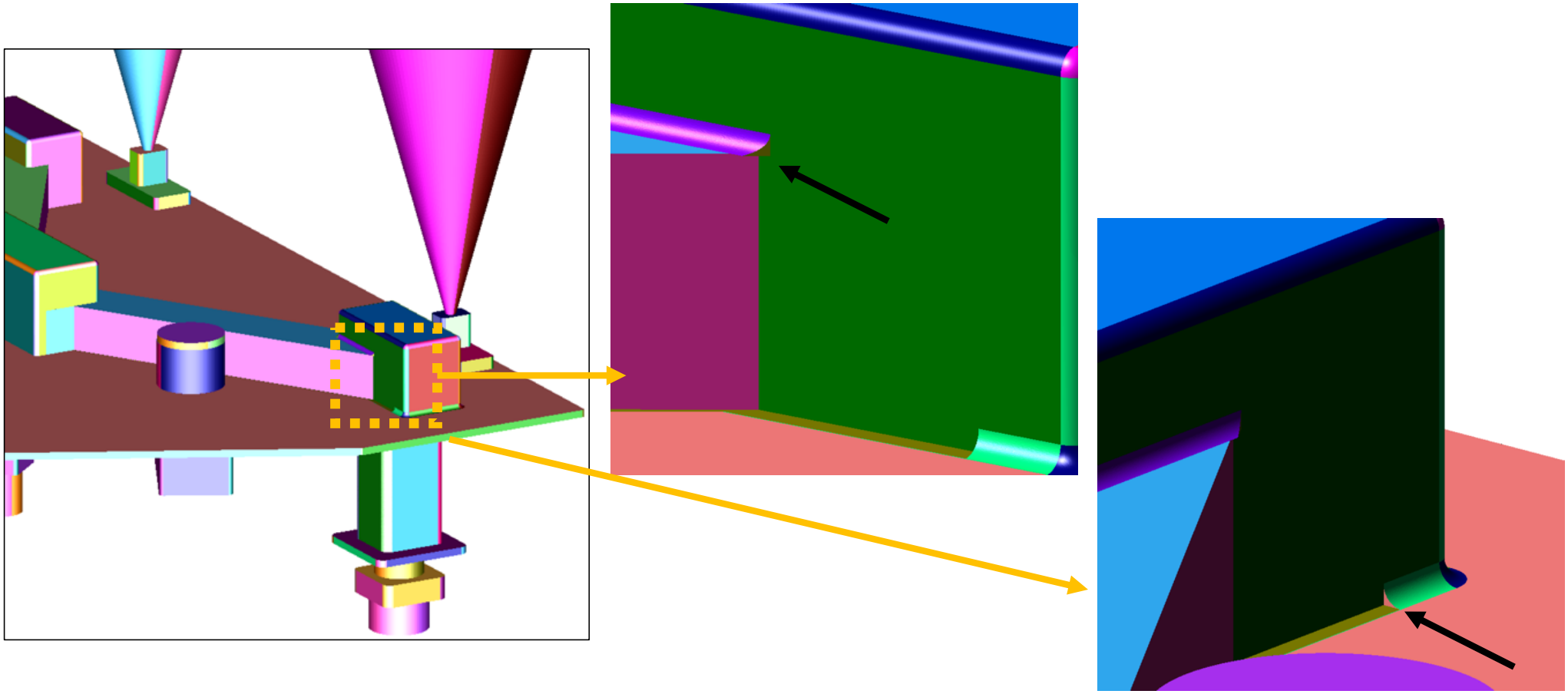
GEOMETRY BEST PRACTICES (9)

Remove insignificant geometric features for CFD simulations



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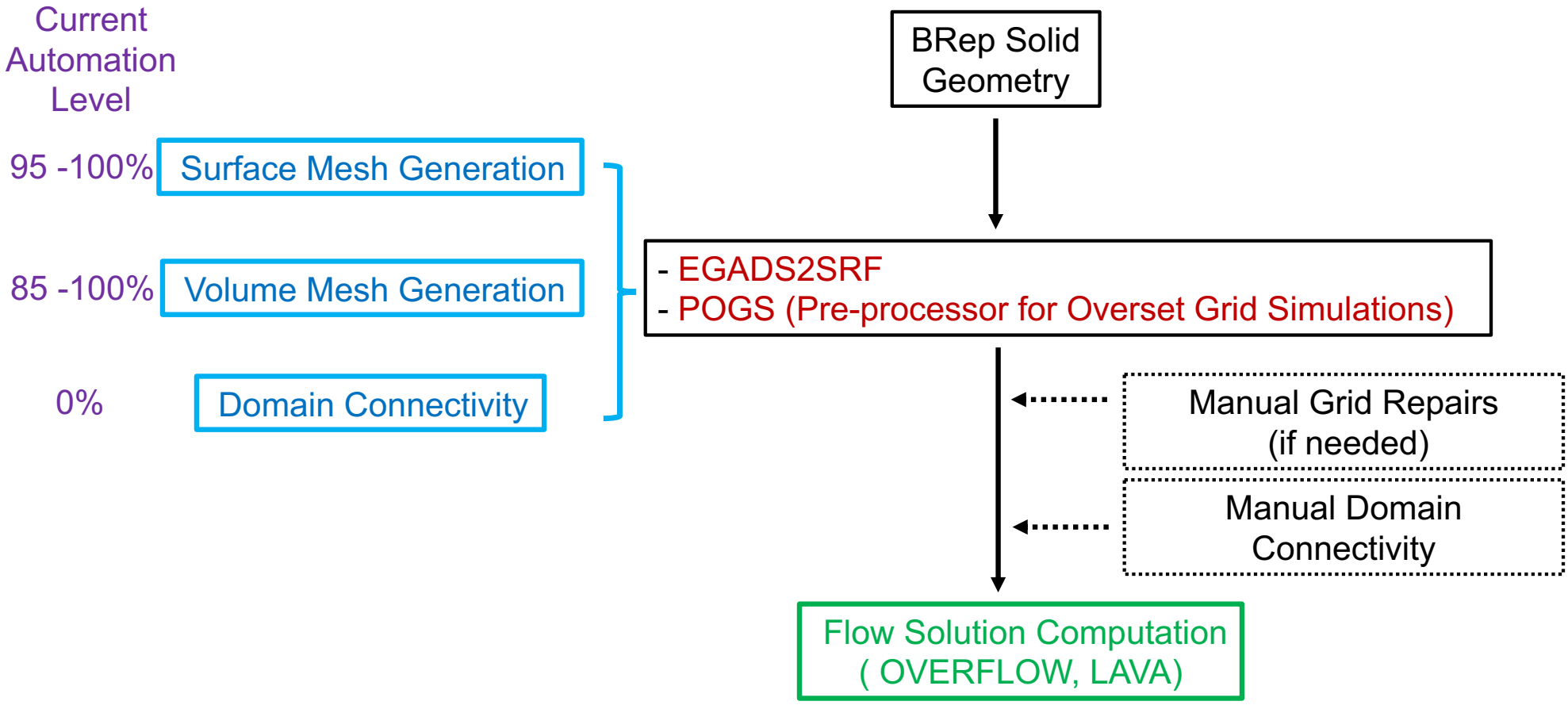
CURRENT AUTOMATIC/MANUAL HYBRID PROCEDURE



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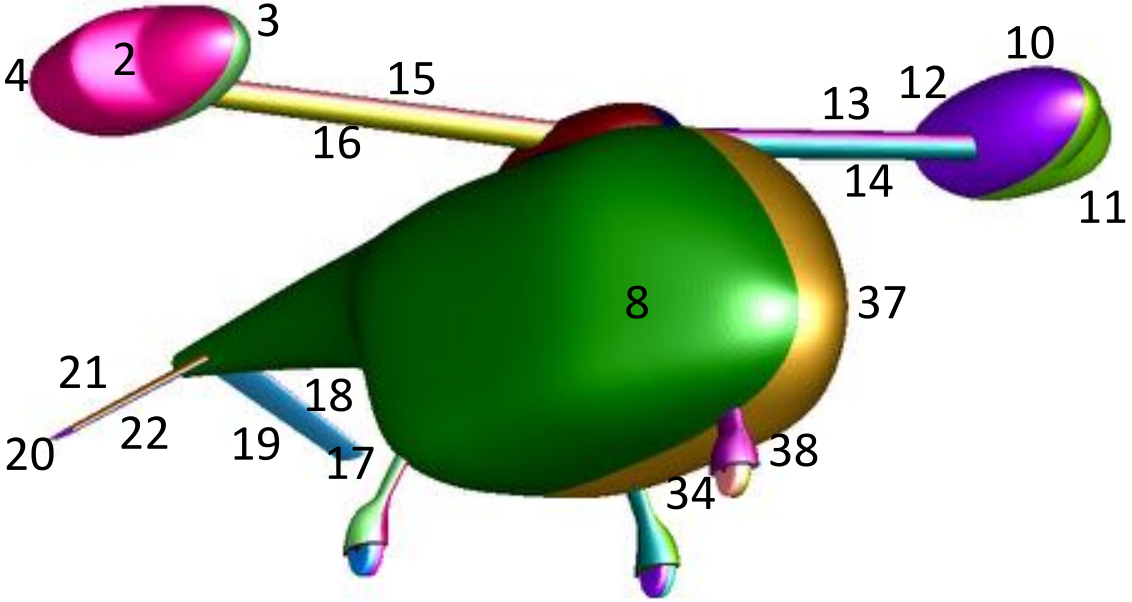
GEOMETRIC COMPONENTS SPECIFICATION

- Text file: component name + list of face numbers
- Information usually not available from geometry file (STEP/IGES)
- Manual construction with OVERGRID + Text Editor
  (< 10 minutes for example below)
- Enables:
  - Local component characteristic length -> local max grid spacing
  - Auto construction of input file for component aero loads computation
  - Single component meshing option



Component/Face Data File (.gcomp)

Right_LandGear 1,23:27	Left_Wing 13:14
Rotor_1_Cowling 2:4	Right_Wing 15:16
Main_Fuselage 5:6,8,37	Left_Tail 17:19
Fuselage_Fairing 7,9	Right_Tail 20:22
Rotor_2_Cowling 10:12	Left_LandGear 28:33
	Front_LandGear 34:36,38:40

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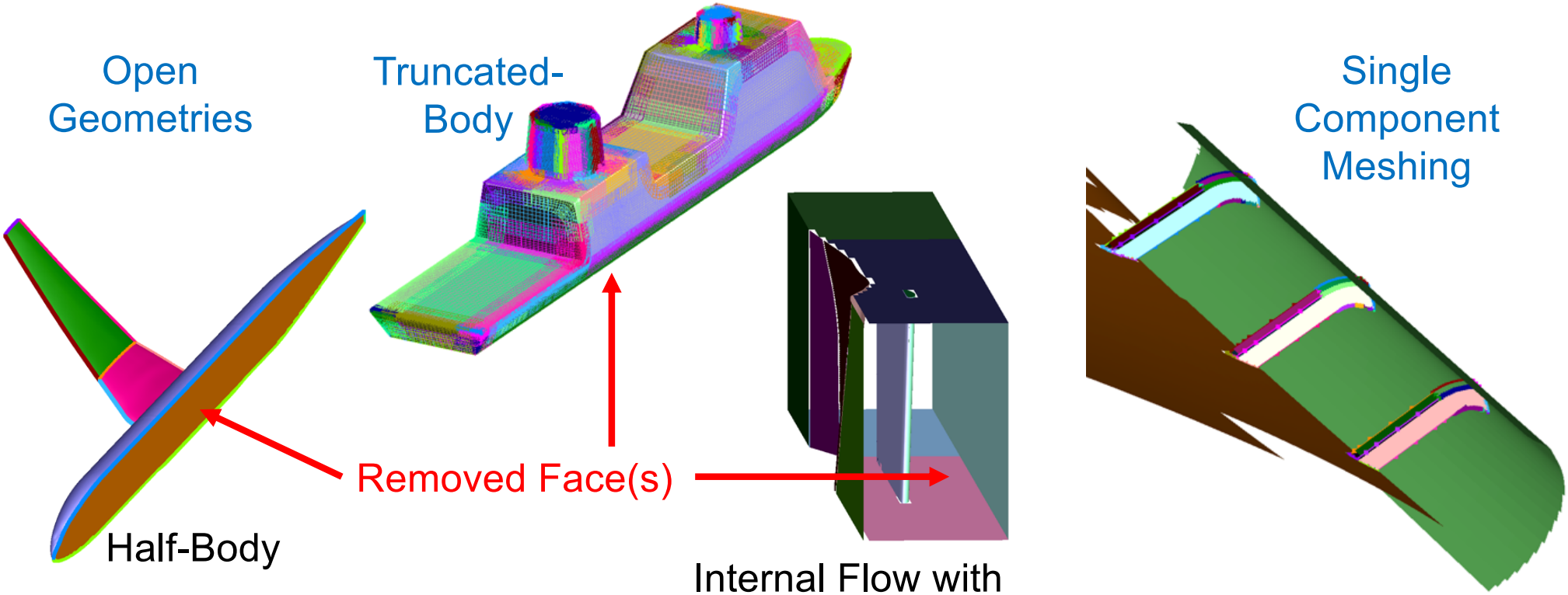
OPEN GEOMETRIES & SINGLE COMPONENT MESHING

Open Geometries

Truncated-Body

Single Component Meshing



- User-specified list of faces to remove
- Auto-update of face/edge/node topology

E.g., mesh one or more slat brackets + connected faces

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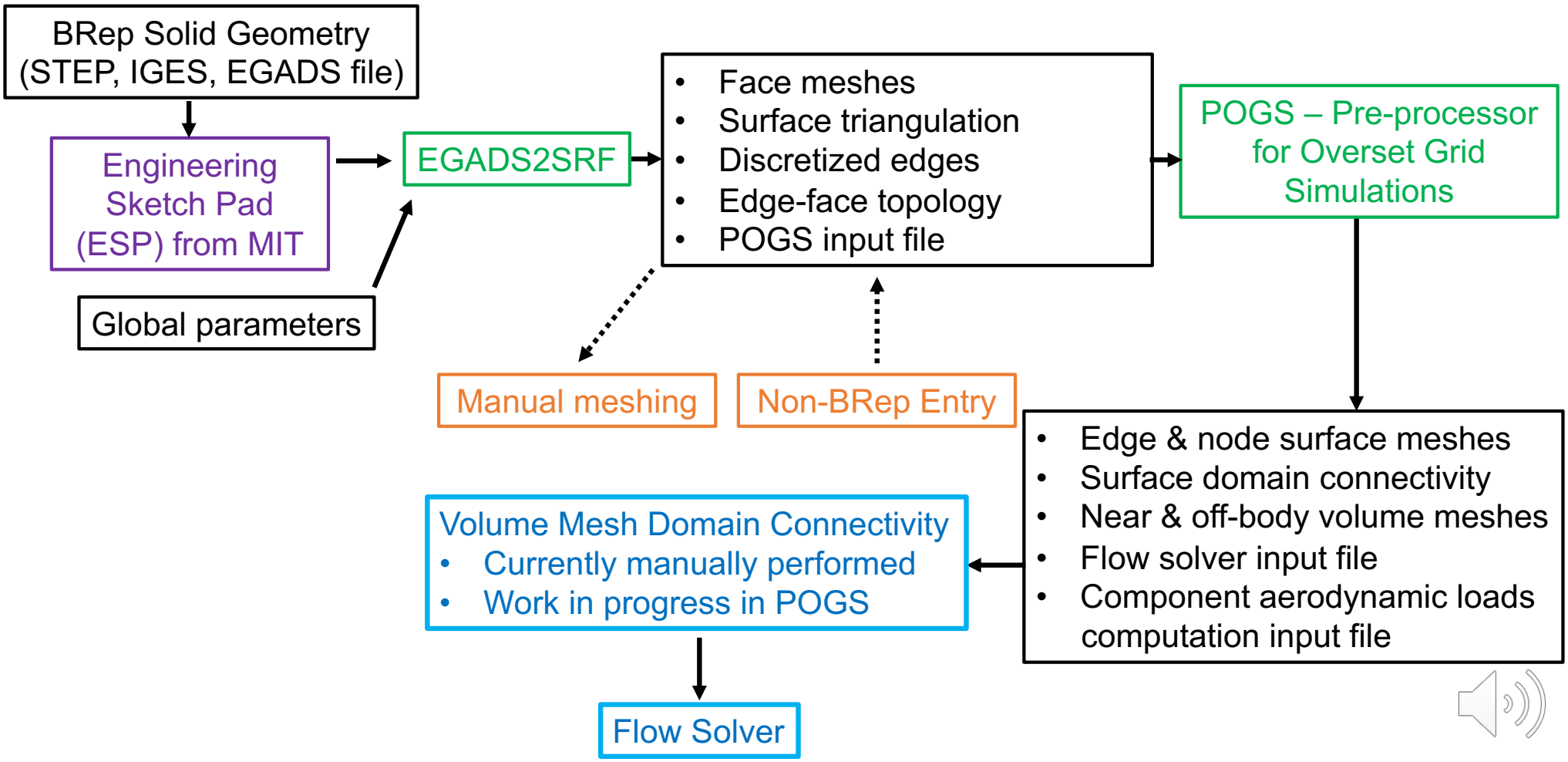
AUTOMATION SOFTWARE FLOW CHART



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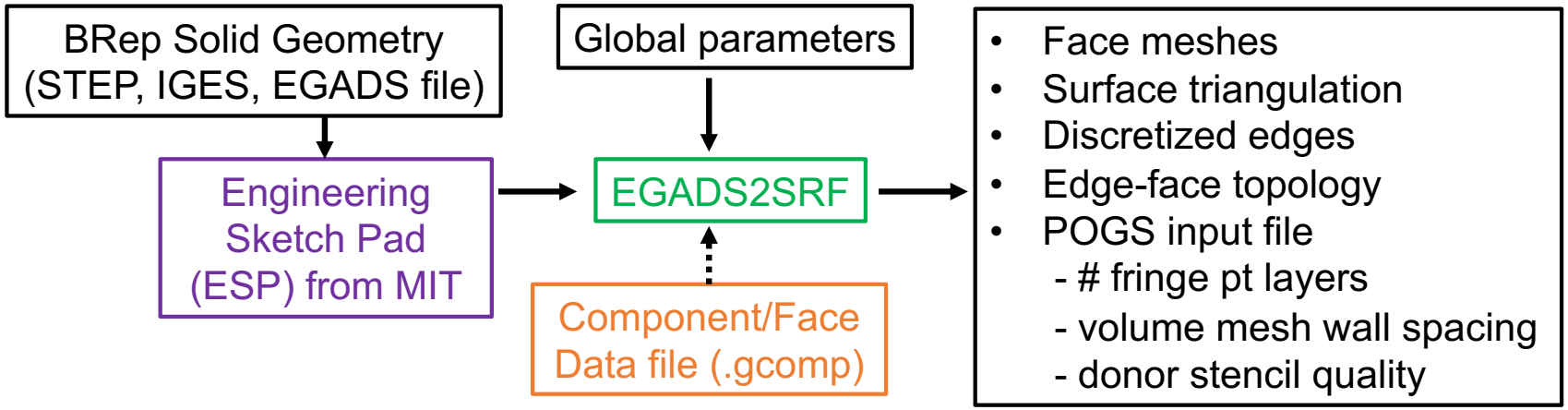
EGADS2SRF EXECUTION



- Install Engineering Sketch Pad (http://acdl.mit.edu/ESP/PreBuilts)
- Instructions in CGT doc directory

egads2srf --help

egads2srf -i geom.ext {options} > e.o

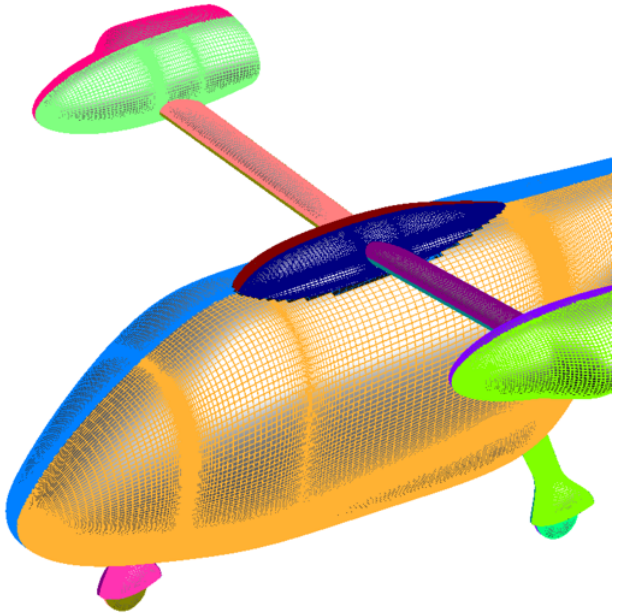
Options: -i {rootname}.{ext} (geometry filename, ext = stp/igs)

-maxa 4.0 (max dihedral angle)	-dswall 1.0e-5 (volume mesh wall spacing)
-maxe 1.0 (max edge length)	-intr (interior geometry)
-maxsr 1.2 (max stretching ratio)	-frm “5,12” (list of faces to remove)
-npmin 5 (min # pts on edge)	-gcomp htail (grid this component only)
-scale 12.0 (units scale factor)	-c (get contents info without meshing)
	-r (rerun with same parameters as last run)

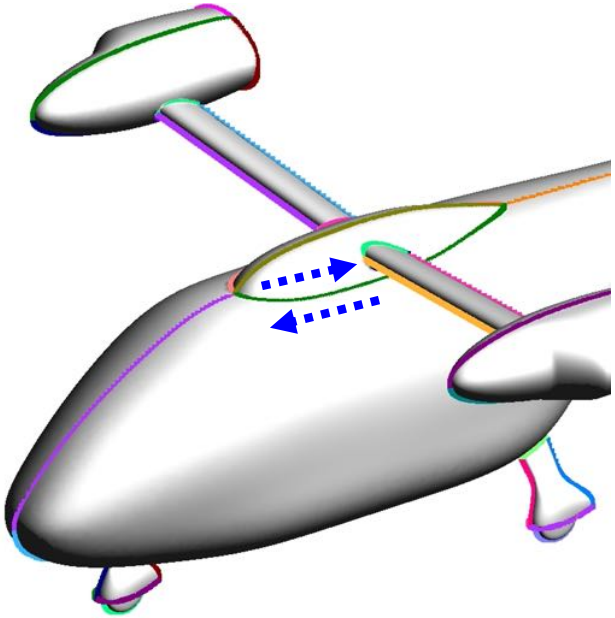
EGADS2SRF OUTPUT

Visual these 3 files in OVERGRID

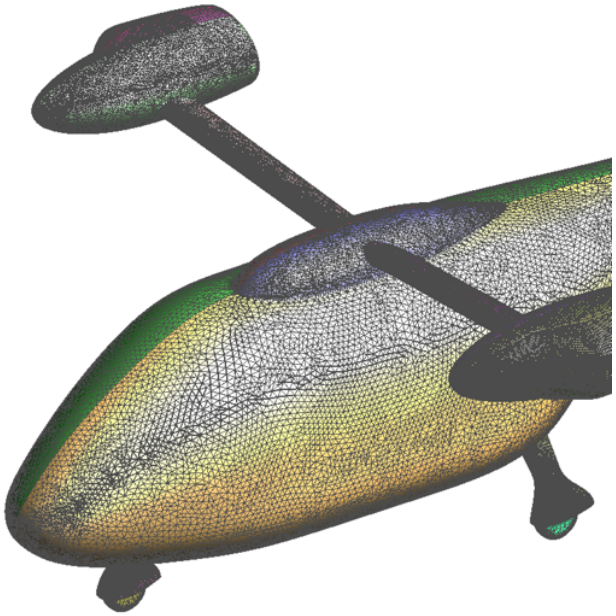
Starting point for POGS or manual meshing



Face meshes (plot3d surface grids with iblanks, .uvin)



Edge curves (plot3d curve grids, .cur)



Surface triangulation (Cart3d, .i.tri)

Other Files

.uv (u,v) values of face mesh vertices

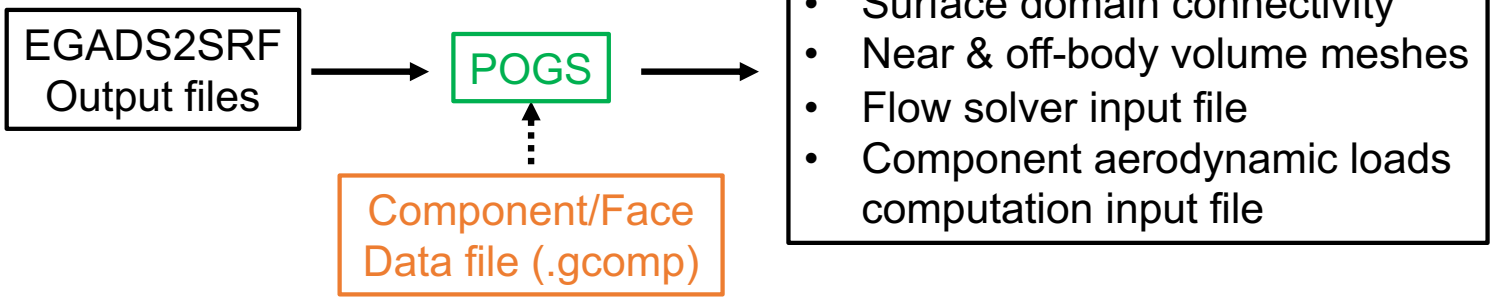
.cuv (u,v) values of edge curve vertices

.triq (u,v) values of triangulation vertices

.topo topology (adjacent faces & sense for each edge, text)

.sur.i POGS input parameters file (text)

POGS EXECUTION



pogs --help

pogs {options} < pogs.i > pogs.o

Common options:

-v	print diagnostics
-novol	stop after making surface meshes
-nobox	stop after making near-body volume meshes
-docon	restart in volume connectivity mode (work in progress)

Main parameters in pogs.i

-maxa 4.0	(max dihedral angle)	isym	(configuration symmetry 0/1/2/3 = none/x/y/z)
-maxe 1.0	(max edge length)	nfringe	(# fringe point layers)
-maxsr 1.2	(max stretching ratio)	stenqual	(minimum donor stencil quality)
-npmin 5	(min # pts on edge)	dswall	(volume mesh wall spacing)

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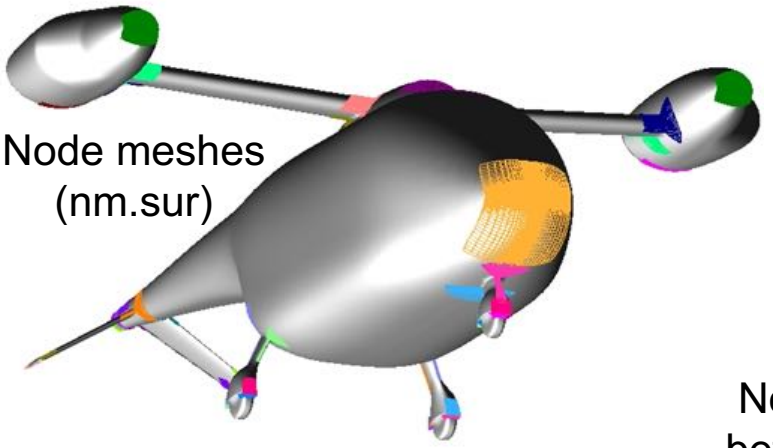
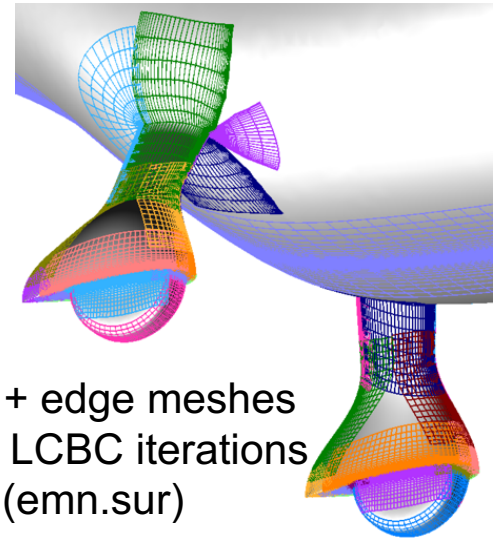
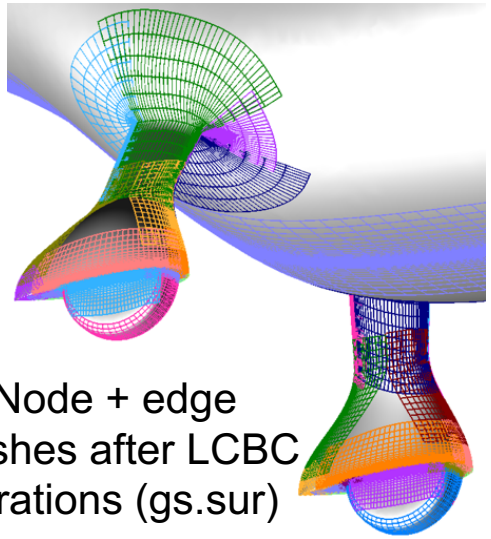
POGS OUTPUT (1)
-novol



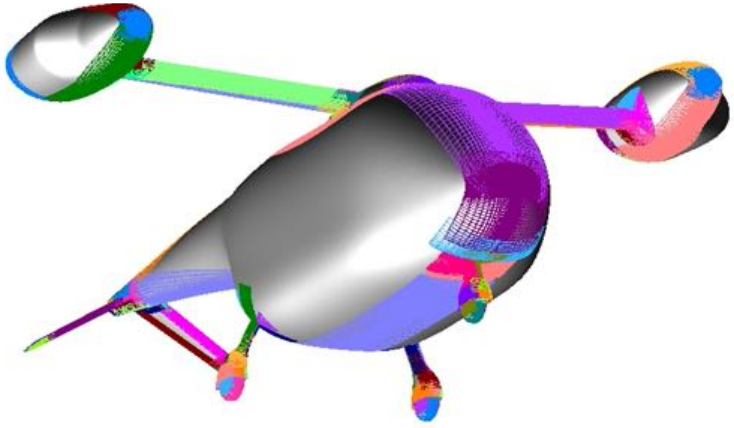
Node meshes (nm.sur)



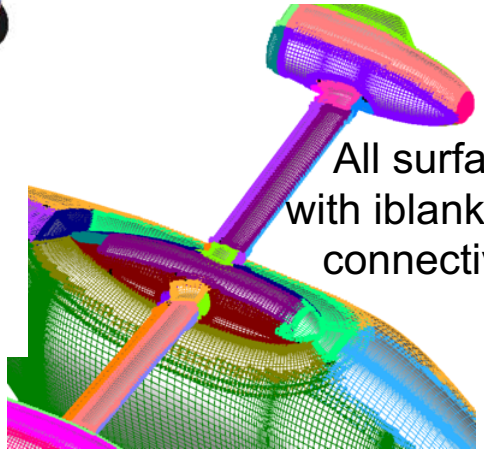
Node + edge meshes before LCBC iterations (emn.sur)



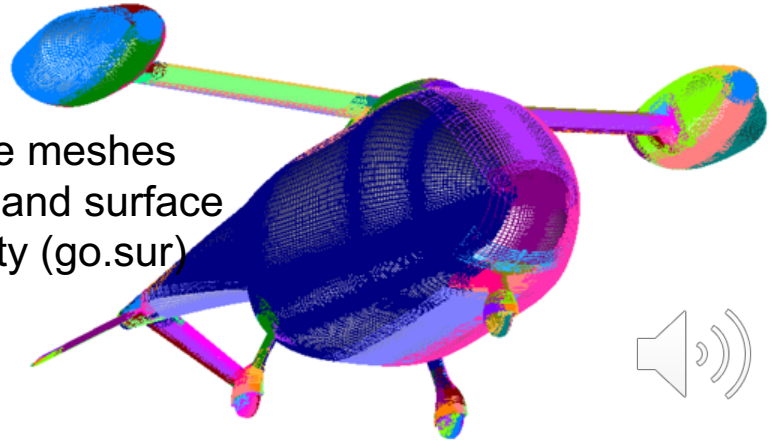
Node + edge meshes after LCBC iterations (gs.sur)



Node + edge meshes (emn.sur)



All surface meshes with iblanks and surface connectivity (go.sur)



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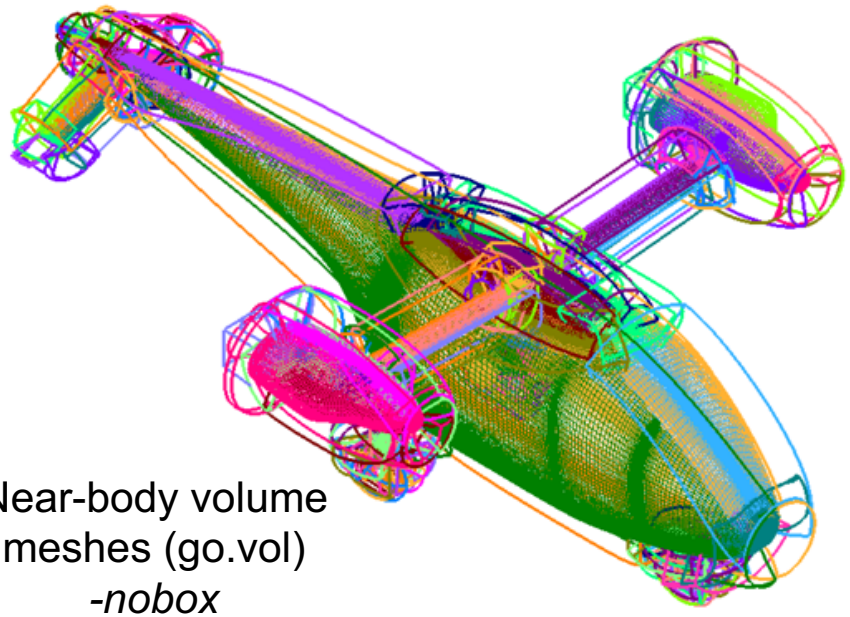
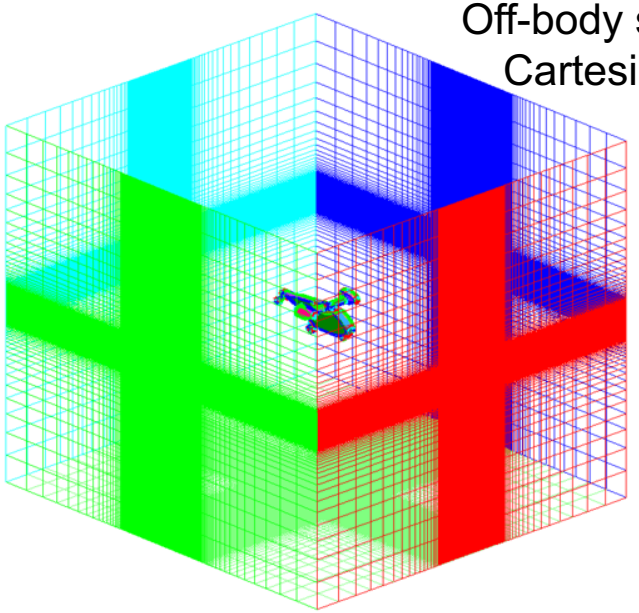
POGS OUTPUT (2)



Near-body volume meshes (go.vol)
-nobox



Off-body stretched Cartesian grid

OVERFLOW – namelist input
LAVA – boundary conditions

FOMOCO (CGT MIXSUR/OVERINT) input file
Auto-defined components from Component/Face data file (.gcomp)

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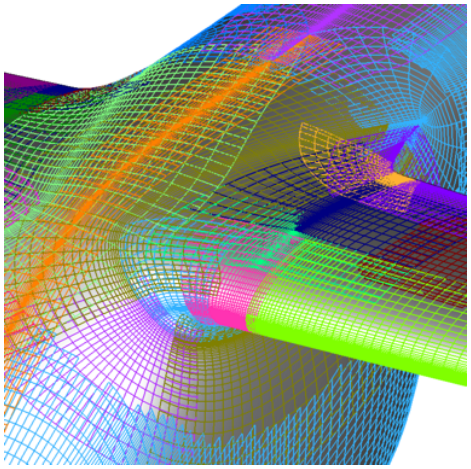
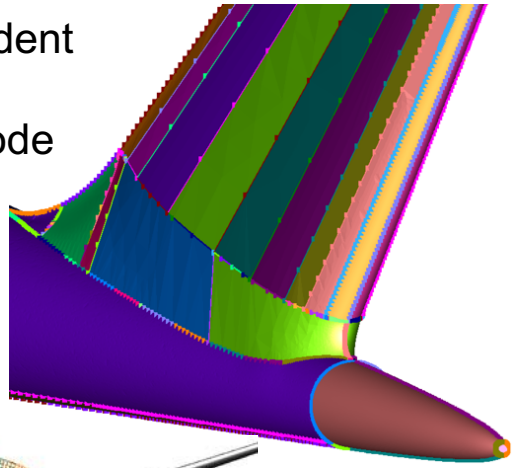
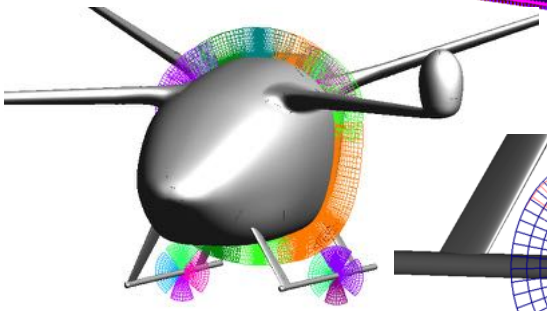
CURRENT LIMITATIONS AND WORK IN PROGRESS

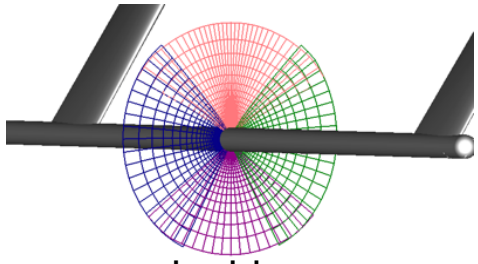
Surface domain decomposition is dependent on BRep topology

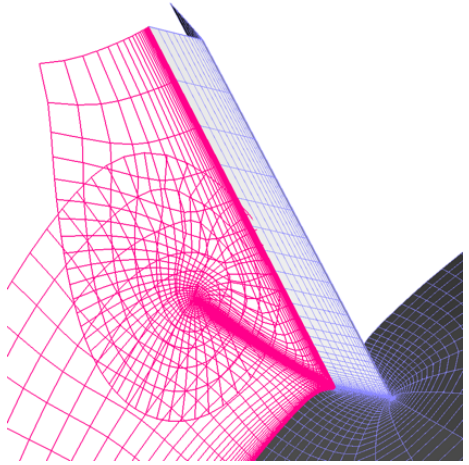
Meshes ~ # Faces + # Edges + # Node











Some volume meshes need manual repair (~0 -15%) *

Volume mesh domain connectivity is manually performed *

Most regions – single-mesh coverage with clean 2-mesh overlap
Some regions – may have multiple-mesh coverage with excessive overlap

Volume mesh side boundary coupling may need manual mesh repair

* Automation work in progress

SUMMARY

- Low to medium complexity cases
  - 99 - 100% acceptable surface meshes
  - 94 - 100% acceptable volume meshes

- Significant reduction in effort and time using hybrid approach: EGADS2SRF + POGS followed by manual repairs and connectivity
  - Weeks/months -> days
  - Days -> hours

AVAILABILITY

- Basic version of EGADS2SRF in CGT 2.2
- Improved EGADS2SRF and POGS to be in CGT 2.3 (~early-mid 2023)

ACKNOWLEDGEMENTS

Funding

NASA ARMD Projects
Transformational Tools and Technologies (TTT)
Revolutionary Vertical Lift Technology (RVLT)
Advanced Air Transport Technology (AATT)

Computational Resources

NASA Advanced Supercomputing (NAS) facility