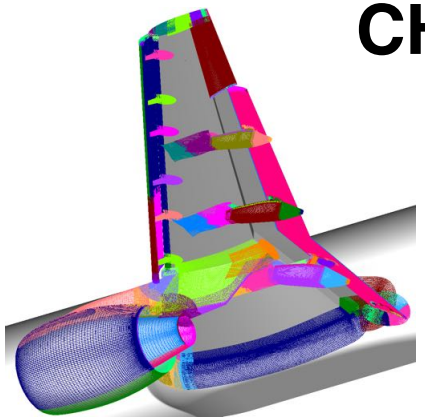
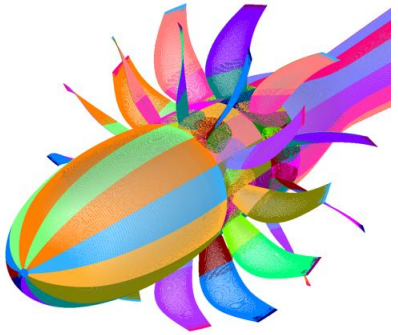
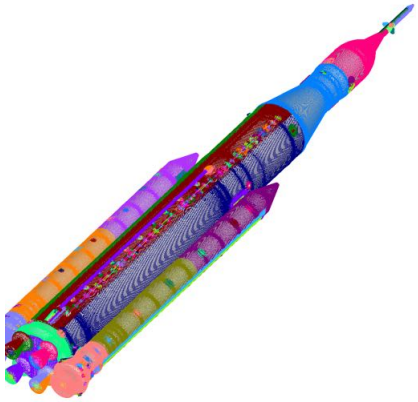
Ames Research Center



CHIMERA GRID TOOLS TUTORIAL: PART 1
GENERAL MODULES



William M. Chan
Shishir A. Pandya



NASA Ames Research Center

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

OVERVIEW

- Introduction

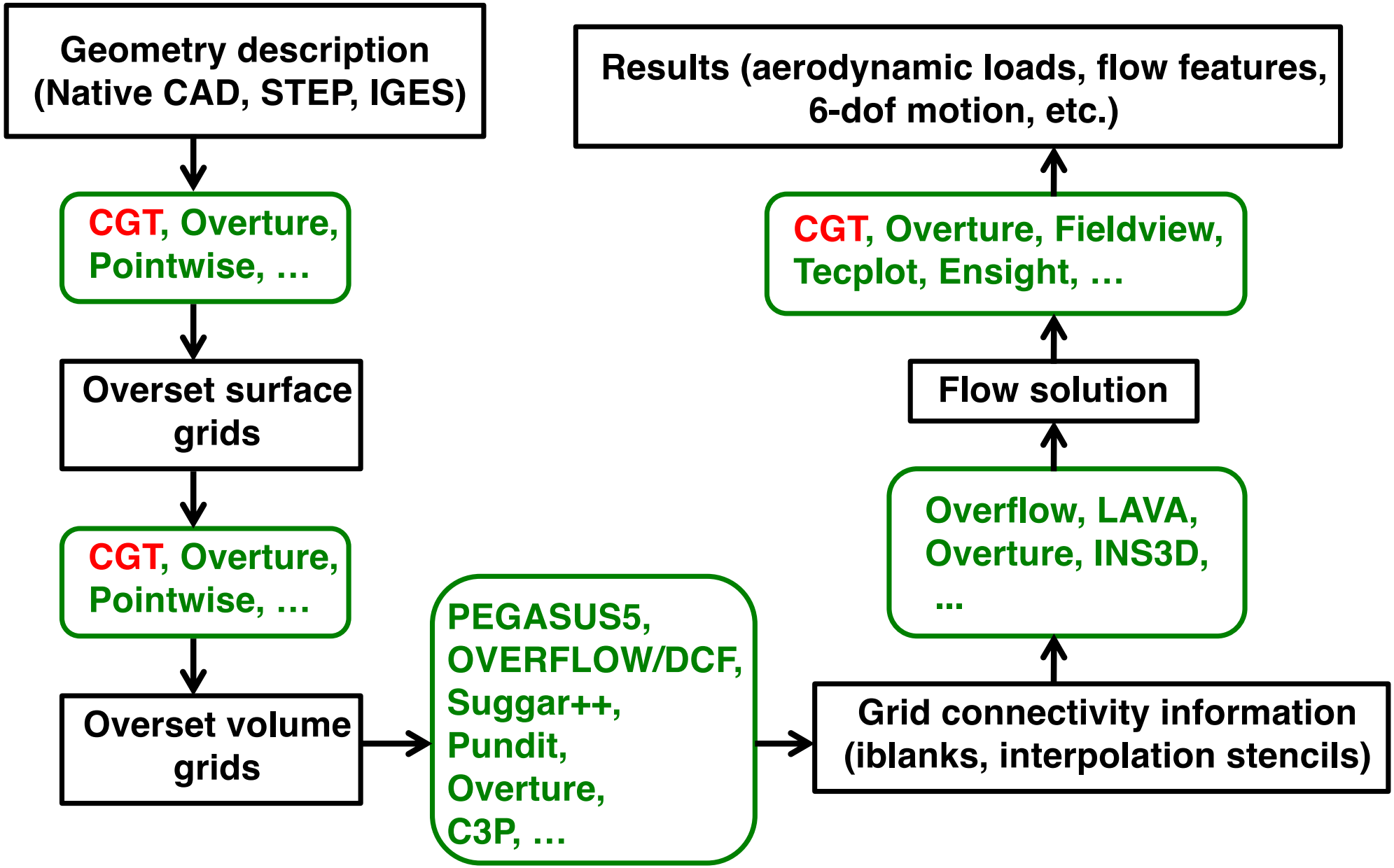
- Pre-processing

- Post-processing

- Miscellaneous modules

- Tutorials

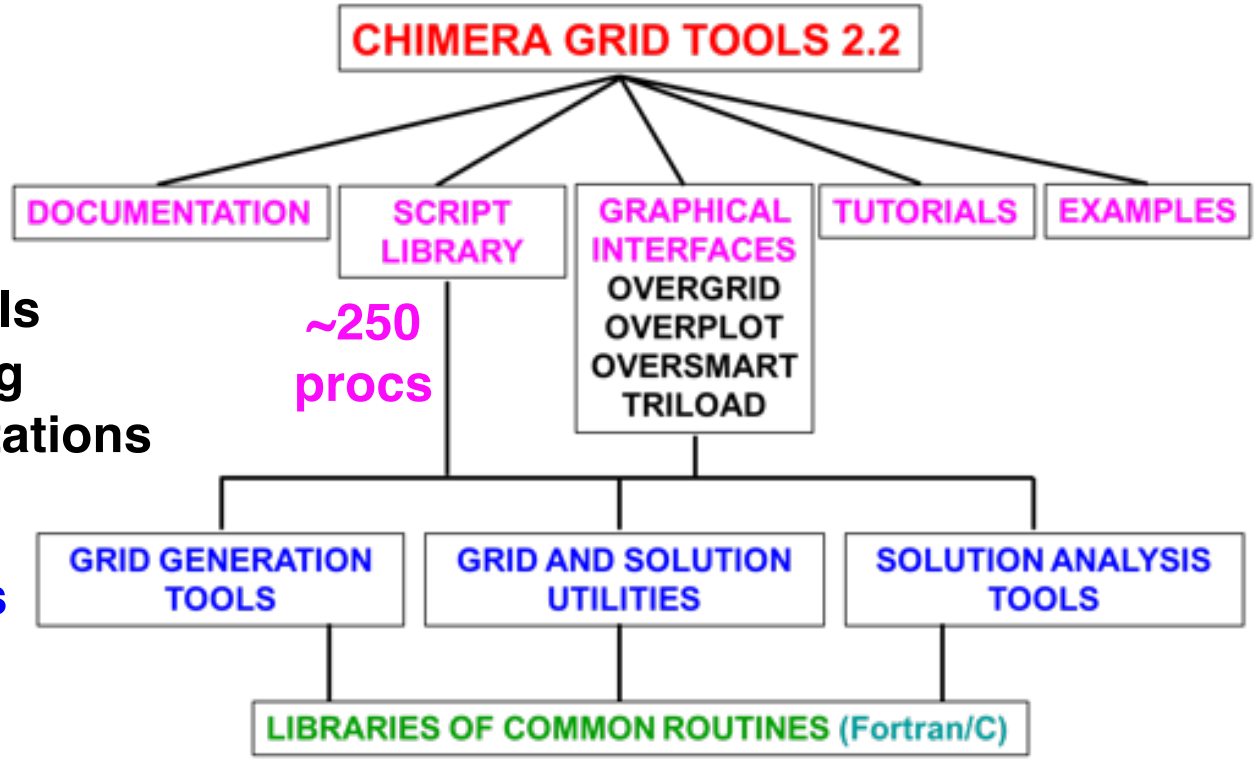
TYPICAL MODELING AND SIMULATION PROCESS USING OVERSET GRIDS



CHIMERA GRID TOOLS (CGT) Version 2.2

What is CGT

- A collection of software tools
  for pre- and post-processing
  of overset grid CFD computations



Authors

2.2: William Chan, Shishir Pandya, Stuart Rogers, James Jensen, Henry Lee

Earlier: David Kao, Pieter Buning, Robert Meakin, David Boger, Steve Nash

Availability

NASA Software Catalog (https://software.nasa.gov/software/ARC-16025-1B)

- U.S. citizens/permanent residents working under U.S. organization in the U.S.
- Fill out and return Software Usage Agreement form
- Source (Linux, Unix, Mac OS-X)
- Version 2.2+ available for use by authors' associated projects

INSTALLATION, DOCUMENTATION, TUTORIALS

Installation software requirements

- Fortran 90 compiler (ifort, gfortran 4.4+) : all
- C compiler (gcc 4.4+, icc) : all
- C++ compiler (g++ 4.4+, icc) : USURP
- OpenGL, X11, Tcl/Tk 8.6.8 or earlier : OVERGRID
- Python, swig, gnuplot : OVERSMART
- Tcl wish, xmgrace or gnuplot : OVERPLOT

Installation instructions

- chimera2.2/doc/{INSTALLATION.html, overgrid.html}

Supported platforms

- Linux, Mac OS-X, (Windows: workable, unsupported)

Documentation

- chimera2.2/doc/man.html -> *.html

Tutorials

- chimera2.2/tutorials/* contains tutorials for OVERGRID, Script Library, and various scripting exercises

EXECUTABLES

Run configure script to generate Makefiles

configure -- help **(get list of options)**

Executables

- **single precision set**
- **double precision set**

File Attributes for I/O

- **big/little endian**
  - **controlled by environment variable (ifort, gfortran)**
  - **controlled by compiler flag (pgf90)**
- **single/double precision and big/little endian auto-detected by FFIO enabled modules**
- **file conversion and attribute determination using overConvert**

OVERGRID auto-detects single/double precision, big/little endian

PRE-PROCESSING MODULES

PRE-PROCESSING USING CGT

- Procedure and Best Practices
- Geometry input
- OVERGRID GUI
- Script Library

PRE-PROCESSING STEPS AND BEST PRACTICE

Task: Given complex geometry definition, create input files needed for overset grid CFD analysis

- Grid file containing overset volume grids and iblanks
- Connectivity file containing fringe points, donor stencils, interpolation coefficients
- Flow solver input file with boundary conditions for each grid
- Input file for performing forces and moments integration on components of interest
- Input files for coupled physics
  - Prescribed/6-DOF input files for relative motion problems
  - Species convection
  - Structural deformation

Best practice:

- Develop pre-processing script to create all input files needed above
- Use CGT's OVERGRID to check and visualize individual steps
- Use CGT's Script Library to record steps into script
- Check grid and connectivity quality using variety of tools

PRE-PROCESSING STEPS

Geometry Input – discrete or analytic

Surface Grid Generation

- on STEP, IGES, CAD via discretized surface geometry descriptions (triangulation and structured patches)
- algebraic, hyperbolic

Volume Grid Generation

- near-body curvilinear (hyperbolic)
- off-body Cartesian

Domain Connectivity Inputs

- Xray map creation and hole-cut instructions
- PEGASUS5
- C3P

Flow Solver Inputs (OVERFLOW)

- boundary conditions
- component hierarchy and prescribed/6-DOF dynamics
- prescribed dynamics animation (OVERGRID)

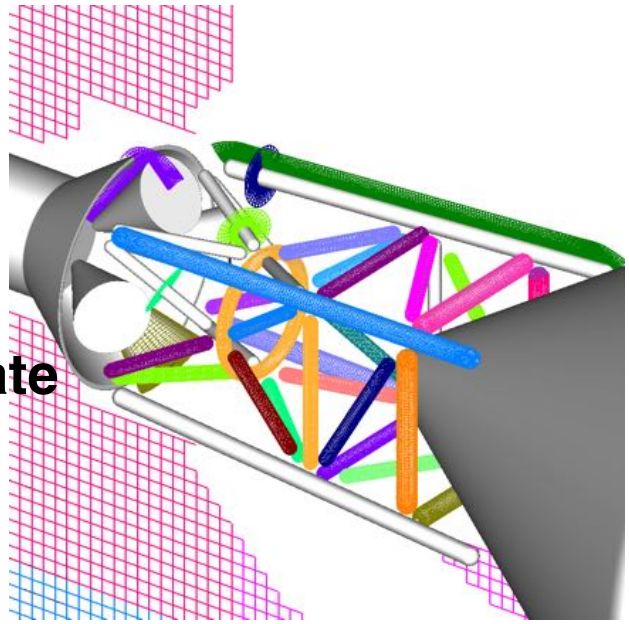
DISCRETE GEOMETRY CREATION

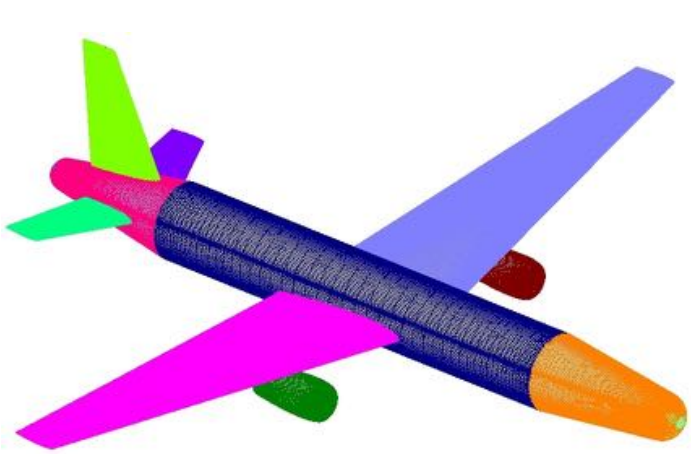
Script Library has macros to create

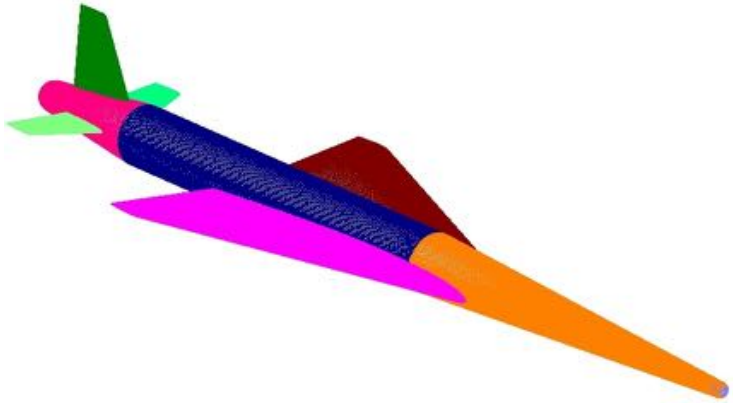
- Points
- Straight lines
- Analytic curves
- Cylinders
- Spheres
- Frustums
- Cartesian boxes
- Airfoil shapes
- > NACA 4 and 5 digit series
- > PARSEC

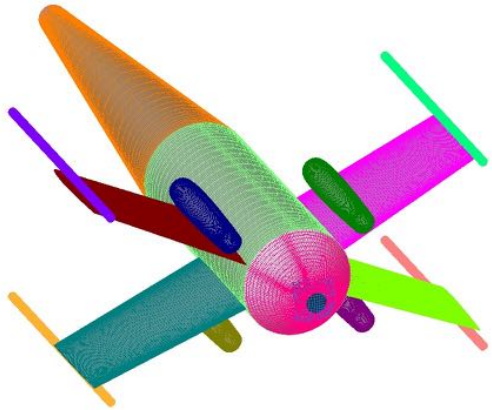
Combine with basic macros to generate more complex shapes

- Translate
- Scale
- Rotate
- Mirror
- Extract
- Concatenate
- Revolve
- Duplicate









ANALYTIC AND DISCRETE GEOMETRY INPUT

STEP, IGES, EGADS via Engineering Sketch Pad (ESP)

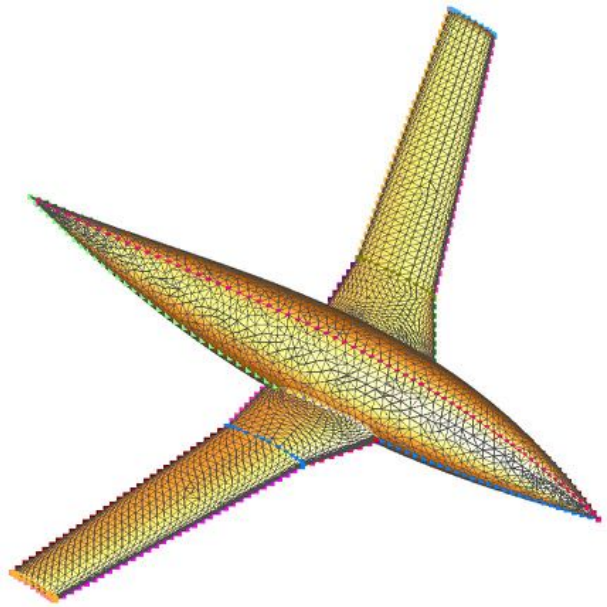
- Boundary Representation (BRep) solids
- Use EGADS2SRF module to generate discrete representations
- Open source

Native CAD (Pro-E, Catia V5, Parasolid, OpenCASCADE, SolidWorks, UniGraphics, FELISA) via CAPRI library from CADNexus

- Use CAD2SRF module to generate surface triangulations
- Need CAD license and CAPRI users license
- Not tested under CGT 2.2

Surface Triangulation

- CART3D (.tri, .triq, .trix)
- UCD (.ucd)
- STL (.stl)
- FRO (.fro)
- FAST (.fst)



Structured Surface Patches

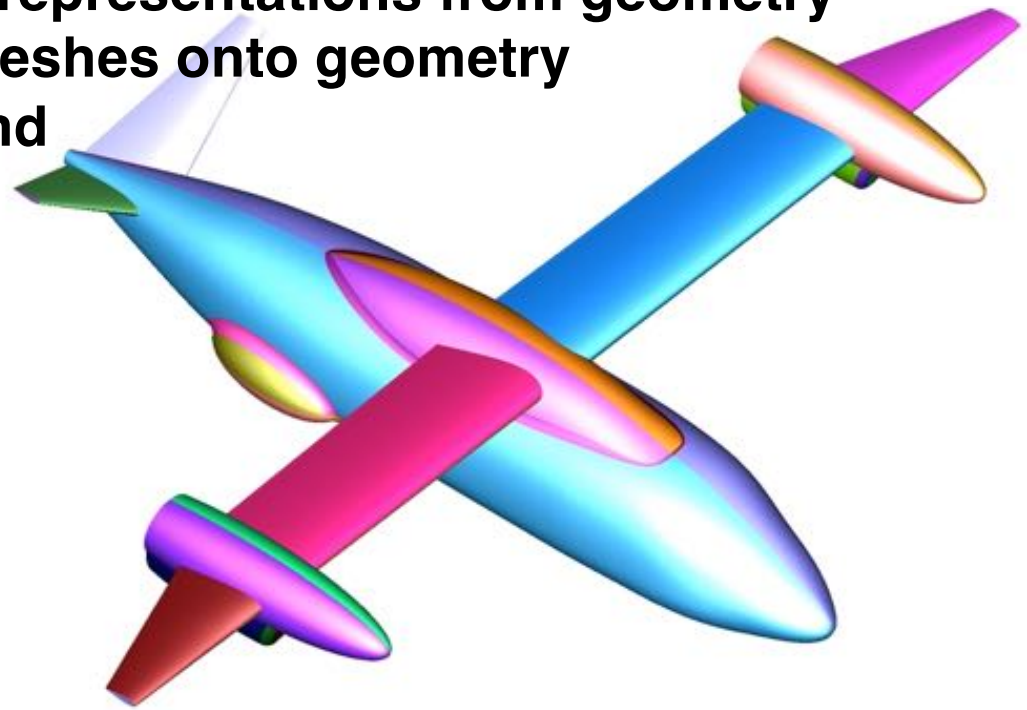
- PLOT3D format

GEOMETRY INTERFACE

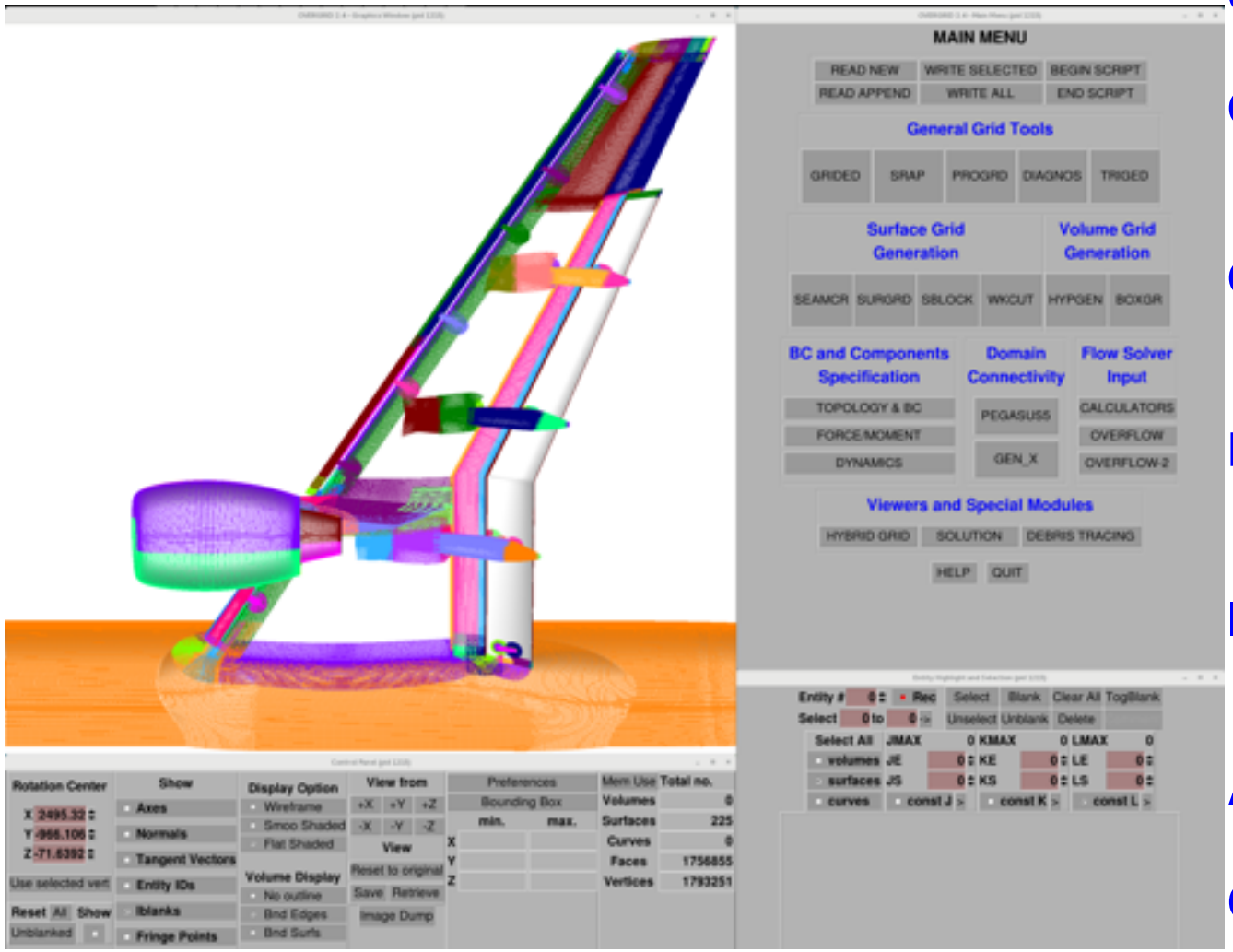
- Engineering Sketch Pad (ESP) open source library from MIT
  - Parametric geometry creation and processing

- Geometry formats allowed
  - Boundary Representation (BRep) solids in STEP or IGES files
  - Engineering Geometry Aircraft Design System (EGADS) geometry files

- CGT modules
  - EGADS2SRF generates discrete representations from geometry
  - SRF2EGADS projects discrete meshes onto geometry
  - OVERGRID provides GUI front end



OVERGRID



Supported platforms – Linux, Mac OS-X

Geometry
- interface via ESP

Grid
- processing, redistribution, projection

Generators
- surface grids, volume grids, hole-cutters

Diagnostics
- grid & connectivity quality

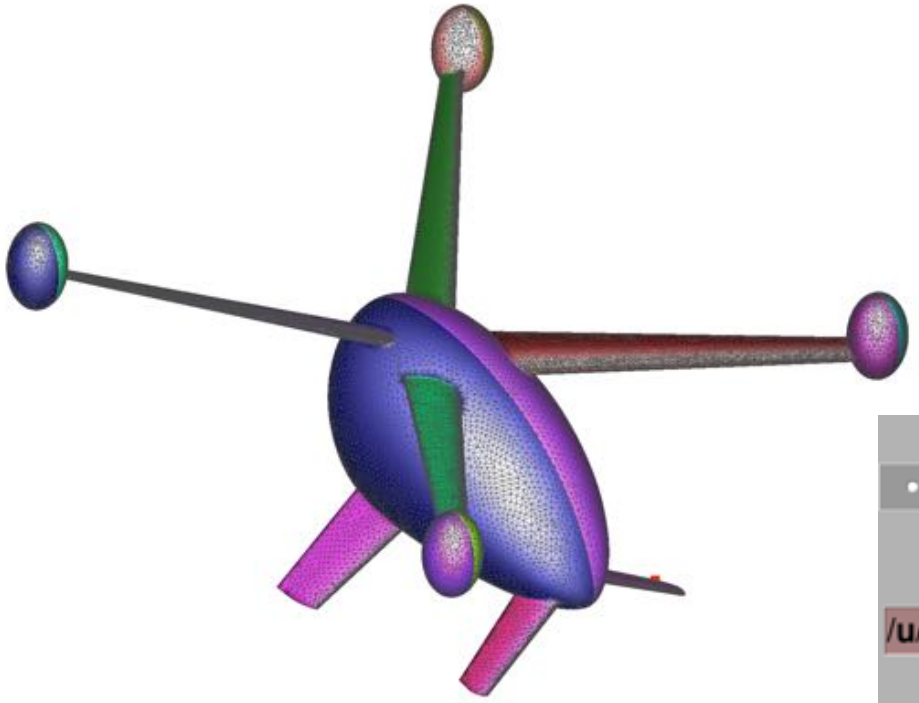
Input preparation
- flow solver b.c. & params, debris trajectory

Animation
- multi-comp. dynamics

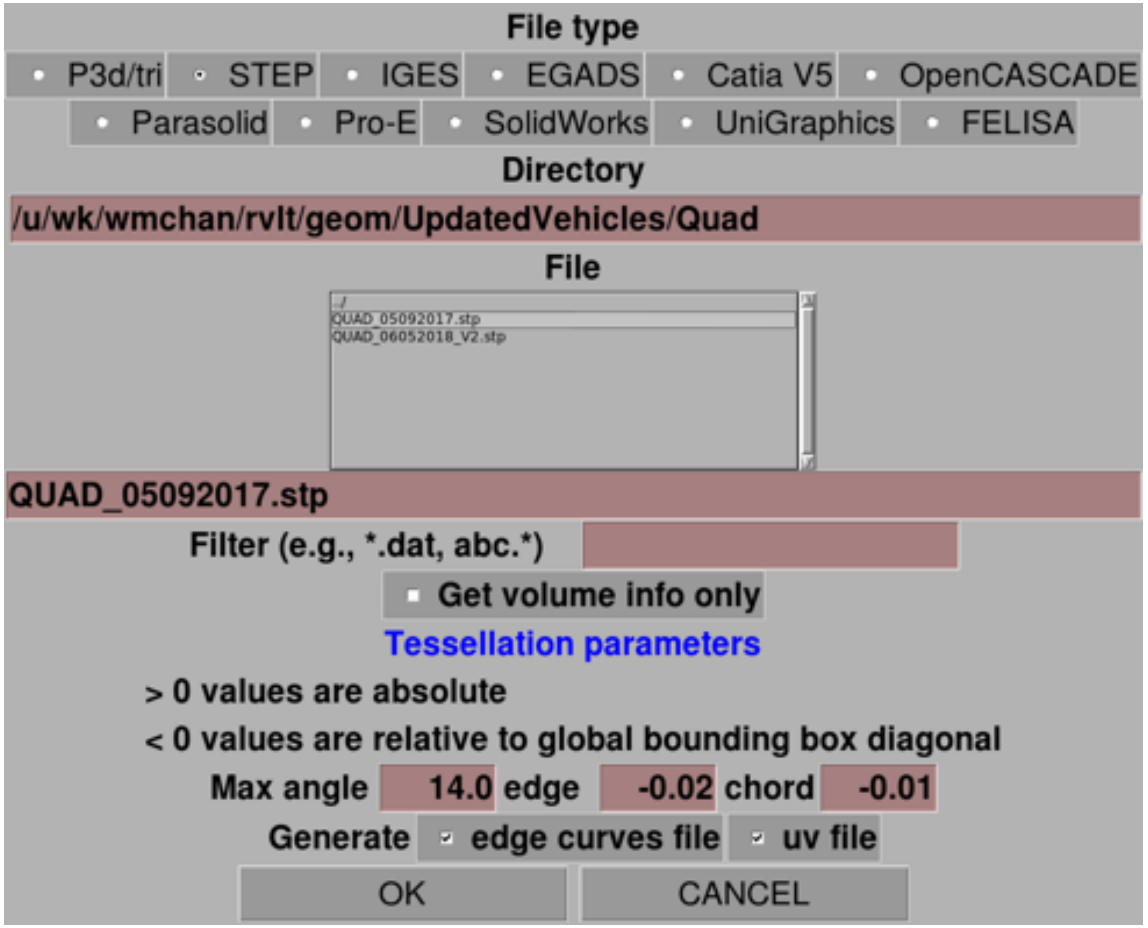
Calculators
- Standard atmosphere, mass properties, 6-dof

Viewers
- solution, force/moment components, strand mesh

OVERGRID: VISUALIZATION OF STEP, IGES, EGADS FILES



- Type “overgrid” on command line to launch window below
- Select STEP, IGES, or EGADS
- Auto call to egads2srf
- Auto load triangulation file



Control: maximum
- dihedral angle
- cell size
- chordal deviation

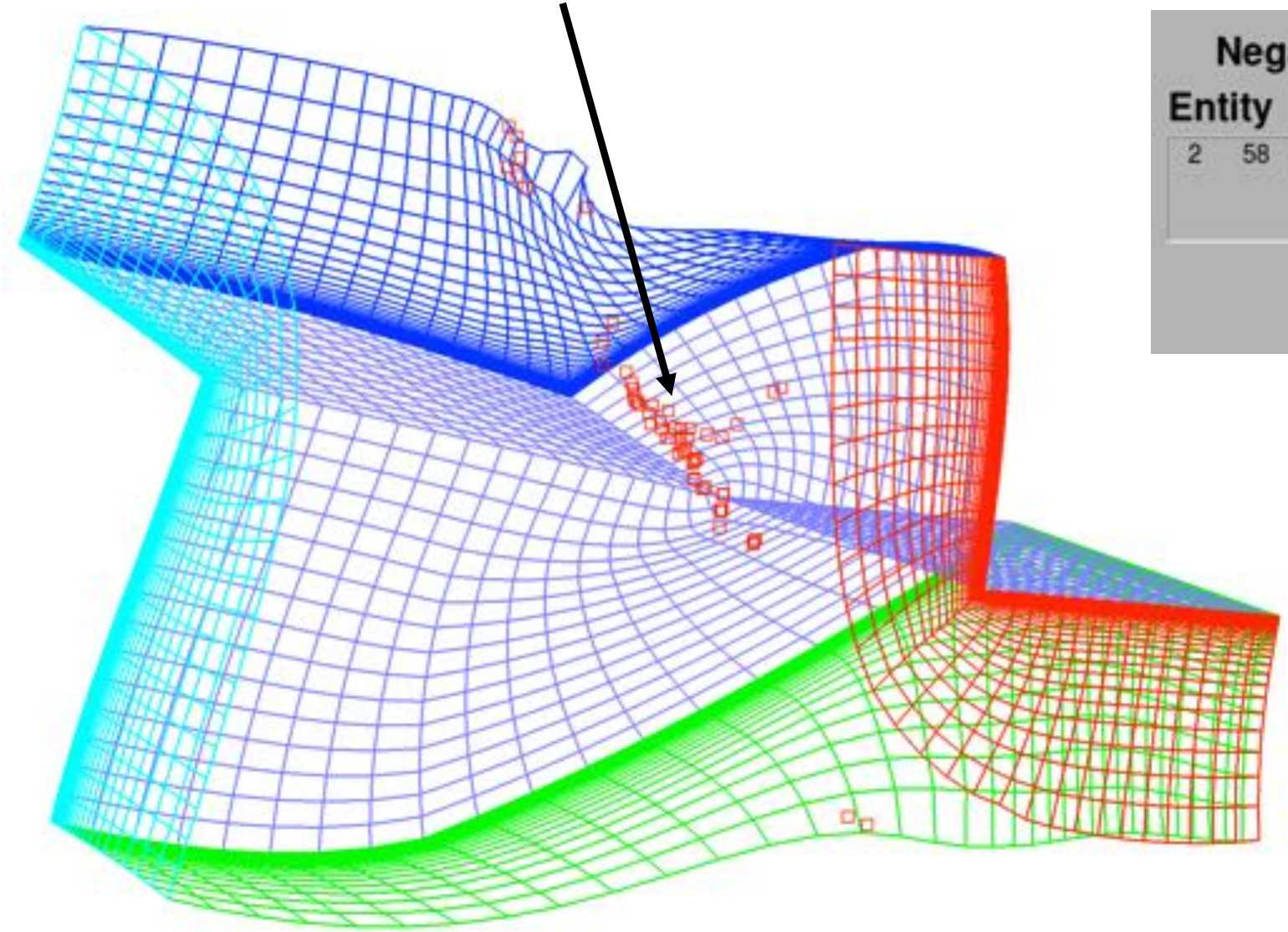
OVERGRID: COMMAND LINE OPTIONS

Scripted dumping of image files in non-interactive mode enabled by command line options

-2 : dual screen
-l/-r : location of smaller screen for horizontal stack (l=left, r=right)
+x/+y : x and y shifts for window placement
-cmd : read command line arguments from specified file
-cntrfun/-shadfun/-wirefun : 0/1 turn off or on contour/shaded/wireframe display for solution function
-dp : use double precision mode to read ascii structured grid files
-fun : plot function *fun_name* in solution viewer, valid *fun_name* include q1,q2,...,u,v,w,velocity magnitude,Mach number,pressure,Cp, sound speed,temperature,internal energy,total enthalpy,entropy
-img : dump image to specified filename (non-interactive mode)
-maxval/-minval : set max/min value of contours to specified value
-nlevel : set number of contour levels
-noax/-nogrid : do not display axis/grid wireframe
-nolog : do not write *overgrid.log* file
-qfile : load structured grid solution from specified *solution* file
-sub : load solution subsets from specified *subsets* file
-vp : load view point from specified *viewpoint* file

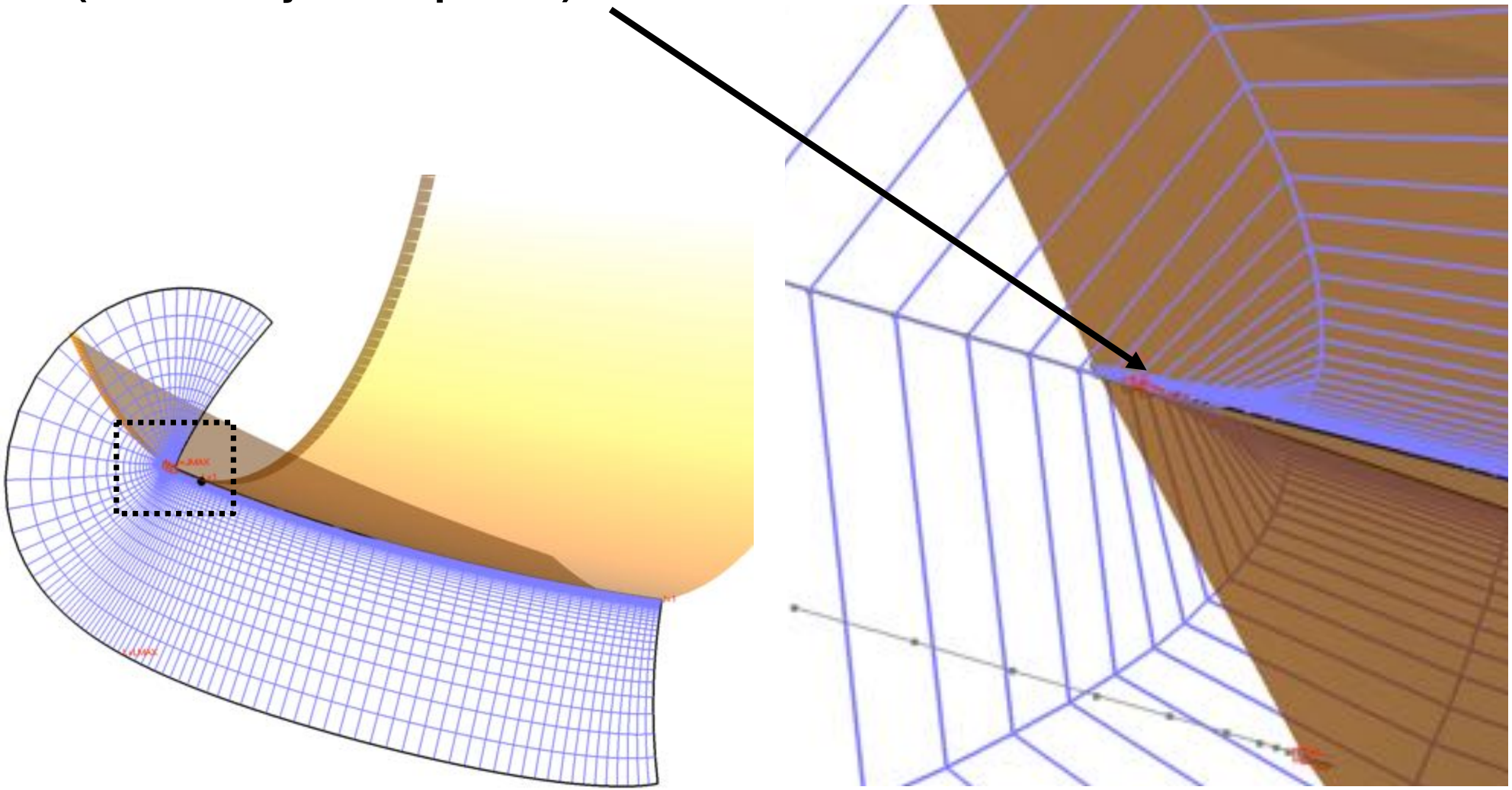
GRID QUALITY CHECKS (1)
Must-Pass: Jacobians (OVERGRID-DIAGNOS, MINMAX)

Jacobian computed using same subroutine as in target flow solver (negative Jacobian locations marked by red squares)



GRID QUALITY CHECKS (2)
Must-Pass: Self-Intersections (OVERGRID-DIAGNOS, GRIDED)

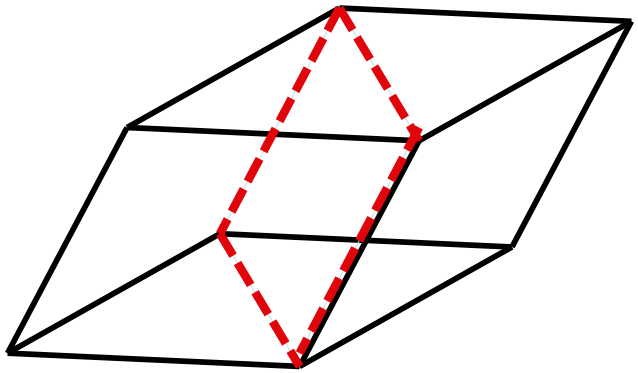
Self-intersection of volume grid points against surface grid (marked by red squares)



GRID QUALITY CHECKS (3)
Mostly-Pass: Cell Volumes (OVERGRID-DIAGNOS)

Cell volume computed by hexahedral decomposition into 6 tetrahedrons

OVERGRID Diagnostic

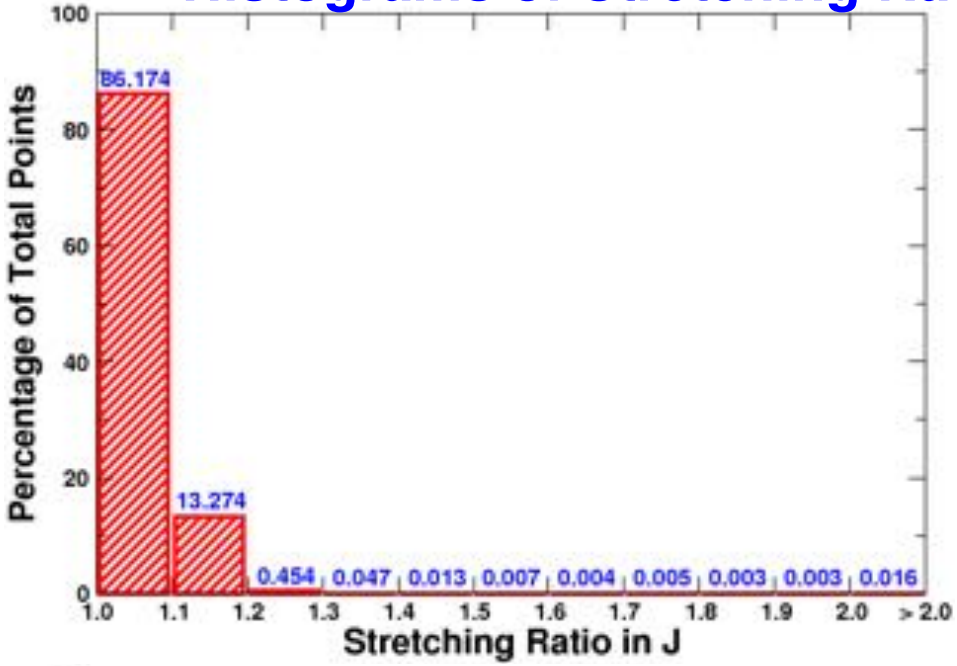


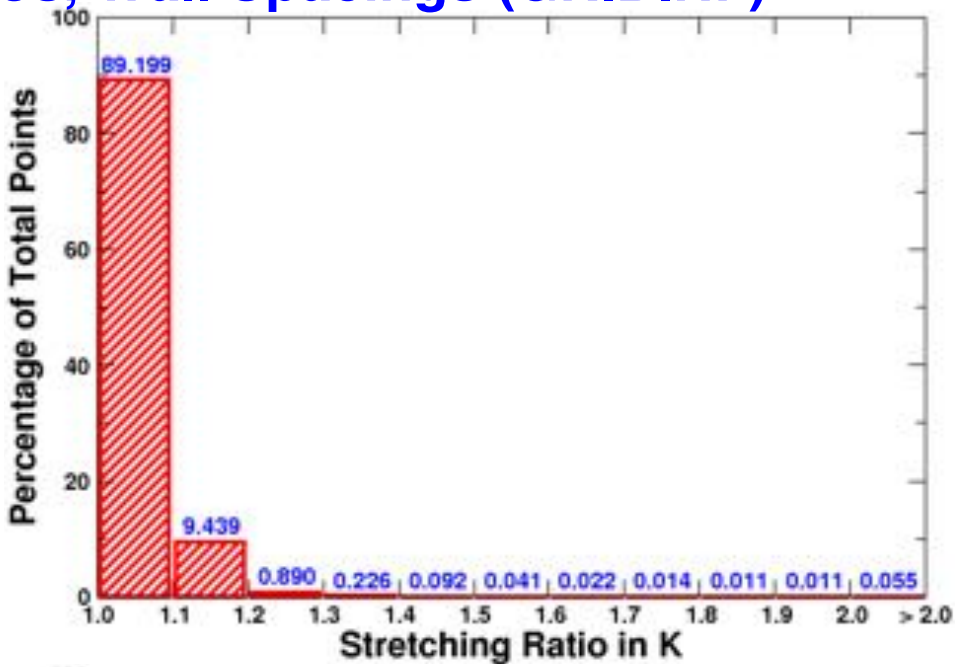
- Cut into 2 prisms
- Cut each prism into 3 tets
- Bad cell if
  1. any tet volume < 0
  2. sum of 6 tet volumes < 0

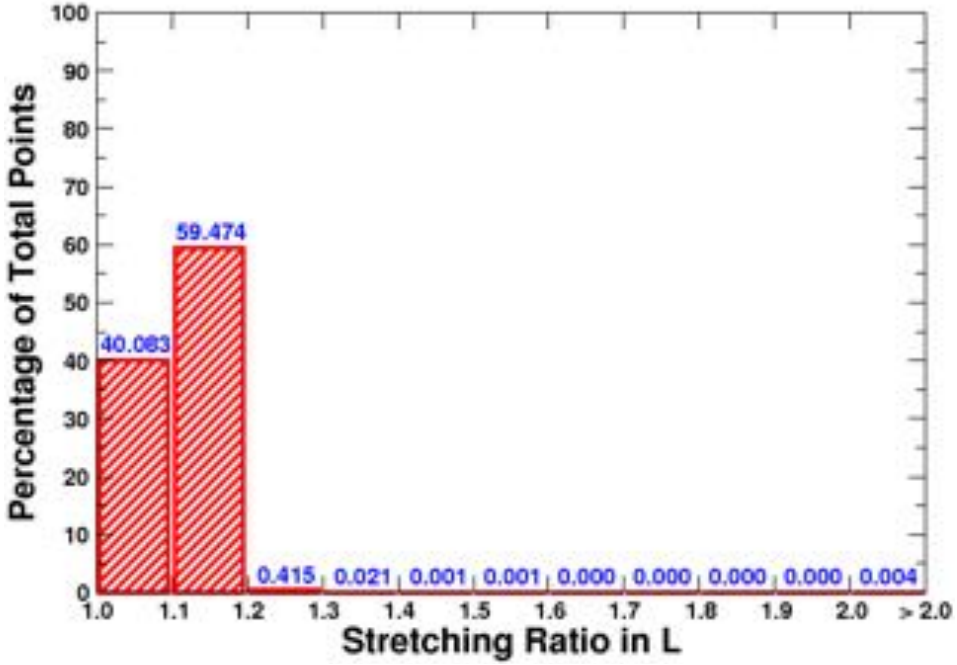
Cell Volume Check

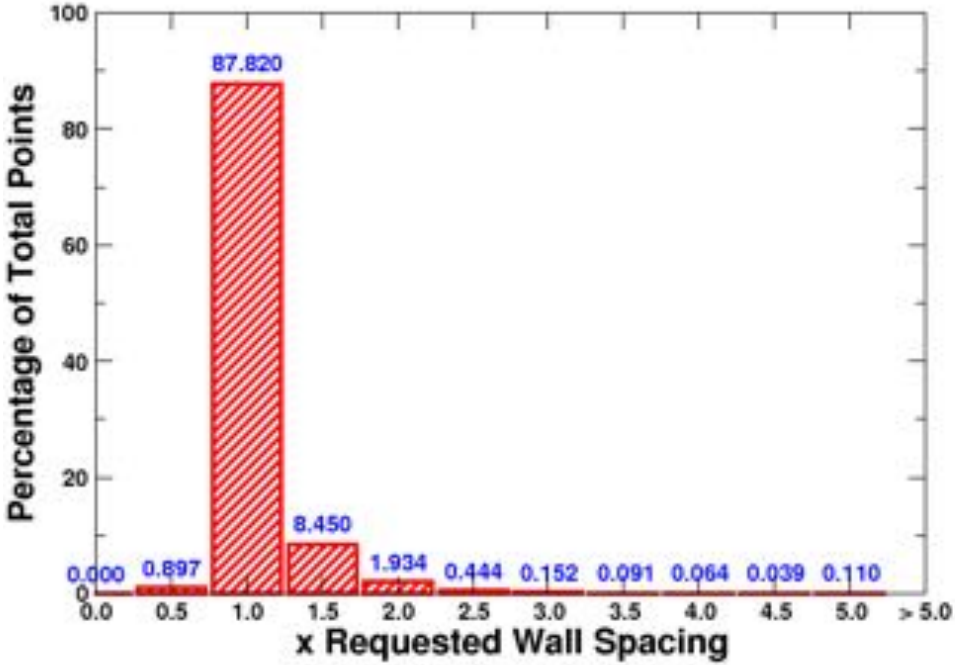
	Sum 6 tets			One or more tets	
	Negative sum			Negative vol	
Entity	# Cells	(J,K,L)	Min Vol	# Cells	Min Tet Vol
1	0				
2	0				
3	0		2.526e-04	9	-2.719e-06
4	0				
5	0		9.463e-04	186	-2.195e-04
6	0				
7	0		4.672e-04	59	-2.892e-04
8	0		3.594e-05	12	-4.785e-07
9	0		5.191e-04	6	-1.232e-07
10	1	(26,38,28)	-1.567e-03	216	-1.884e-03
11	0				
12	0				

GRID QUALITY CHECKS (4)
Histograms of Stretching Ratios, Wall Spacings (GRIDINF)



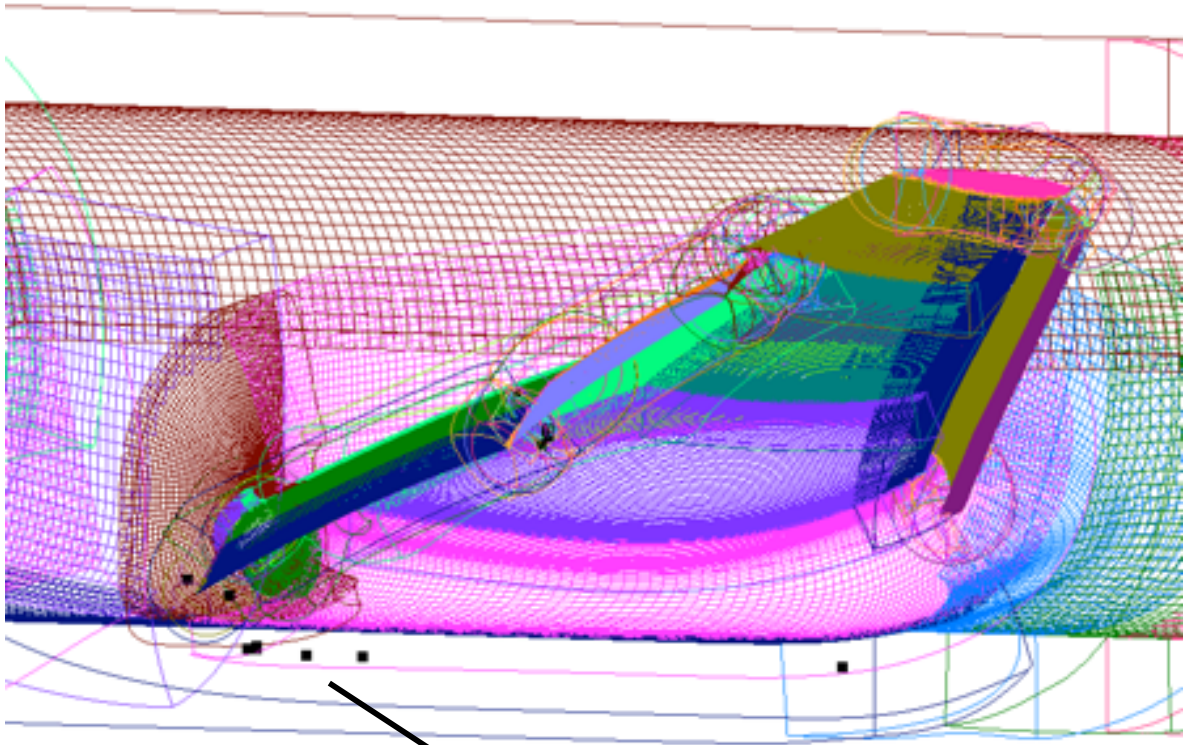


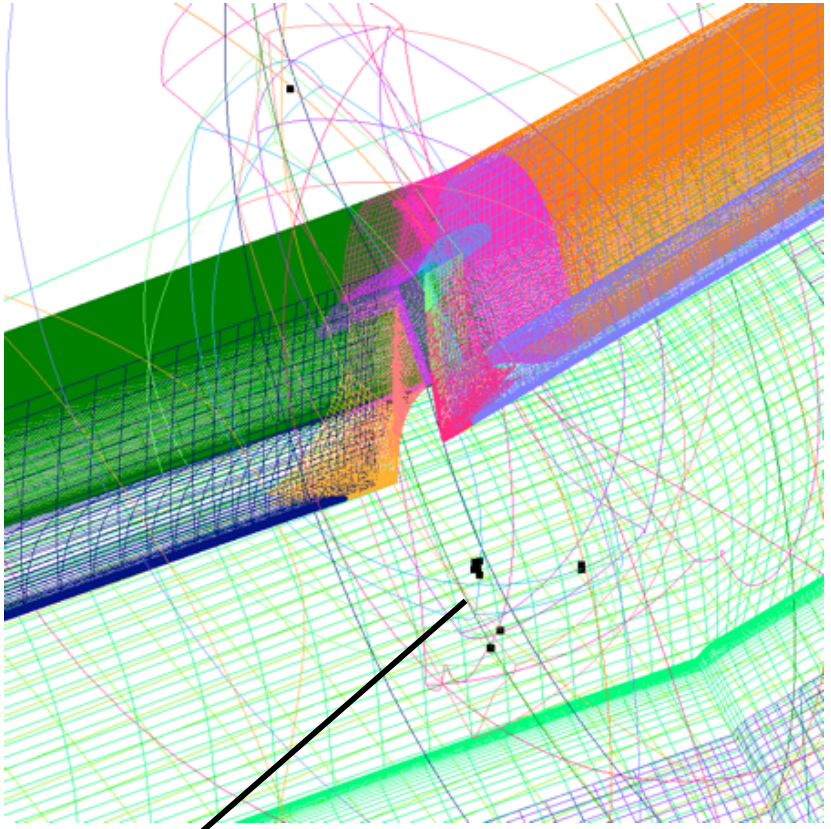




DOMAIN CONNECTIVITY QUALITY CHECKS (1)
Total number, location, and spread of orphan points (OVERGRID)

Fringe pt – pt at outer/hole boundaries that receives donor information
Donor stencil - a cell that supplies interpolation data to a fringe pt
Orphan pt – a fringe pt that failed to find a valid donor stencil



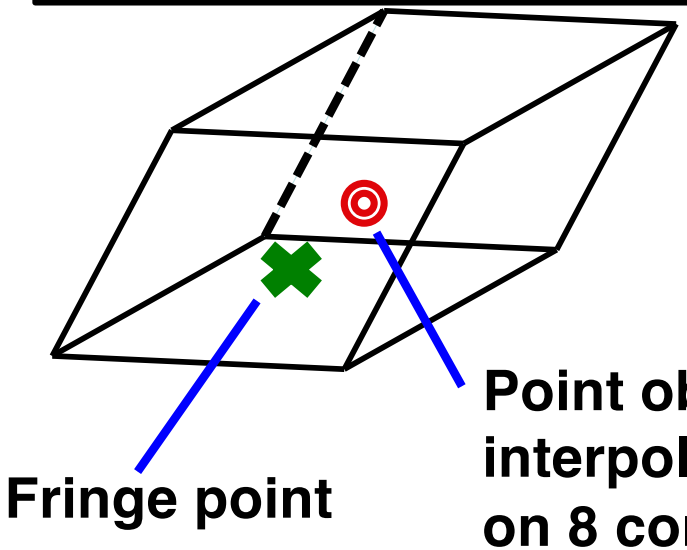


Total = 25, sparse points away from surface

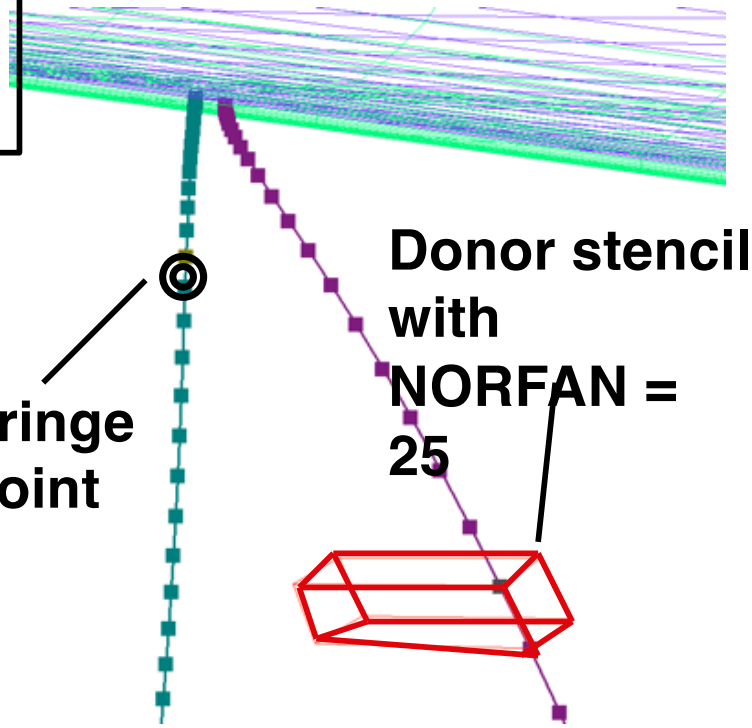
DOMAIN CONNECTIVITY QUALITY CHECKS (2)
Fringe Point Donor Stencil Accuracy (OVERGRID, INTCHK)

Histogram of distance between fringe point and vertex obtained by donor stencil interpolation (intchk)

Distance	Number of pts	% Total
d < 0.0001,	2592370,	89.207
0.0001 <= d < 0.001,	127886,	4.401
0.001 <= d < 0.01,	128241,	4.413
0.01 <= d < 0.1,	47312,	1.628
0.1 <= d < 1.0,	10167,	0.350
1.0 <= d < 10.0,	49,	1.7E-03
10.0 <= d,	0,	0.0



Set NORFAN carefully in OVERFLOW for viscous stencil repair

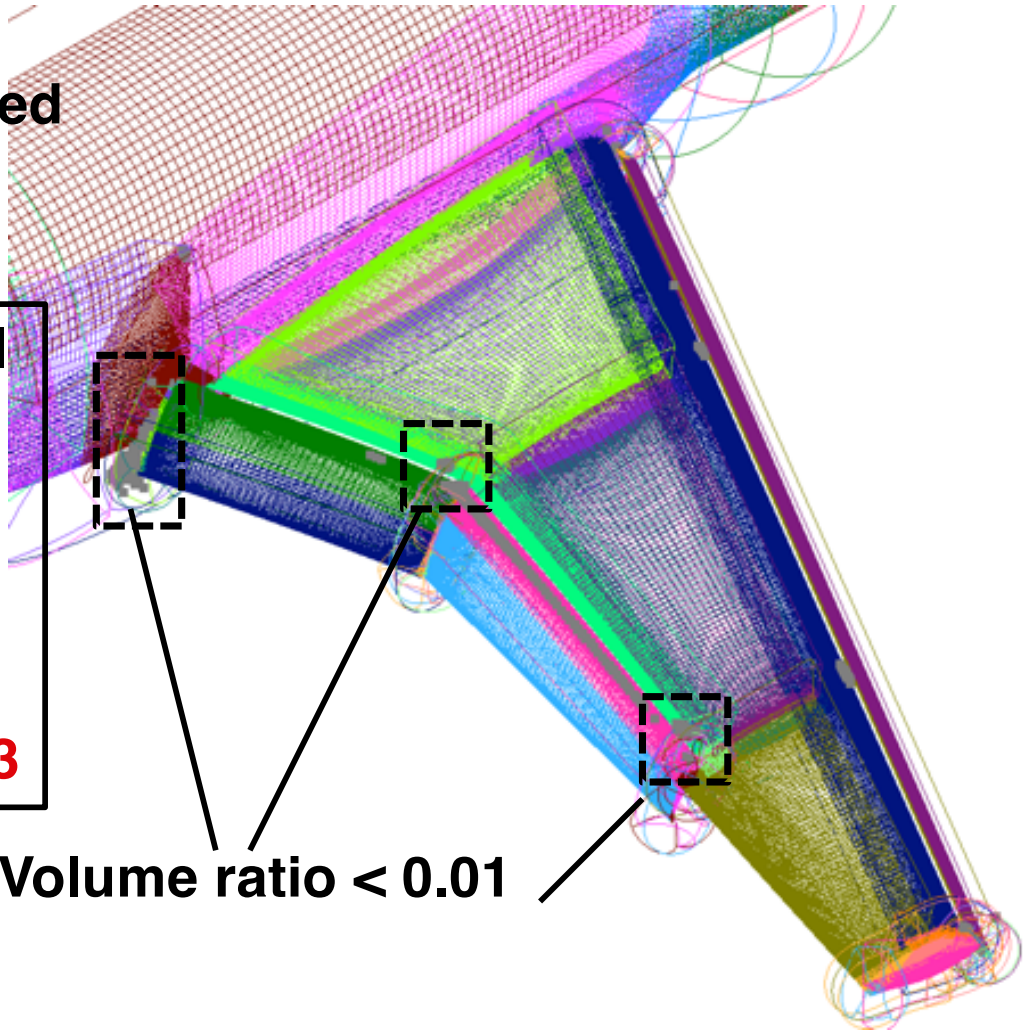


DOMAIN CONNECTIVITY QUALITY CHECKS (3)
Donor Stencil Attributes Compatibility (OVERGRID, INTCHK)

Compatibility of cell attributes between fringe point and donor stencil
- **Cell volume ratio histogram table (intchk) and location map (OVERGRID)**
- **Bad ratio => gradients cannot be transferred accurately between grids**

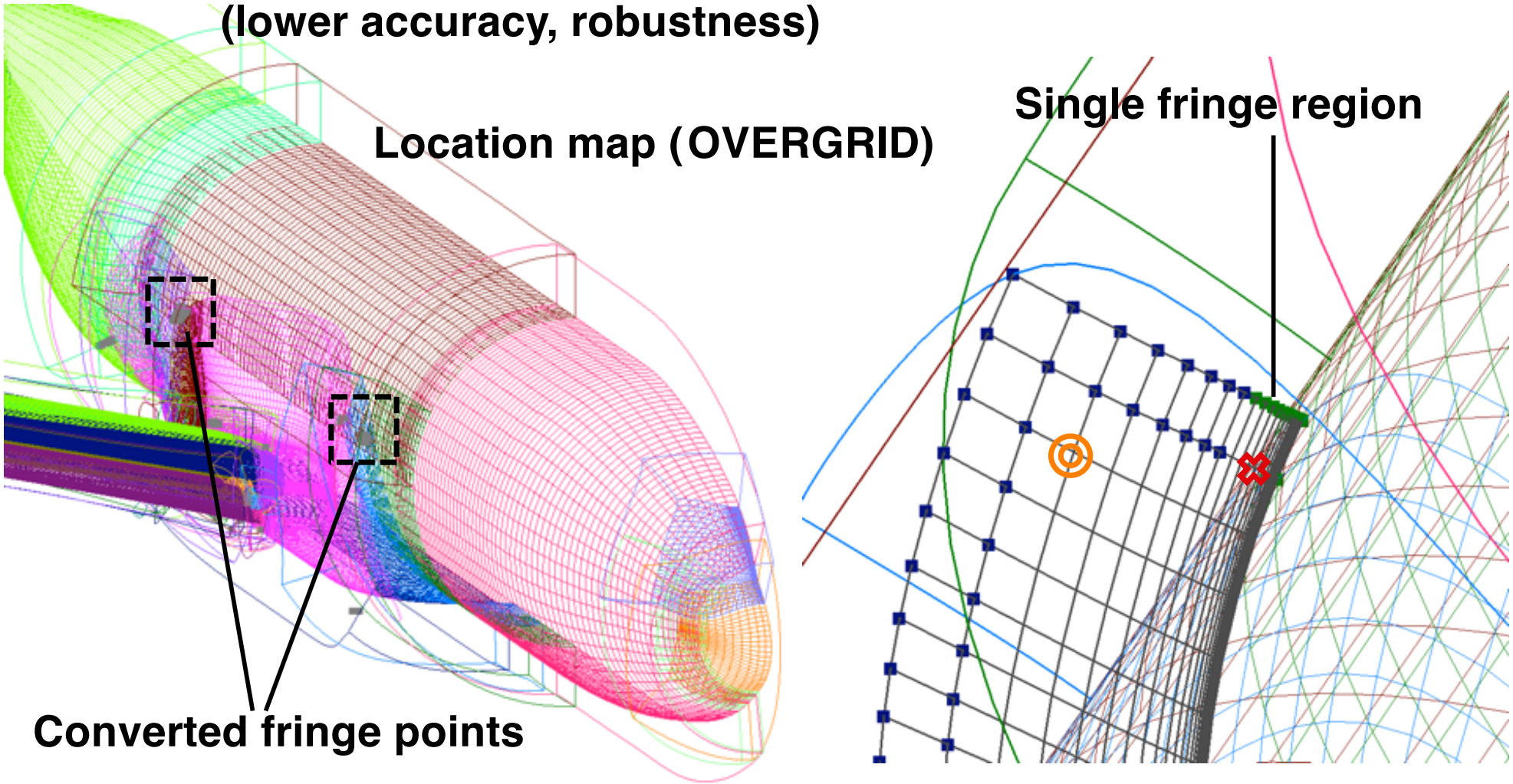
Other attributes that could be checked
- **Cell aspect ratio, orientation**

Volume ratio	# Pts.	% Total
0.5 <= C <= 1.0	2714268	48.26
0.2 <= C < 0.5	1705036	30.32
0.1 <= C < 0.2	670232	11.92
0.01 <= C < 0.1	525048	9.34
0.001 <= C < 0.01	9631	0.17
C < 0.001	21	0.37E-03



DOMAIN CONNECTIVITY QUALITY CHECKS (4)
Conversion to Lower Fringe Layers (OVERGRID, INTCHK)

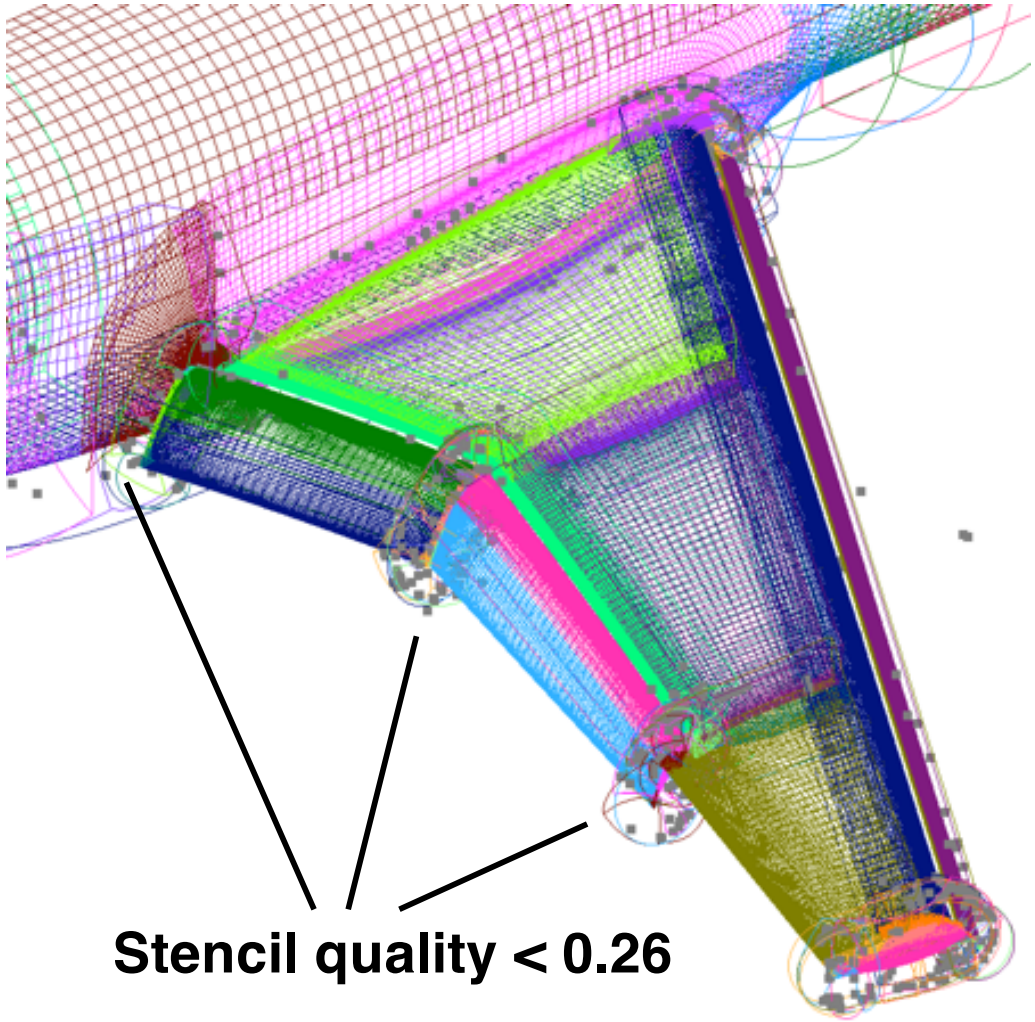
- Insufficient grid overlap to support double fringe locally
- Option to convert from double fringe to single fringe
  => full 5-point differencing stencil not supported in flow solver
  (lower accuracy, robustness)



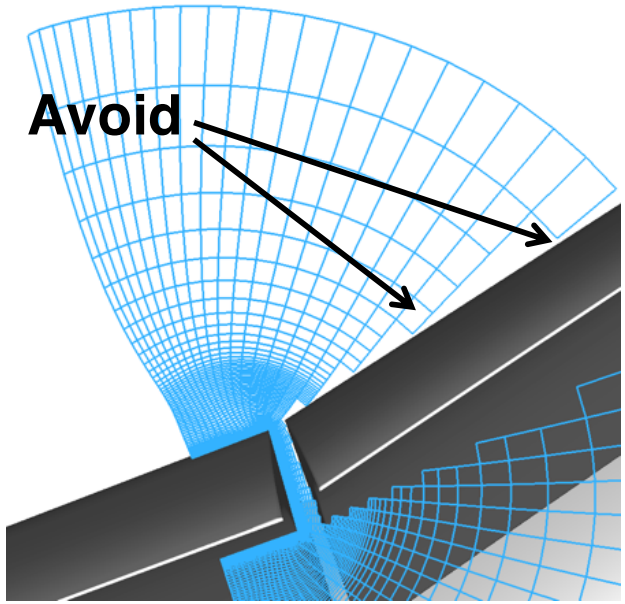
DOMAIN CONNECTIVITY QUALITY CHECKS (5)
Donor Stencil Quality (OVERGRID, INTCHK)

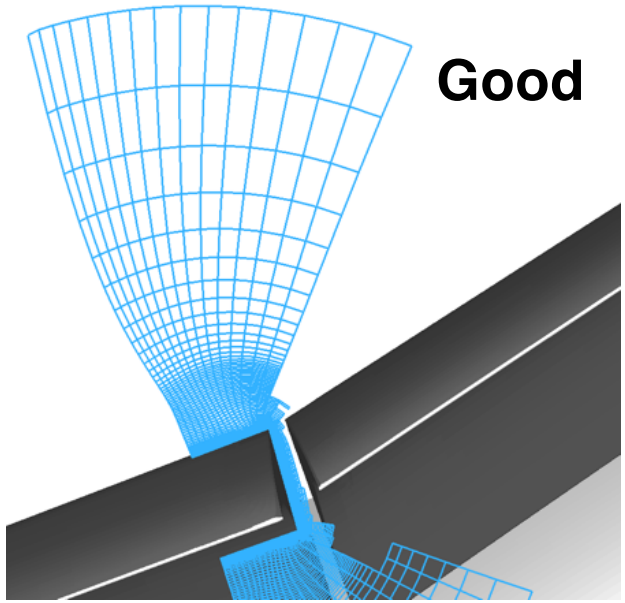
Histogram table (intchk) and location map (OVERGRID)

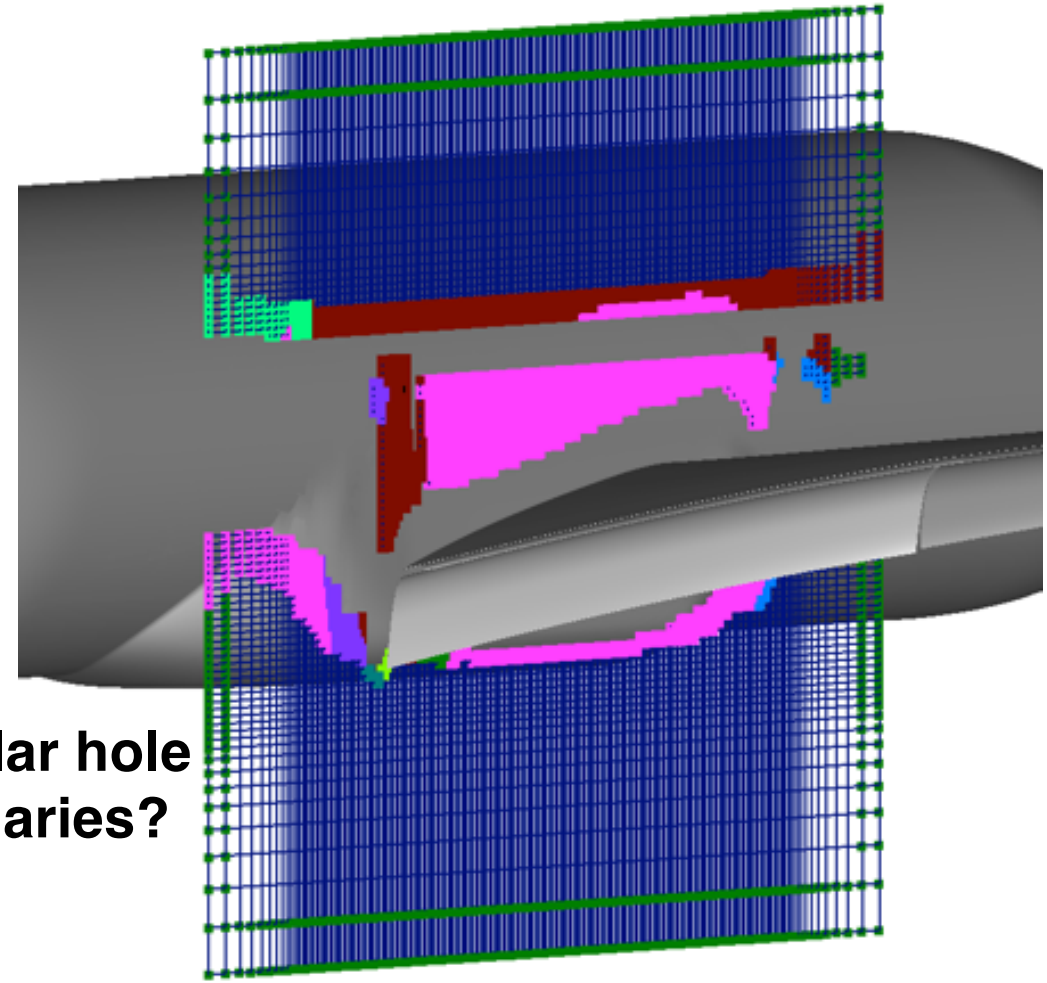
Stencil Quality	Number	% Total
Q = 0.0	0	0.0000
0.0< Q < 0.1	0	0.0000
0.1<= Q < 0.2	0	0.0000
0.2<= Q < 0.3	4858	0.1672
0.3<= Q < 0.4	12120	0.4171
0.4<= Q < 0.5	14660	0.5045
0.5<= Q < 0.6	14054	0.4836
0.6<= Q < 0.7	19504	0.6712
0.7<= Q < 0.8	24788	0.8530
0.8<= Q < 0.9	23280	0.8011
0.9<= Q < 1.0	45317	1.5594
Q = 1.0	2573858	88.5697



DOMAIN CONNECTIVITY QUALITY CHECKS (6)
Hole Boundary Location & Smoothness (OVERGRID)



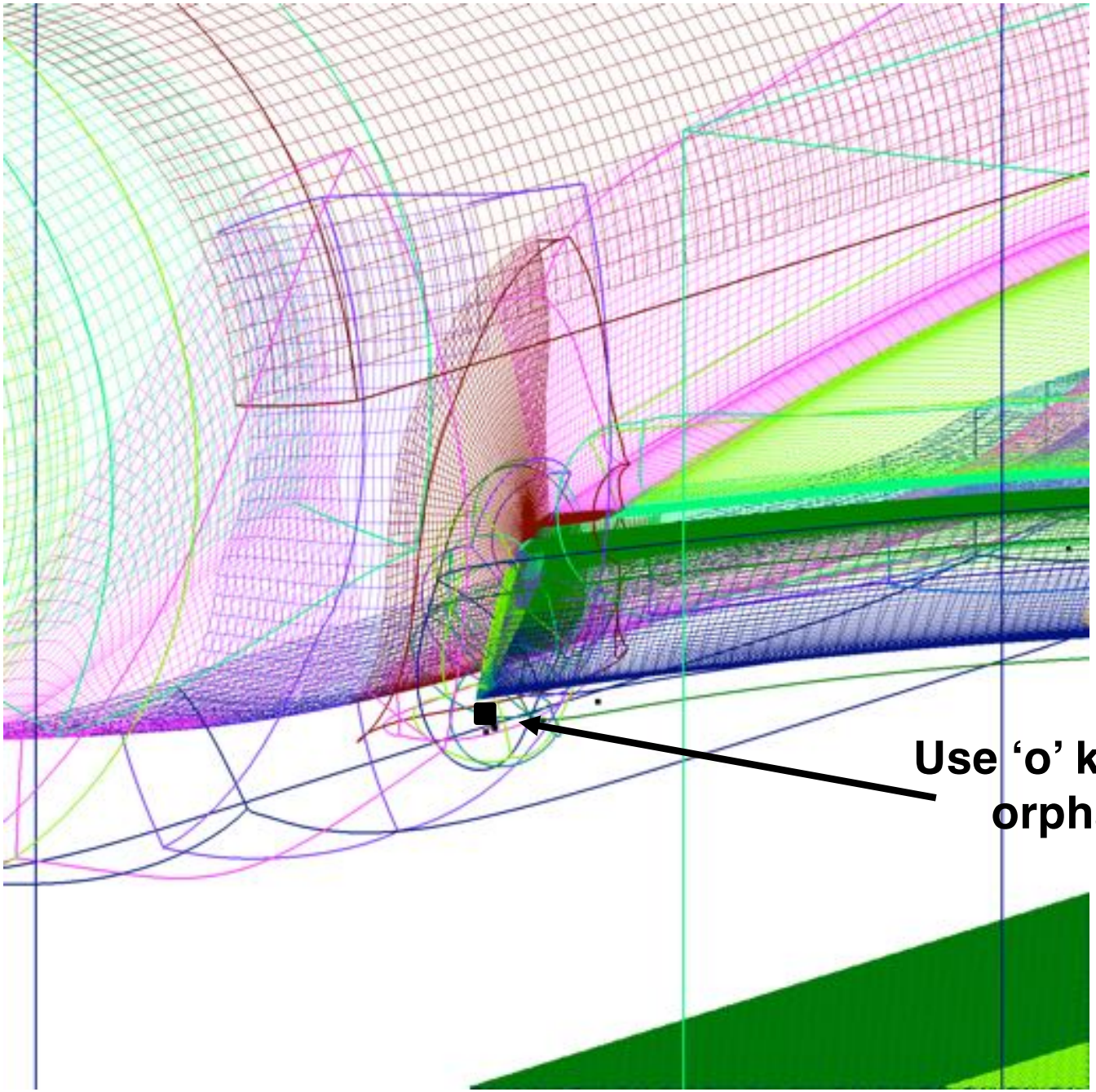




Irregular hole boundaries?

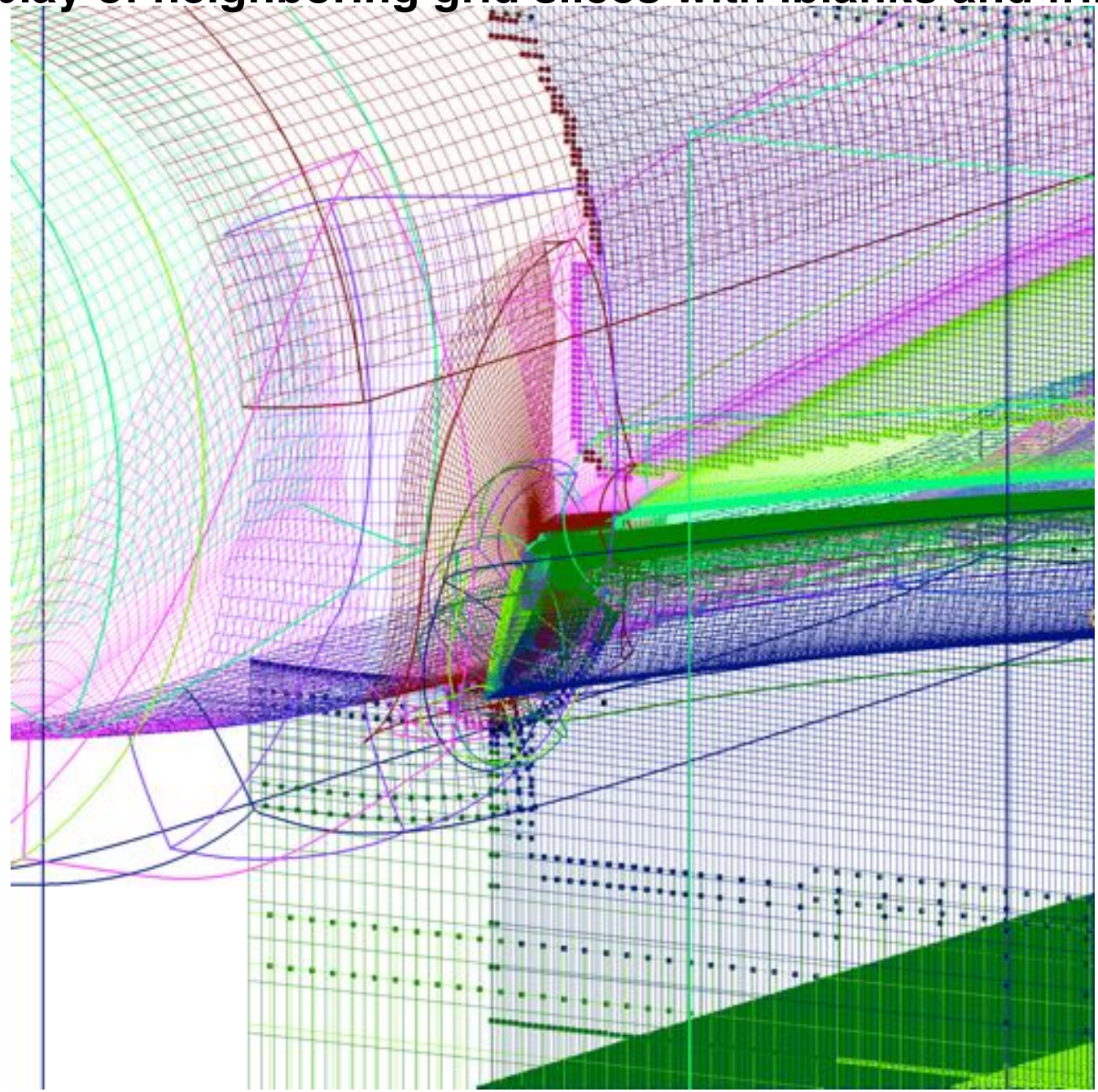
Chan, Pandya, Rogers, Efficient Creation of Overset Grid Hole Boundaries and Effects of Their Locations on Aerodynamic Loads, AIAA Paper 2013-3074, 2013.

ORPHAN POINTS REDUCTION / ELIMINATION IN OVERGRID (1)



ORPHAN POINTS REDUCTION / ELIMINATION IN OVERGRID (2)

Auto display of neighboring grid slices with iblanks and fringe points

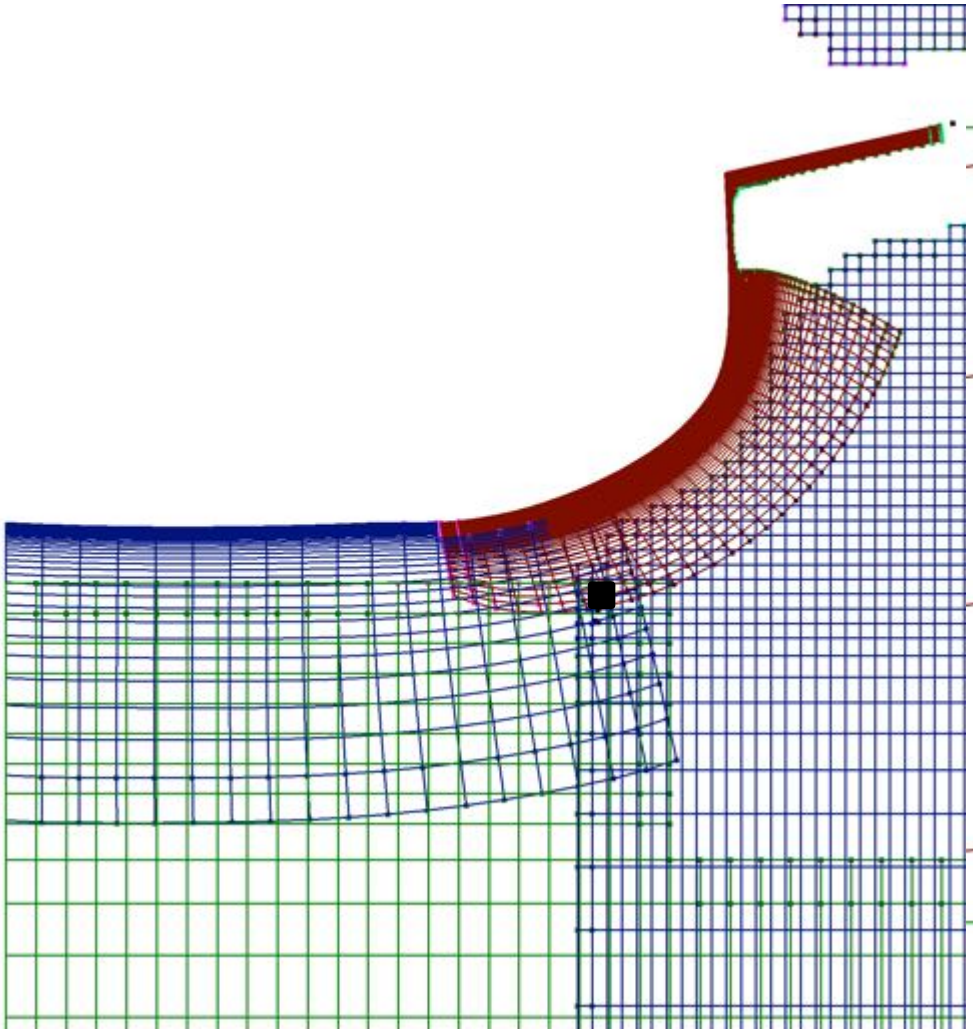


ORPHAN POINTS REDUCTION / ELIMINATION IN OVERGRID (3)

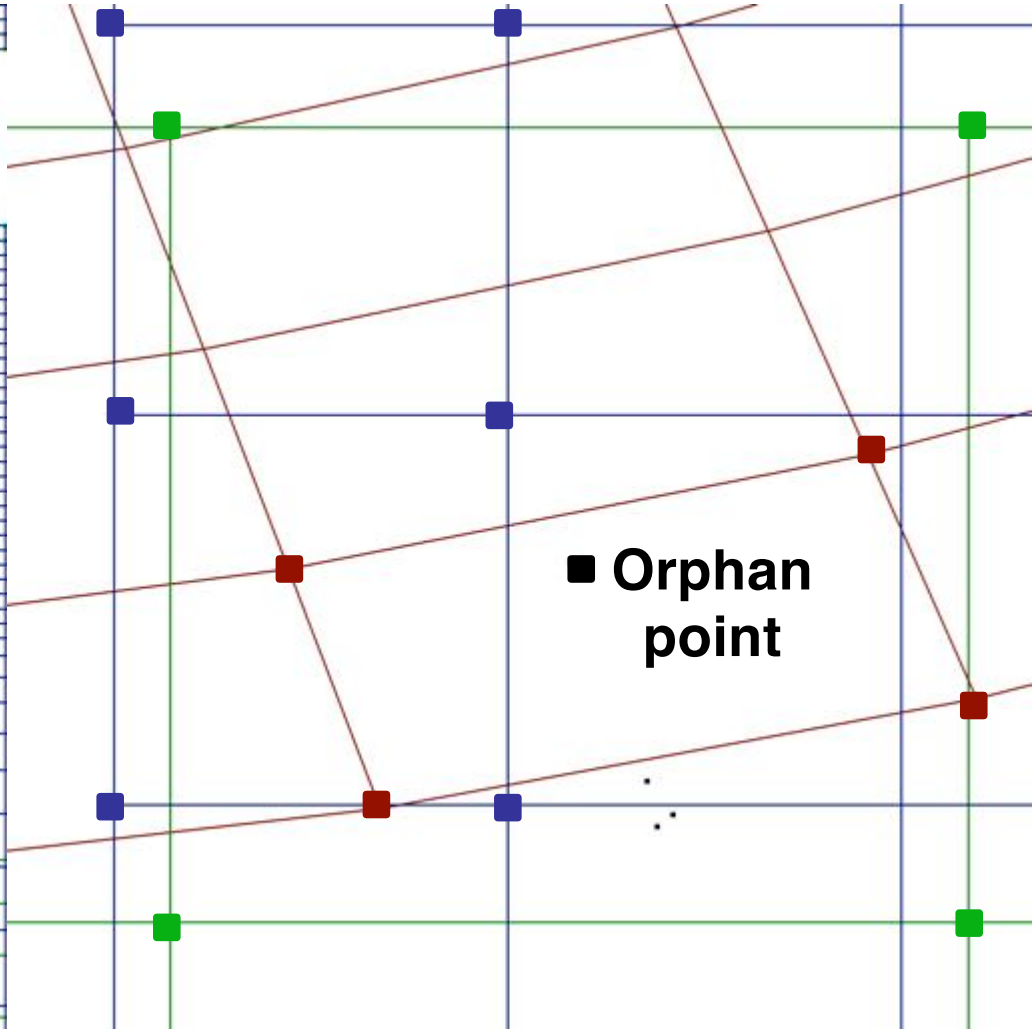
Widgets for toggling display of all neighboring grid slices that may contain selected orphan point

ORPHAN POINTS REDUCTION / ELIMINATION IN OVERGRID (4)

Zoomed-in view



Even more zoomed-in view showing fringe point locations of neighboring slices



CGT SCRIPT LIBRARY

Tcl macros -10x more compact scripts, > 3x faster development time

Low – Mid Level

- File manipulation (e.g., combine files, format conversion,…)
- Geometry creation (e.g., points, lines, analytic curves, cylinders,...)
- Grid information (e.g., interrogate grid dimensions, coordinates, arc lengths, formats,…)
- Grid editing (e.g., extract, concatenate, split, duplicate, swap/ reverse indices, scale, translate, rotate, mirror, revolve, …)
- Grid redistribution
- Surface grid generation (TFI and hyperbolic)
- Volume grid generation (hyperbolic and Cartesian)
- X-ray hole cutter generation and hole cut instructions creation
- Pegasus5 and C3P input preparation
- Force/moments computation inputs
- OVERFLOW boundary conditions inputs and namelist i/o

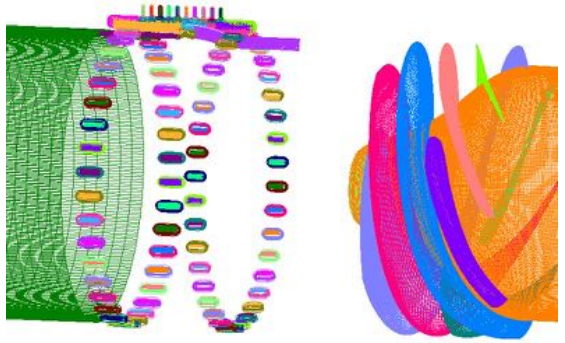
Top Level

- Grid-based approach (Configuration Management Scripts, PEG5)
- Component-based approach (duplicated/moving comp., X-rays)

PRE-PROCESSING STRATEGY USING SCRIPTS

Scripting approach

- rapid replay of all steps
- easy to parameterize inputs (e.g., grid stretching, spacings, etc.)
- easy to make small changes
- recommended even for one-of-a-kind cases
- modification needed if surface topology changes



Surface Grid Generation

- generate grids from
  - surface triangulation
  - surface feature curves

} Derived from STEP / IGES / CAD, or supplied

Volume Grid Generation

- near-body hyperbolic grids, off-body Cartesian grids

Domain Connectivity, Force/Moments Computation, Flow Solver Inputs

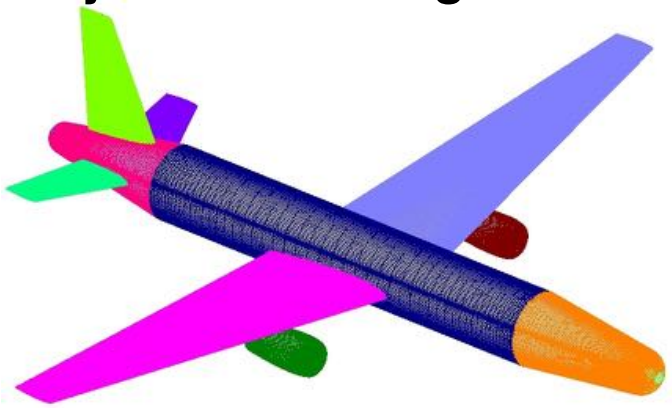
- construct and store common database in script (boundary conditions, component definitions, etc.)

DISTRIBUTED TEAM-BASED SCRIPT DEVELOPMENT

- Identify components of a complex configuration

- A component is a geometric part and may be modeled by one or more grids

- Create stand-alone script for each component
  - generation of surface and volume grids
  - domain connectivity inputs (X-ray maps)
  - solver boundary conditions
  - forces and moments integration inputs



- Each component script can be created by different developers

- Use file repository system to update script so that each team member can get most up-to-date version of each script

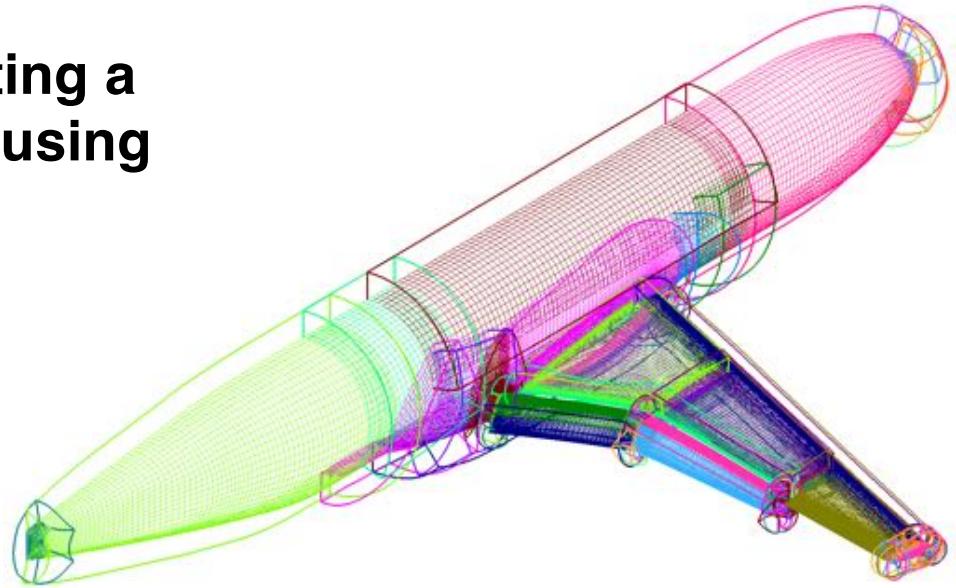
- Share global parameters file (e.g., wall spacing, global spacing, str. ratio, etc.)

- Each developer is responsible for grid connectivity of individual component

- Create master script to call component scripts, assemble final grid system, generate input files for domain connectivity, force/ moment integration, flow solver

MULTI-THREADED TCL SCRIPT FOR VOLUME MESH GENERATION

Script library procedure for generating a system of hyperbolic volume grids using multiple Tcl threads



```
GenHypVolThread  [list grid1.sur grid1.vol $strlist1 $bclist1 $smulist1] \
                 [list grid2.sur grid2.vol $strlist2 $bclist2 $smulist2] \
                 ...
                 [list gridN.sur gridN.vol $strlistN $bclistN $smulistN]
```

where

- grid{i}.sur = input surface grid filename
- grid{i}.vol = output volume grid filename
- strlist{i} = stretching function parameters list
- bclist{i} = boundary conditions parameters list
- smulist{i} = smoothing parameters list

} Inputs for grid{i}

POST-PROCESSING MODULES

POST-PROCESSING USING CGT

Forces and Moments Computation (mixsur/overint, usurp)

Solution Convergence Analysis

- solution/turb. model residuals, forces/moments
- one page overview (oversmart)
- individual plots (overplot)

Flow Visualization (overgrid)

- scalar and vector functions
- turb. model dependent variables, species partial densities
- unsteady 2-D solution animation

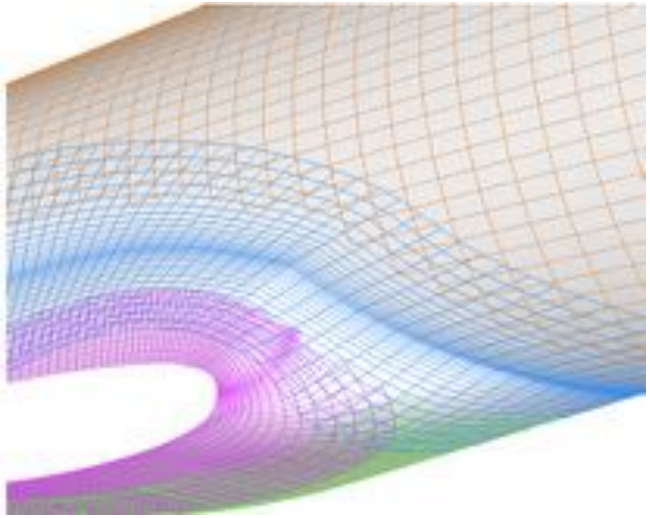
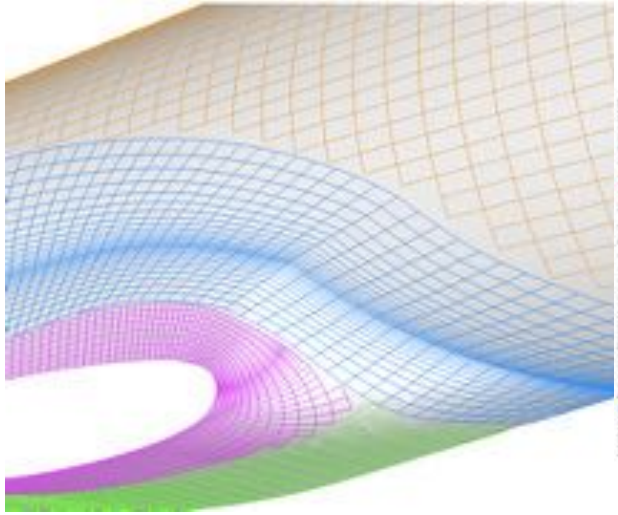
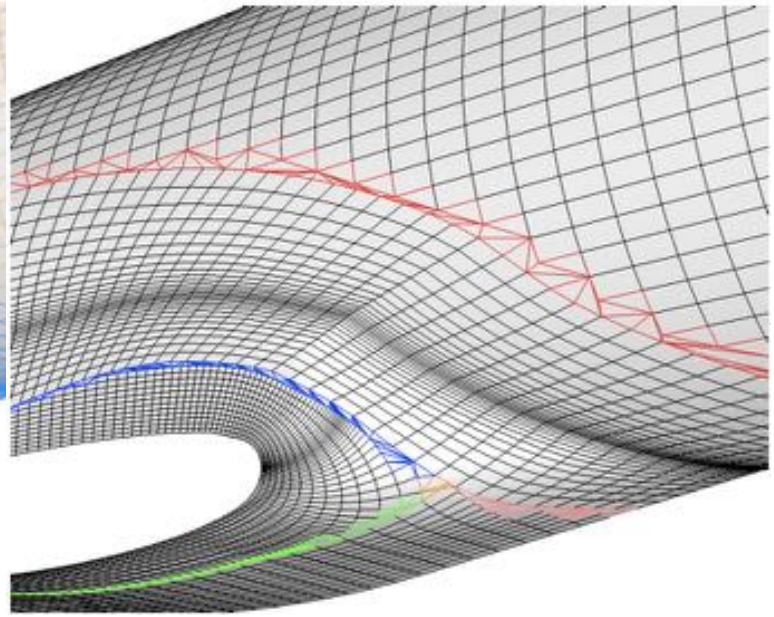
Component Line Loads (triload)

- sectional and cumulative line loads
- Cp on plane cuts

Dynamics Animation (overgrid)

- 6-DOF dynamics output from flow solver

FORCES/MOMENTS INTEGRATION APPROACH 1 – INTEGRATE ON HYBRID SURFACE MESH CGT Modules: MIXSUR, OVERINT

Hybrid mesh generator (MIXSUR)
- **Automatically blank overlapping quads**
- **Automatically fill narrow gap with triangles**
- **Very fast but may sometimes contain a few bad triangles (200 surface grids, 2 million+ surface pts, 22 sec., 1 proc.)**

Integration tool (OVERINT)
- **Integrates on non-overlapping quads and triangles**
- **Integrates linear function exactly**

Chan, W. M., Enhancements to the Hybrid Mesh Approach to Surface Loads Integration On Overset Structured Grids, AIAA Paper 2009-3990

OVERINT OUTPUT FILES

- Surface triangulation solution file derived from hybrid surface mesh generated by MIXSUR (.triq)

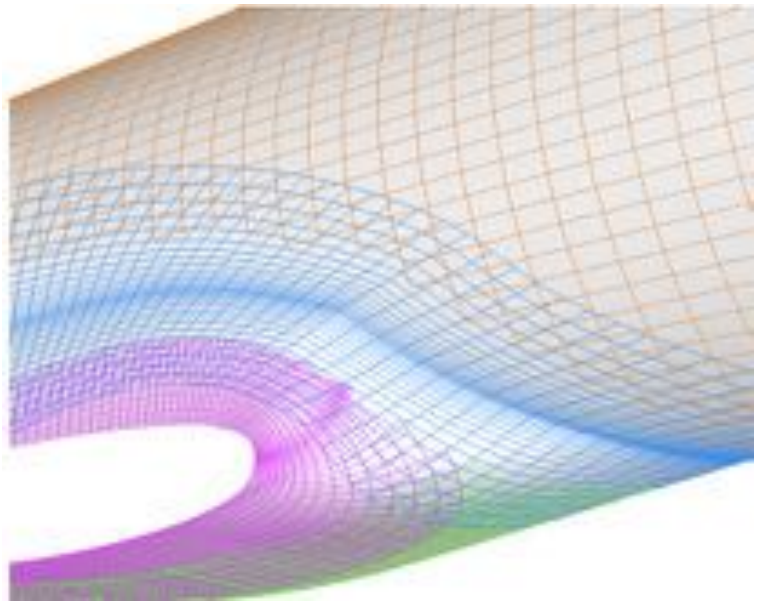
- Surface distributions of local forces and moments

  - Four unstructured surface triangulation files, each with cell-centered scalar variables (extended CART3D .i.tri format)

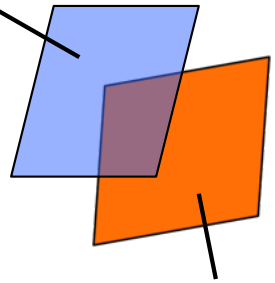
    (1) Cell ΔF
    (2) Cell ΔF / Cell area
    (3) Cell ΔM
    (4) Cell ΔM / Cell area

- Scalars: X, Y, Z components of forces/moments
  total magnitude, pressure, viscous, momentum contributions
  local cell area

FORCES/MOMENTS INTEGRATION APPROACH 2 – INTEGRATE ON WEIGHTED QUADS
CGT Module: USURP



$W_1 = 1$



Polygon subtraction in 3-D

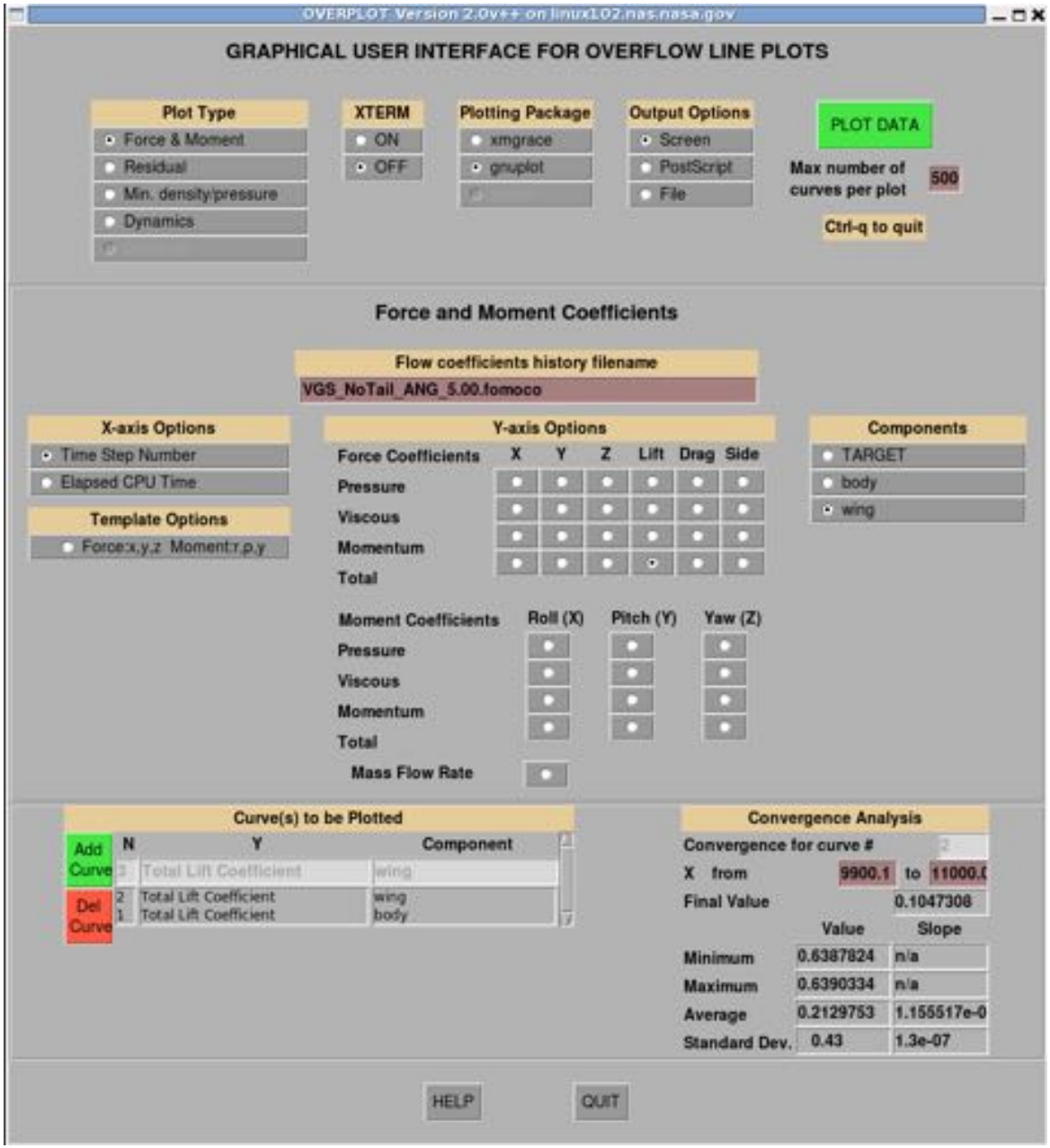
$W_2 = (A_Q - A_{OV})/A_Q$

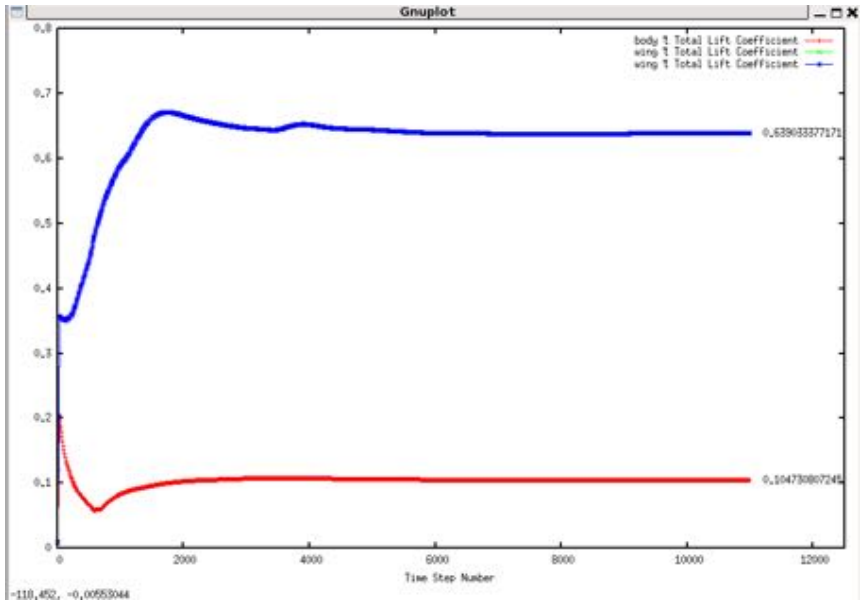
A_Q = Area of quadrilateral
A_{OV} = Area of overlap

Quad panel weights calculator and integrator (USURP)
- Automatically computes panel weight for each quad
- Always returns a result by integrating over all quads
- No hybrid mesh => no visual checks
- Does not integrate linear function exactly
- Also has standalone and OVERFLOW modes

Boger, D. and Dreyer, J., Prediction of Hydrodynamic Forces and Moments for Underwater Vehicles Using Overset Grids, AIAA Paper 2006-1148

OVERPLOT : SOLUTION CONVERGENCE ANALYSIS
Forces/Moments Panel (.fomoco)





- Single coef. plot with option to add more coefs.

- Six coef. matrix plot (Fx, Fy, Fz, Mx, My, Mz)

OVERPLOT: SOLUTION CONVERGENCE DIAGNOSTICS

Residual history plots for components defined for forces/moments computation

GRAPHICAL USER INTERFACE FOR OVERFLOW LINE PLOTS

Plot Type: Force & Moment; Residual; Min. density/pressure; Dynamics
XTERM: ON; OFF
Plotting Package: xmgrace; gnuplot
Output Options: Screen; PostScript; File
PLOT DATA
Max number of curves per plot: 500
Ctrl-q to quit

Residual History Plot Options

Residual history filename: run.resid
OVERFLOW input filename: run.01.inp
Type: Grids; Components

X-axis Options: Time Step Number; Show every 1 point; Show all subiterations

Y-axis Options: L2 of RHS; Linf of RHS; L2 of delta Q; Linf of delta Q; Drop in log of L2 of RHS for sub-iterations; Drop in log of Linf of RHS for sub-iterations; Drop in log of L2 of delta Q for sub-iterations; Drop in log of Linf of delta Q for sub-iterations; CPU time; Number of grid points

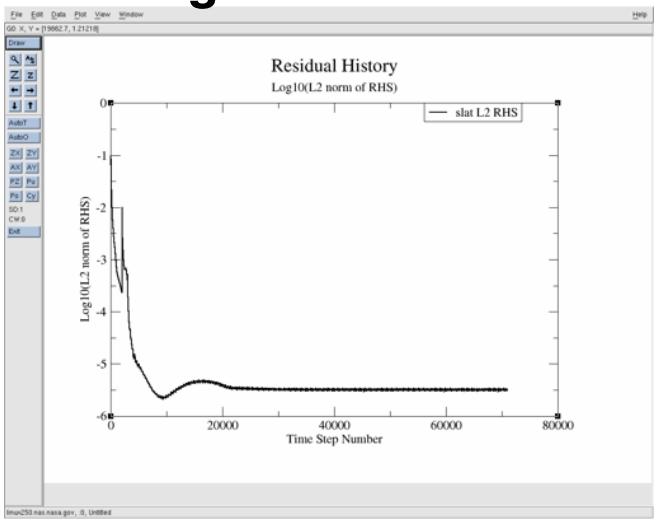
Components # 6: Total; fuse; slat; wing; flapi; flapo
Select All
Plot Component Grids
Grids in component # 12: 'Slat Main Front-14'; 'Slat Main Back-15'; 'Slat In Cap 1-16'; 'Slat In Cap 2-17'; 'Slat In Cap 3-18'; 'Slat In Cap 4-19'; 'Slat In Cap 5-20'; 'Slat Out Cap 1-21'; 'Slat Out Cap 2-22'; 'Slat Out Cap 3-23'

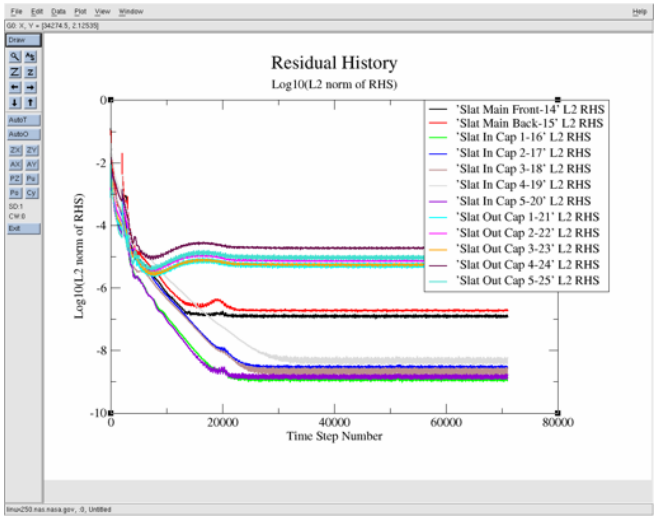
Convergence Analysis
Convergence for curve #
X from -0.1 to -1
Final Value

	Value	Slope
Minimum		
Maximum		
Average		
Standard Dev.		

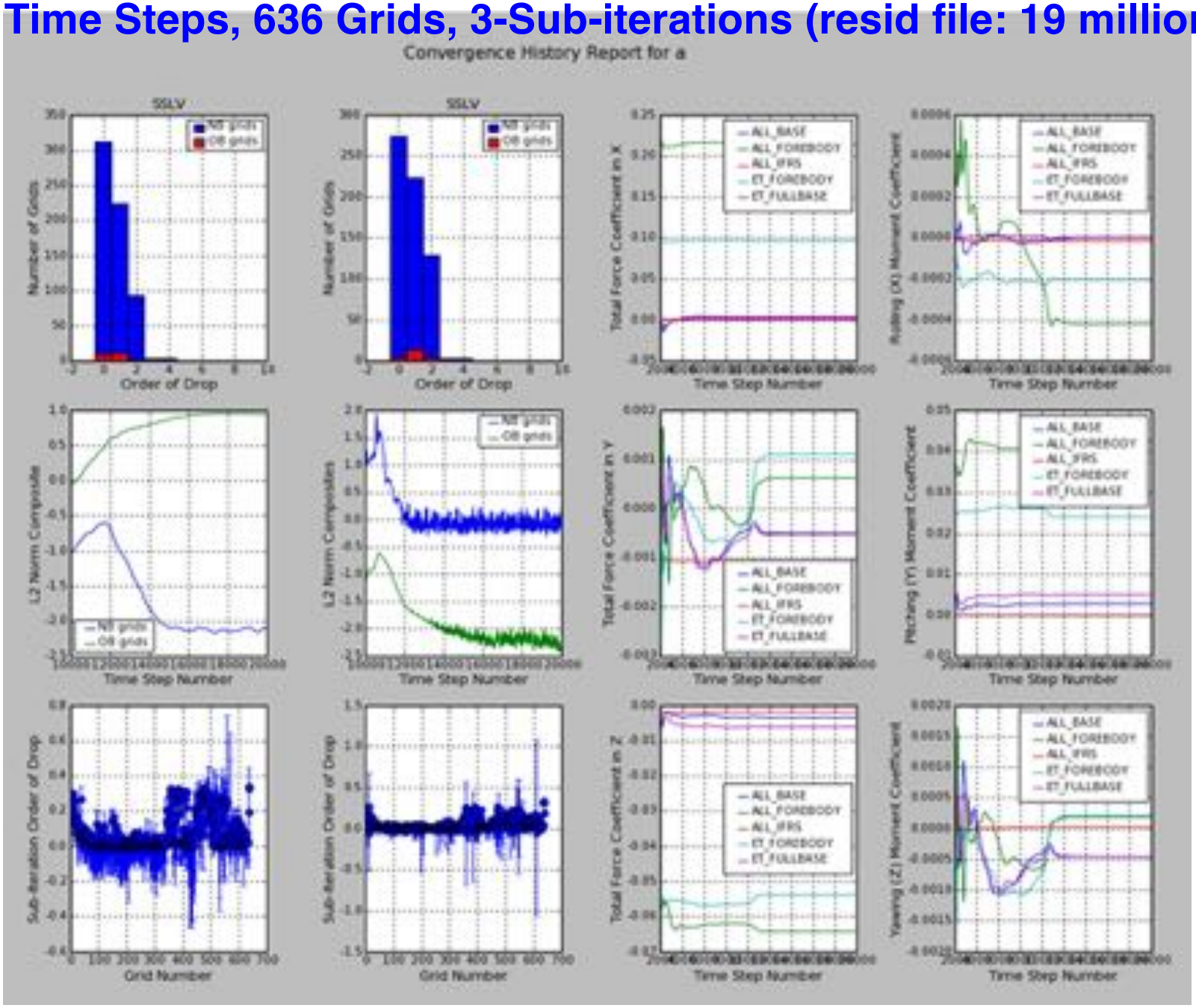
HELP QUIT

Easier to analyze convergence of grid systems with large number of grids





SOLUTION CONVERGENCE ANALYSIS: OVERSMART SUMMARY PAGE
Space Shuttle Launch Vehicle
10,000 Time Steps, 636 Grids, 3-Sub-iterations (resid file: 19 million lines)

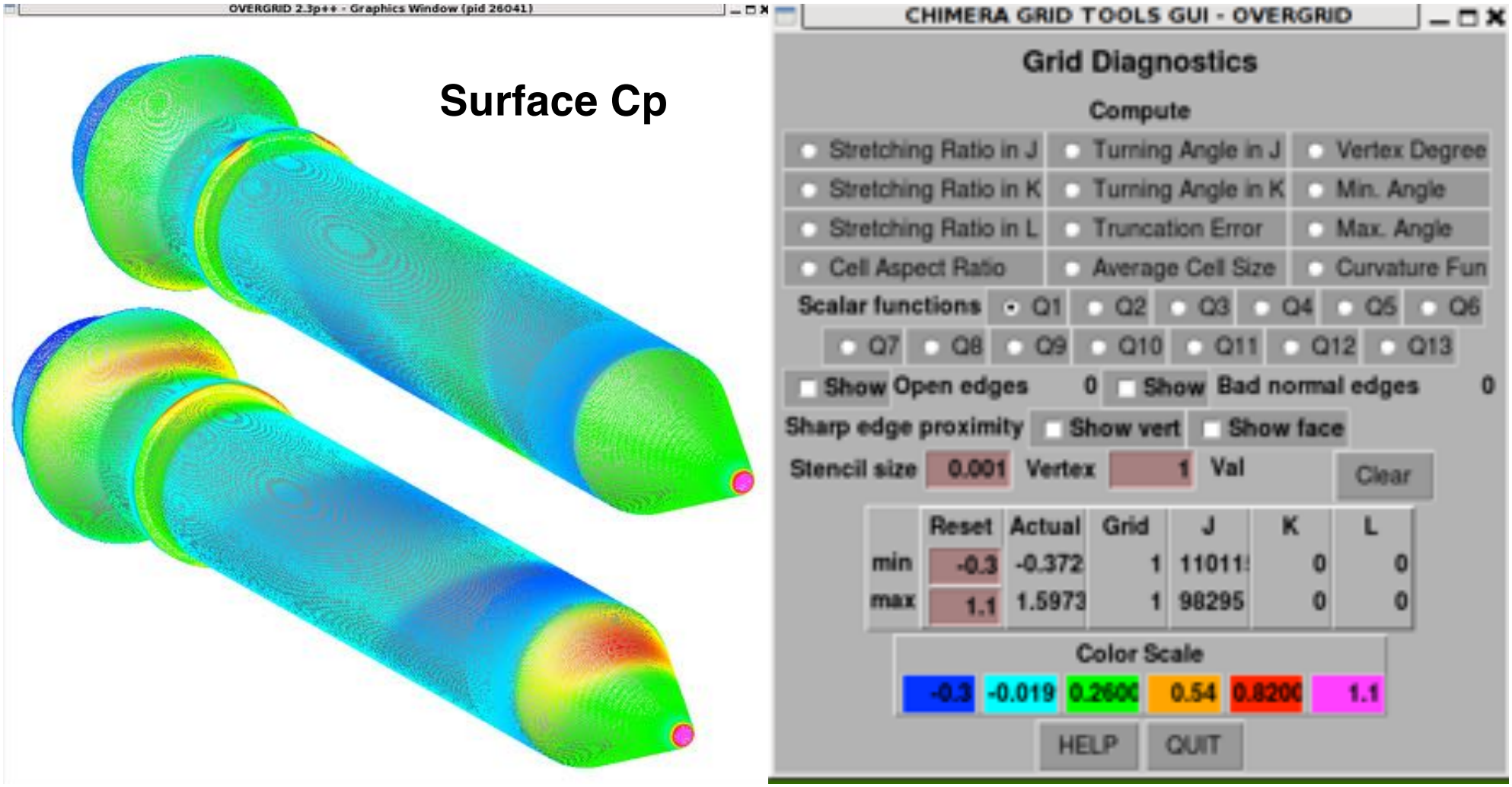


SOLUTION VISUALIZATION

- Flow variables
  - Surface triangulations
    - vertex and cell-centered scalars (.tri, .triq, .trix)
  - Overset structured surface and volume grids
    - steady (scalars and vectors)
    - unsteady (scalars)
    - 2-D moving body with adaptive grids (scalars)
- 6-DOF component trajectories

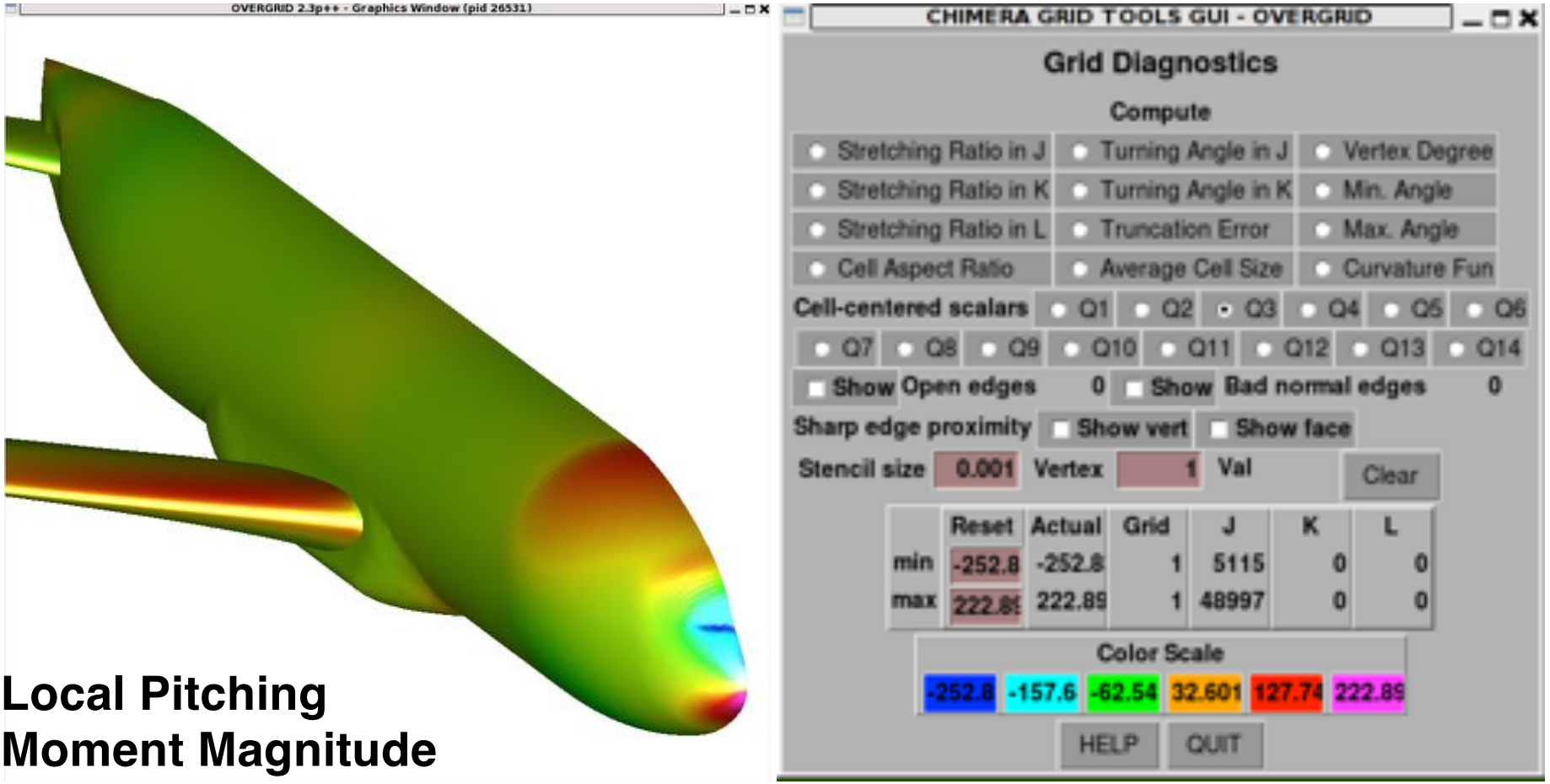
VISUALIZATION OF VERTEX-CENTERED DATA ON SURFACE TRIANGULATIONS (OVERGRID)

Standard CART3D triq file



VISUALIZATION OF CELL-CENTERED DATA ON SURFACE TRIANGULATIONS (OVERGRID)

Extended CART3D tri file with cell-centered scalars
Local forces/moments tri file output from OVERINT

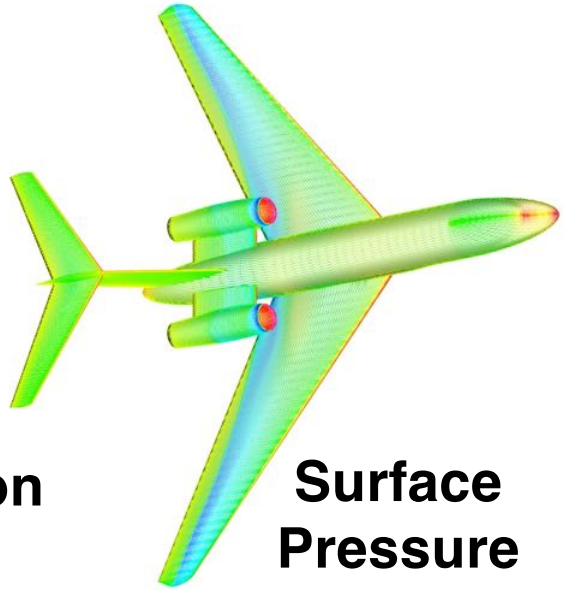


Local Pitching Moment Magnitude

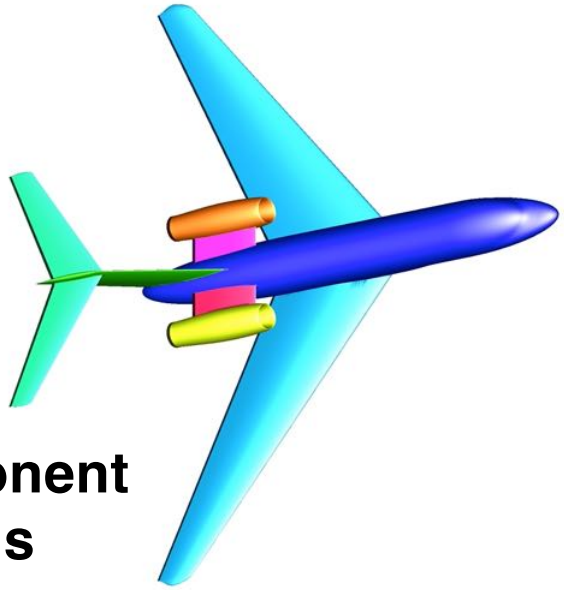
VISUALIZATION OF SURFACE TRIANGULATIONS IN .TRIX FORMAT (OVERGRID)

CART3D trix file with vertex-centered and cell-centered scalars

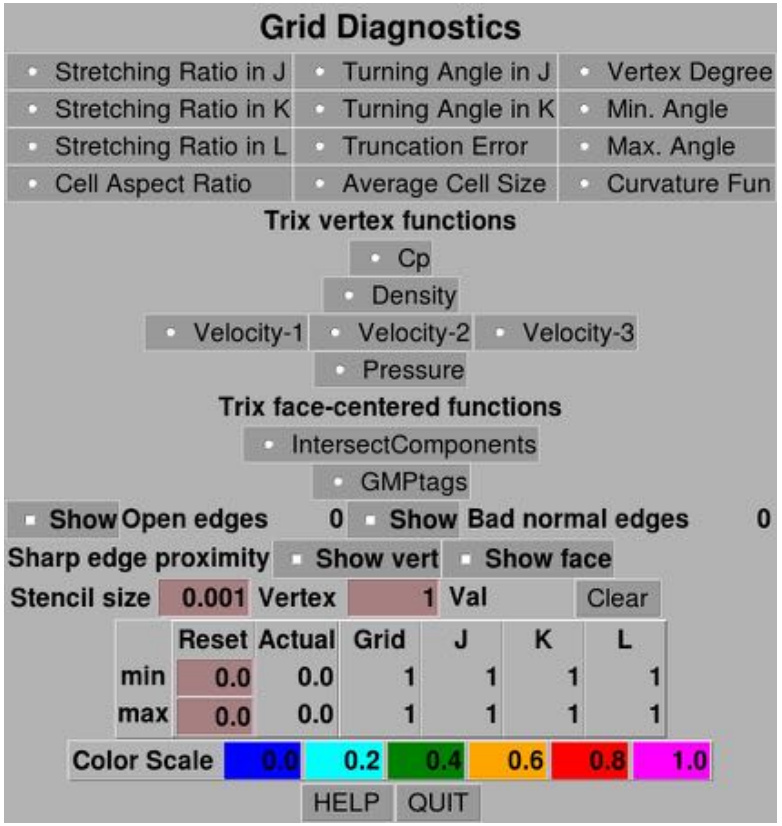
Triangulation Mesh

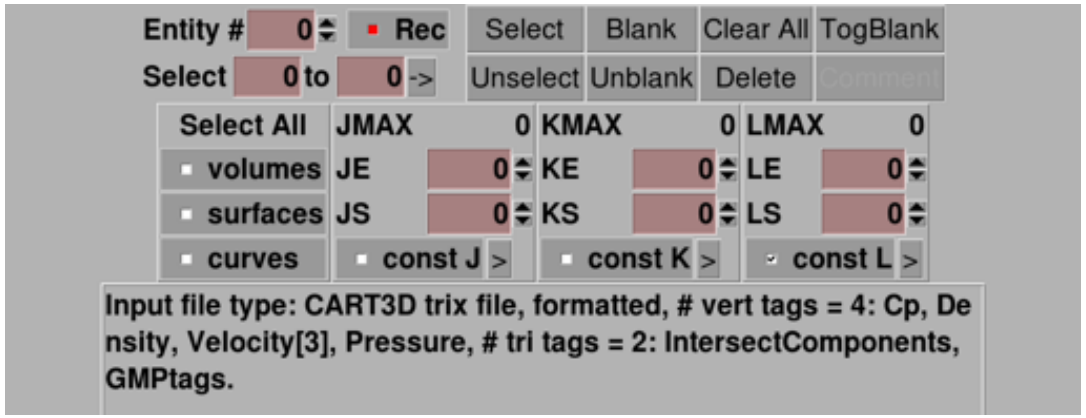


Surface Pressure

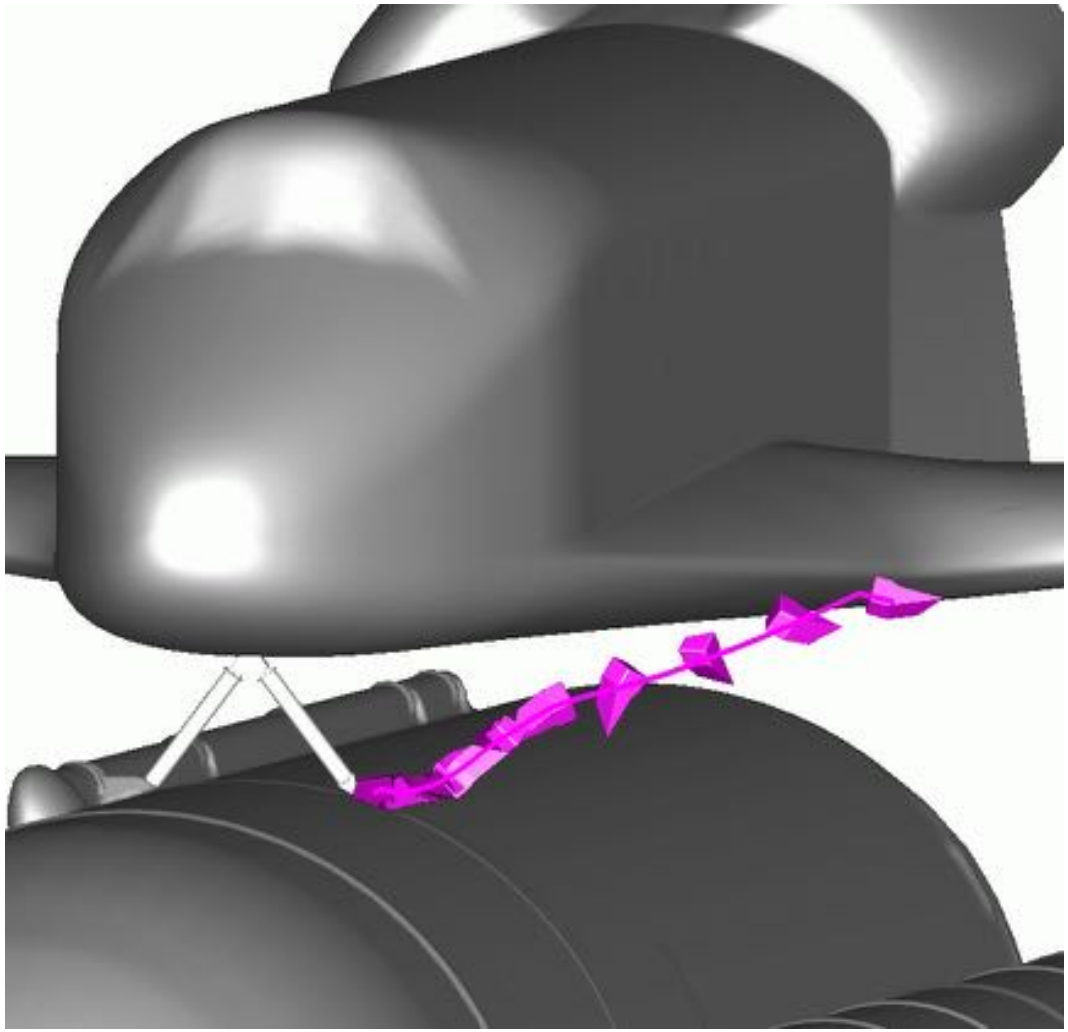


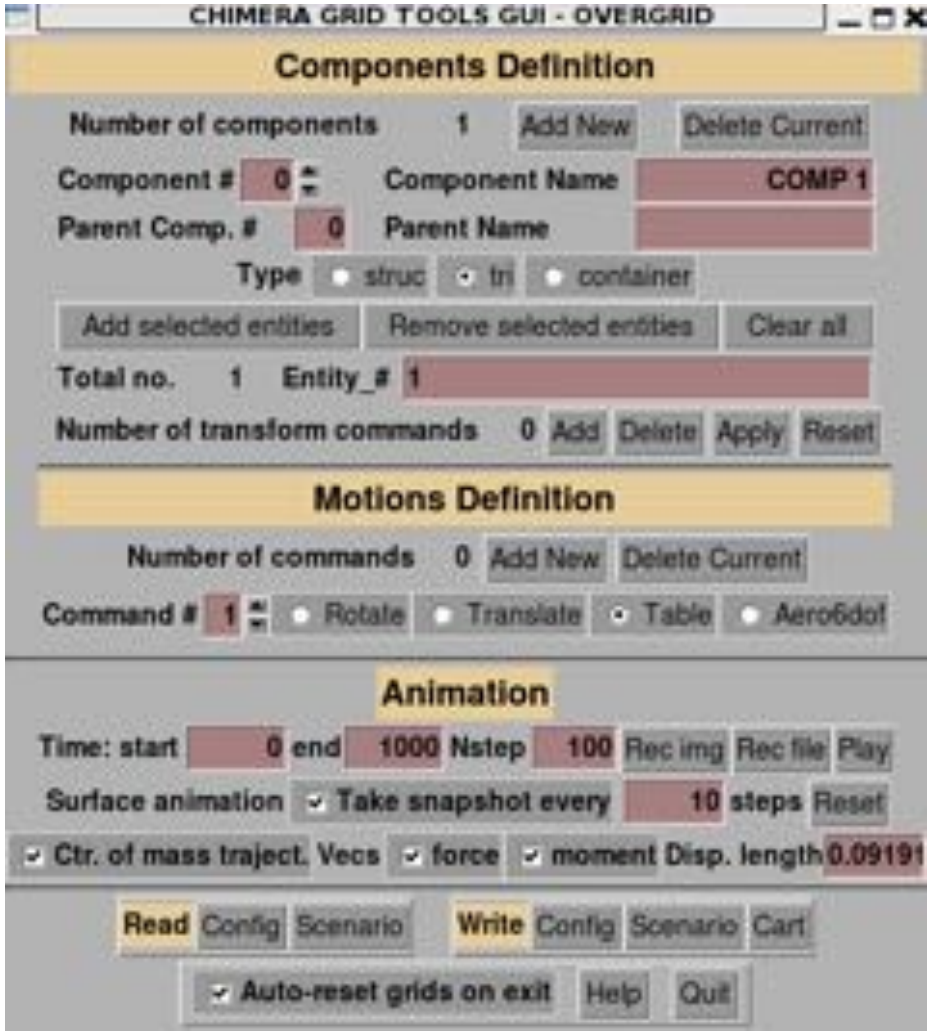
Component Tags





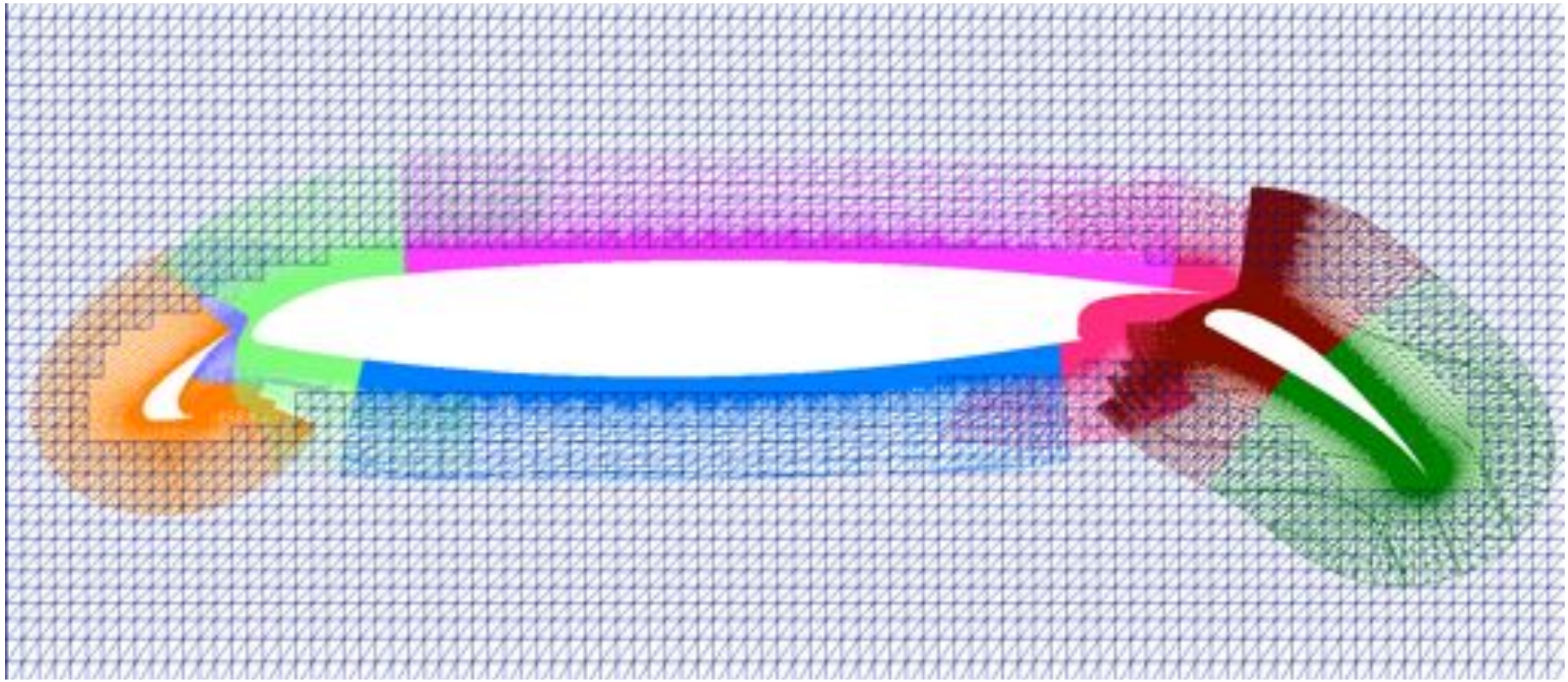
COMPONENT TRAJECTORIES VISUALIZATION FROM SIX-DOF COMPUTATIONS





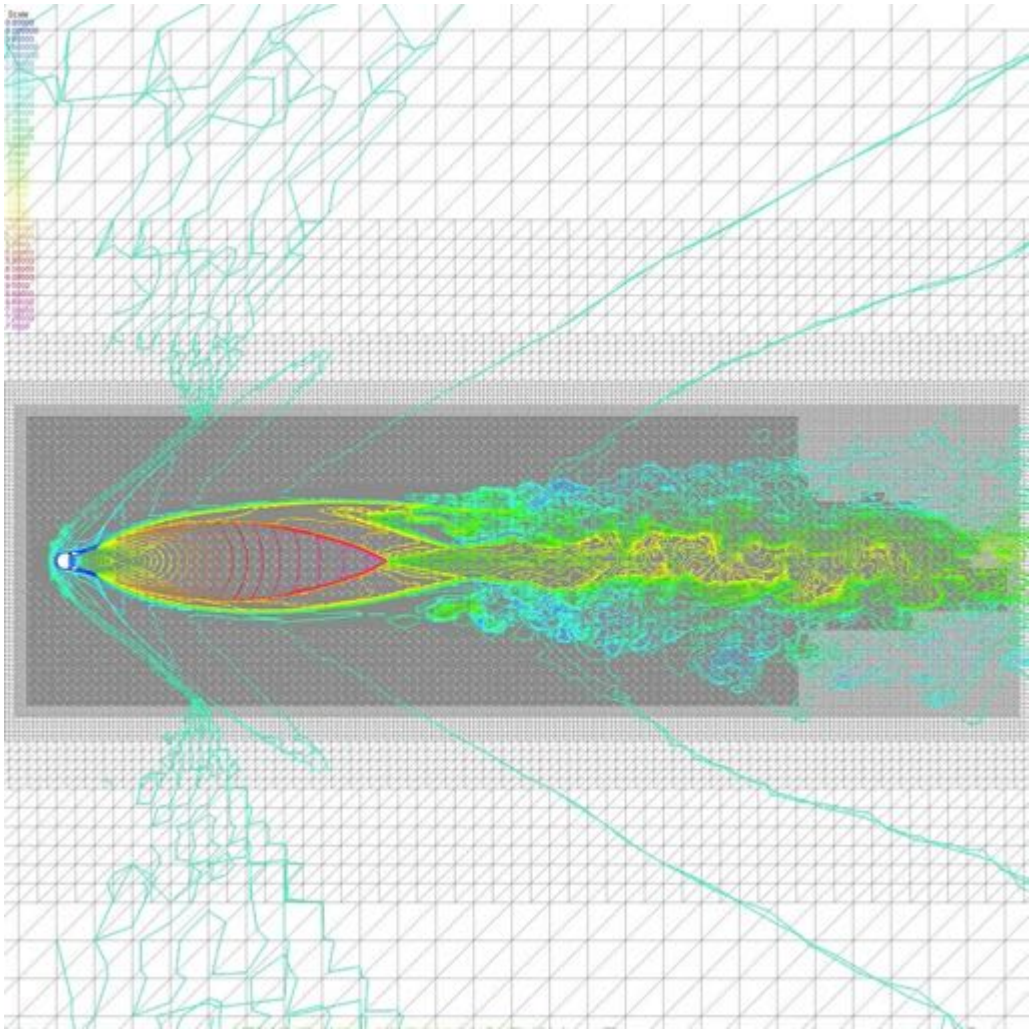
CUT PLANE GENERATION IN CVA

- Generate cut plane through multiple structured overset curvilinear grid and solution file -> .triq file
- Cut
  - constant x/y/z
  - arbitrary defined by Ax + By + Cz + D = 0
- Command line mode and scriptable
- Long term goal of performing control volume analysis



CUT PLANE VISUALIZATION IN OVERGRID (LINE CONTOURS)

Visualize single or multiple frames of .triq files generated by
- **cut-plane option in OVERFLOW**
- **external sources (read from files)**



Solution Viewer for Static and Dynamic Surfaces

Number of near-body grids 1

Surface Specification | Auto subset reset | Adaptive grids

Grid | Show

Q

Frames • single • multiple

Filenames

Root Extension

FT_BF start 002550 end 004750

inc • frame • time 1

Read Files read 0 | Show

Frame # 0 Filename extension REC PLAY

Slow frame play by factor of 1

Scalar Functions

• rho • rho u • rho v • rho w • e

• u • v • w • velocity magnitude • Mach number

• pressure • pressure coefficient • sound speed

• temperature • internal energy • total enthalpy • entropy

Log10

Vector Functions

• velocity

Show arrow head | Scale vector length Scale factor 0.1

Display Options

Wireframe | Line Contours | Shaded Surface

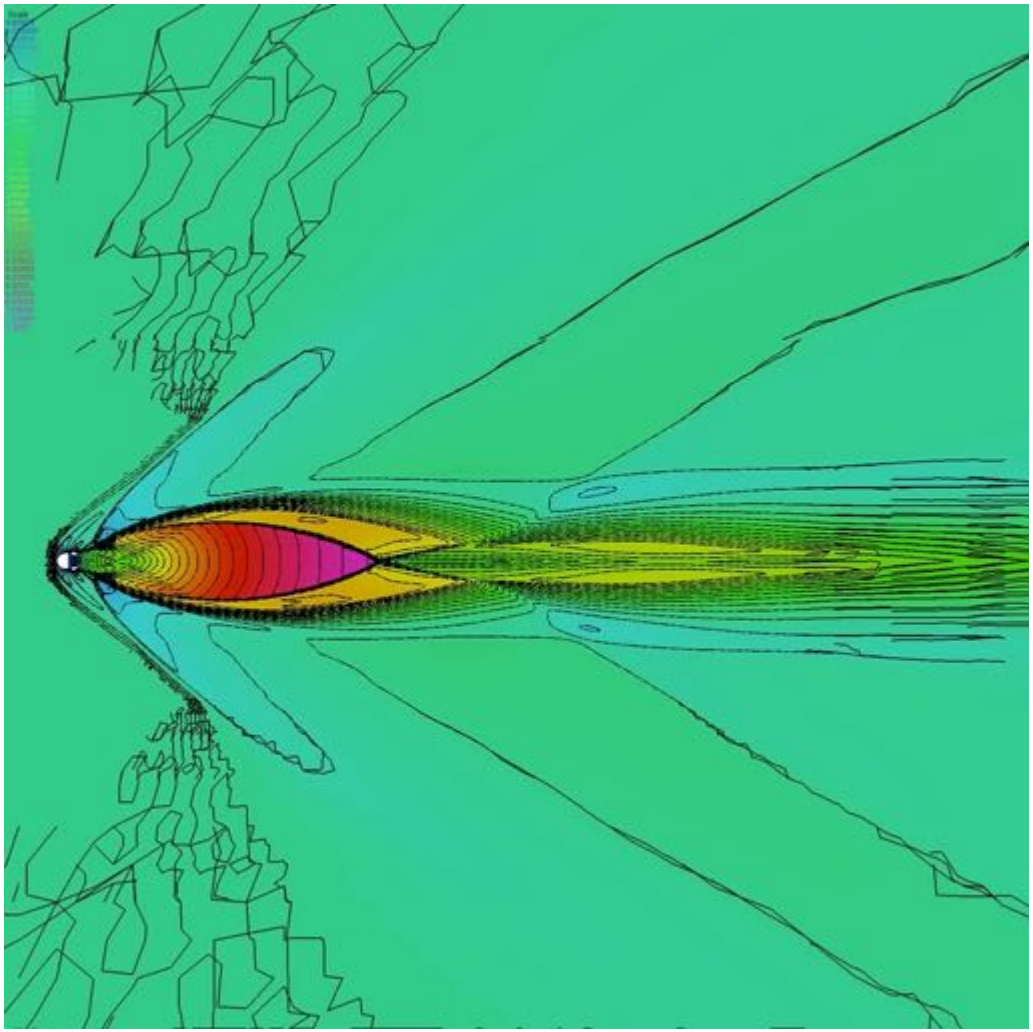
Color scale

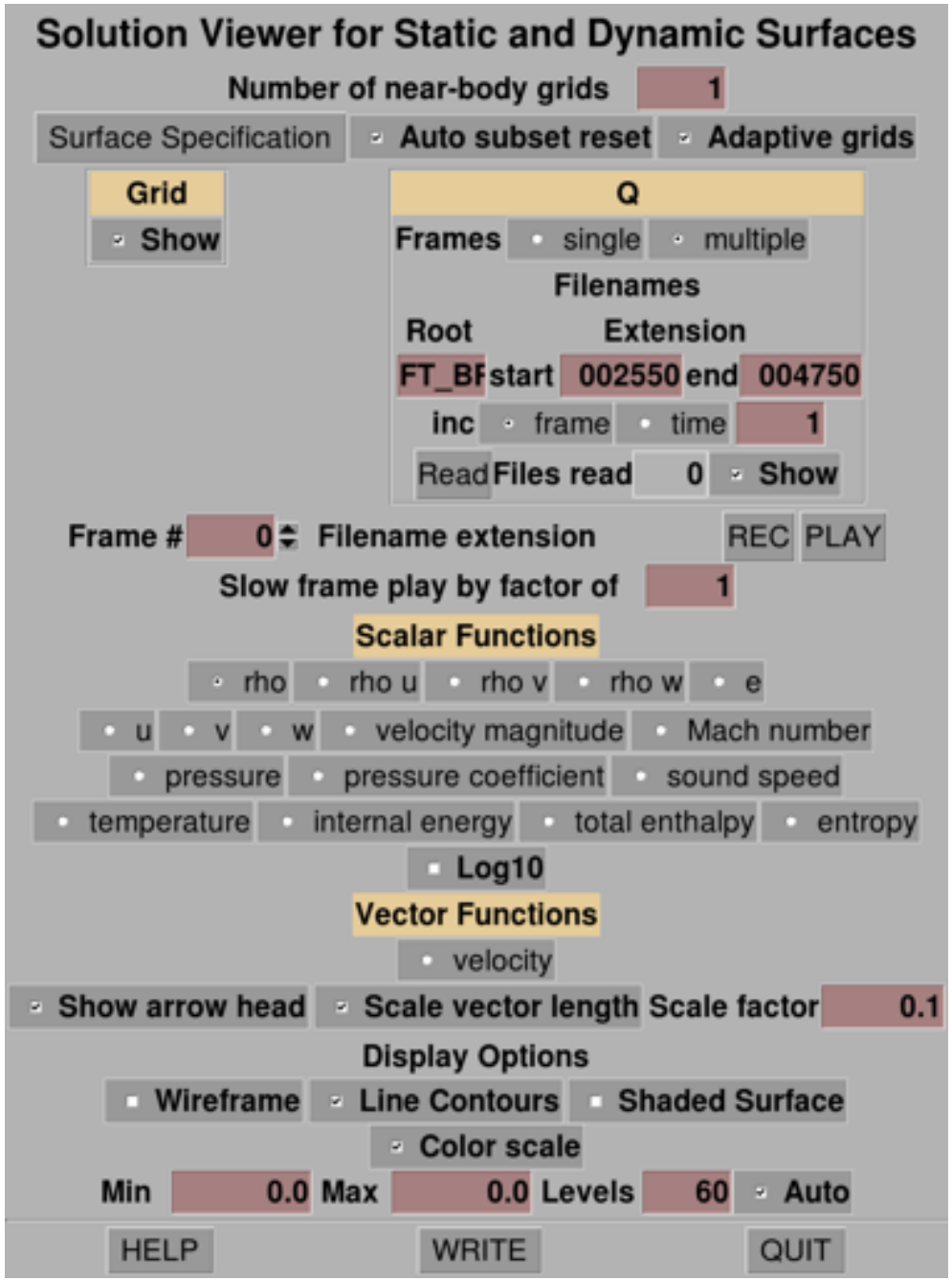
Min 0.0 Max 0.0 Levels 60 | Auto

HELP WRITE QUIT

CUT PLANE VISUALIZATION IN OVERGRID (SHADED CONTOURS)

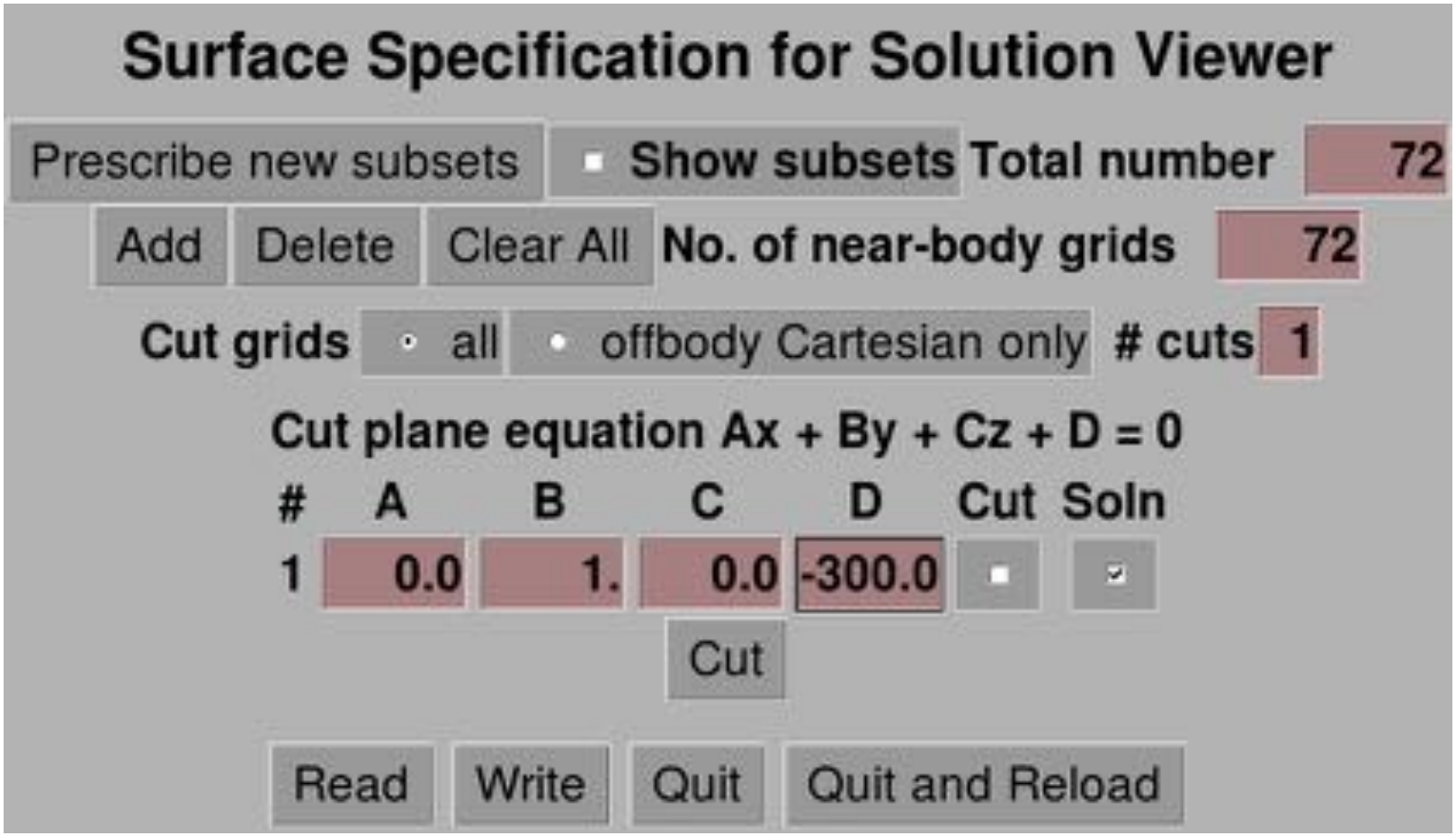
Visualize single or multiple frames of .triq files generated by
- **cut-plane option in OVERFLOW**
- **any other means**



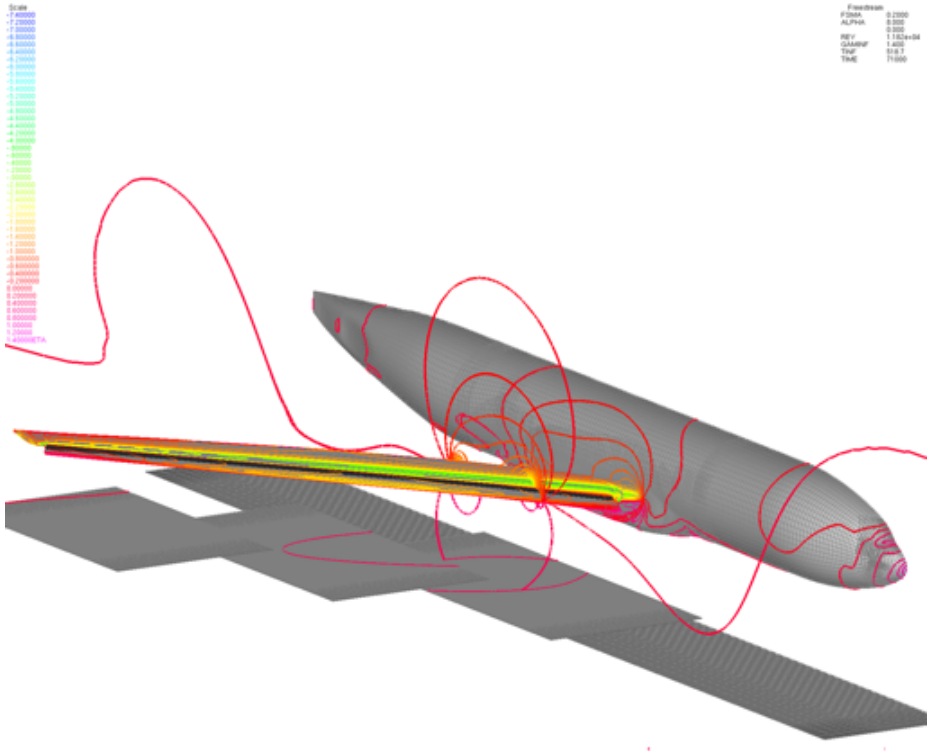


CUT PLANE GENERATION AND VISUALIZATION IN OVERGRID (1)

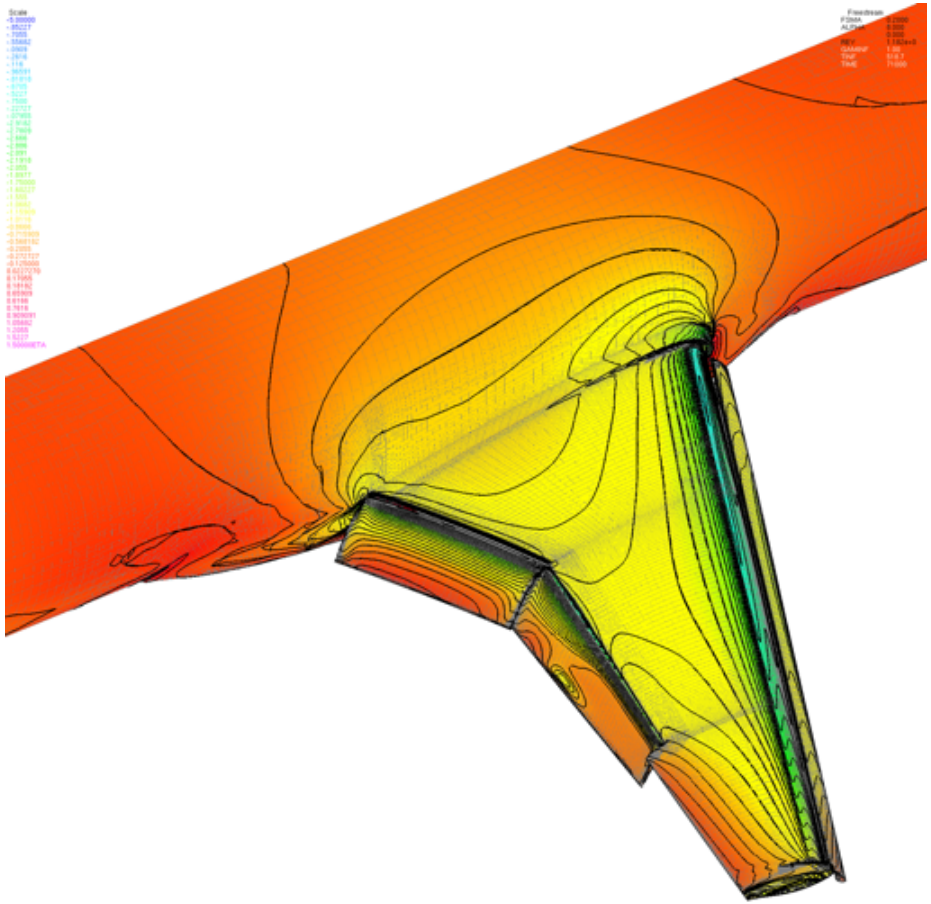
Generate cut planes through multiple structured overset meshes from GUI



CUT PLANE GENERATION AND VISUALIZATION IN OVERGRID (2)



Colored line contours on L=1 surfaces and cut planes

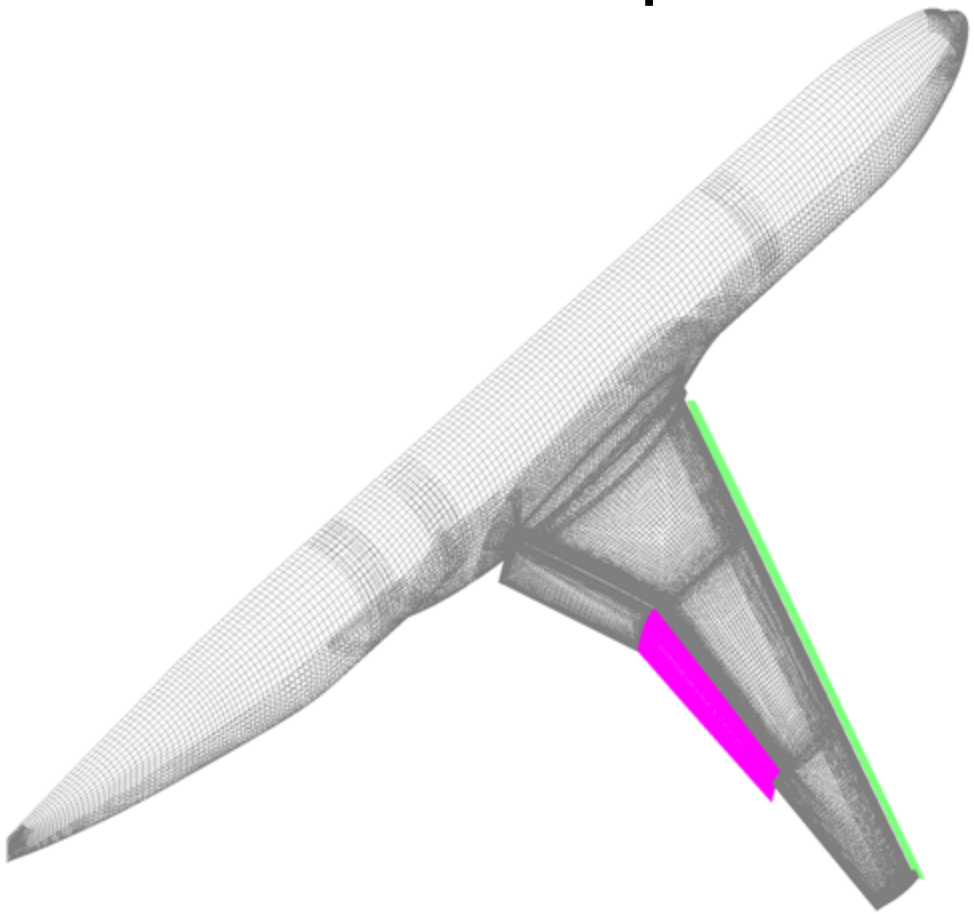


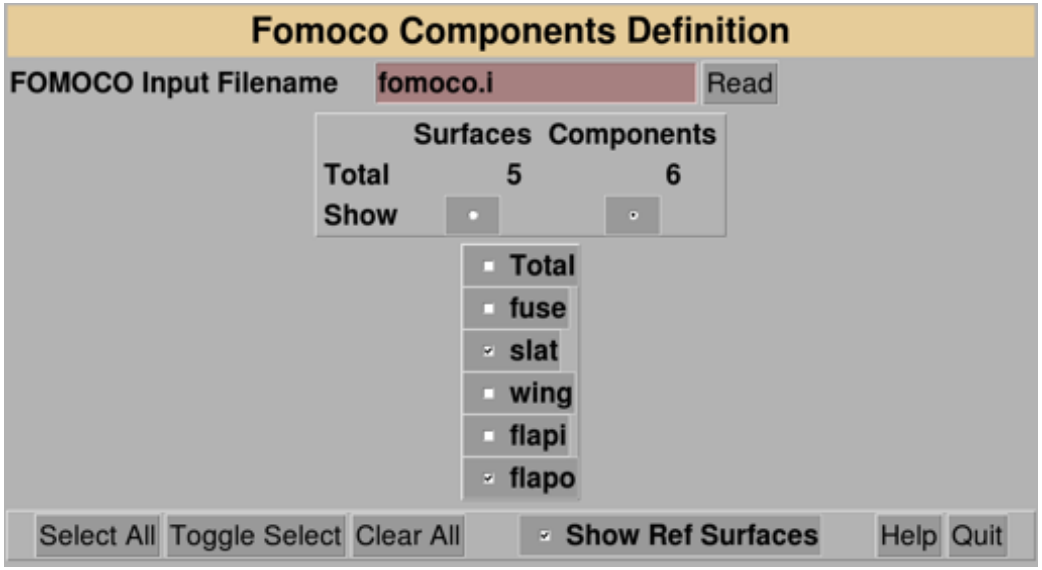
Shaded colored contours with overlayed line contours

OVERGRID: VISUALIZATION OF COMPONENTS DEFINED FOR FORCES/MOMENTS COMPUTATION

- Recent complex configuration applications: 100+ components, each component may contain from a few to 100+ surface subsets

- Need visual check of grid indices used to define components for forces/moments computation



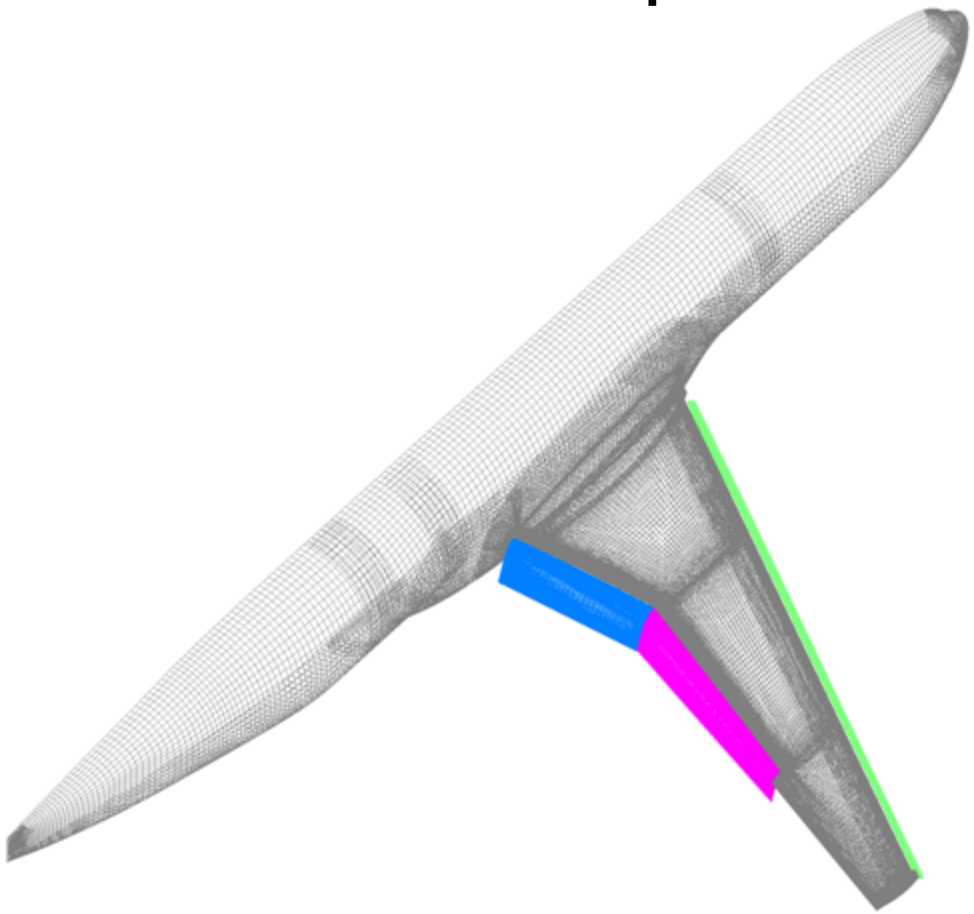


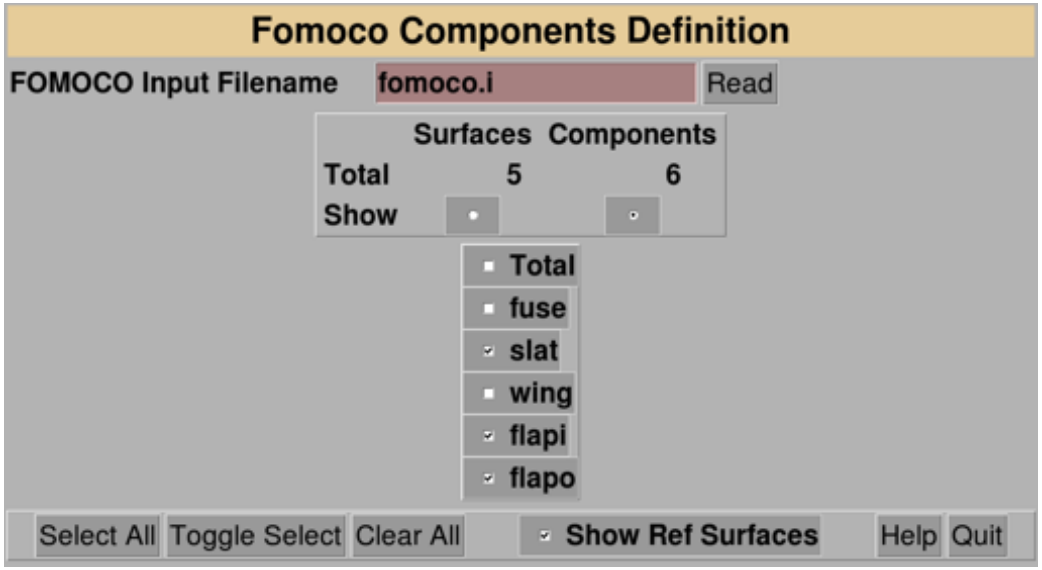
Toggle display of each component in different colors

OVERGRID: VISUALIZATION OF COMPONENTS DEFINED FOR FORCES/MOMENTS COMPUTATION

- Recent complex configuration applications: 100+ components, each component may contain from a few to 100+ surface subsets

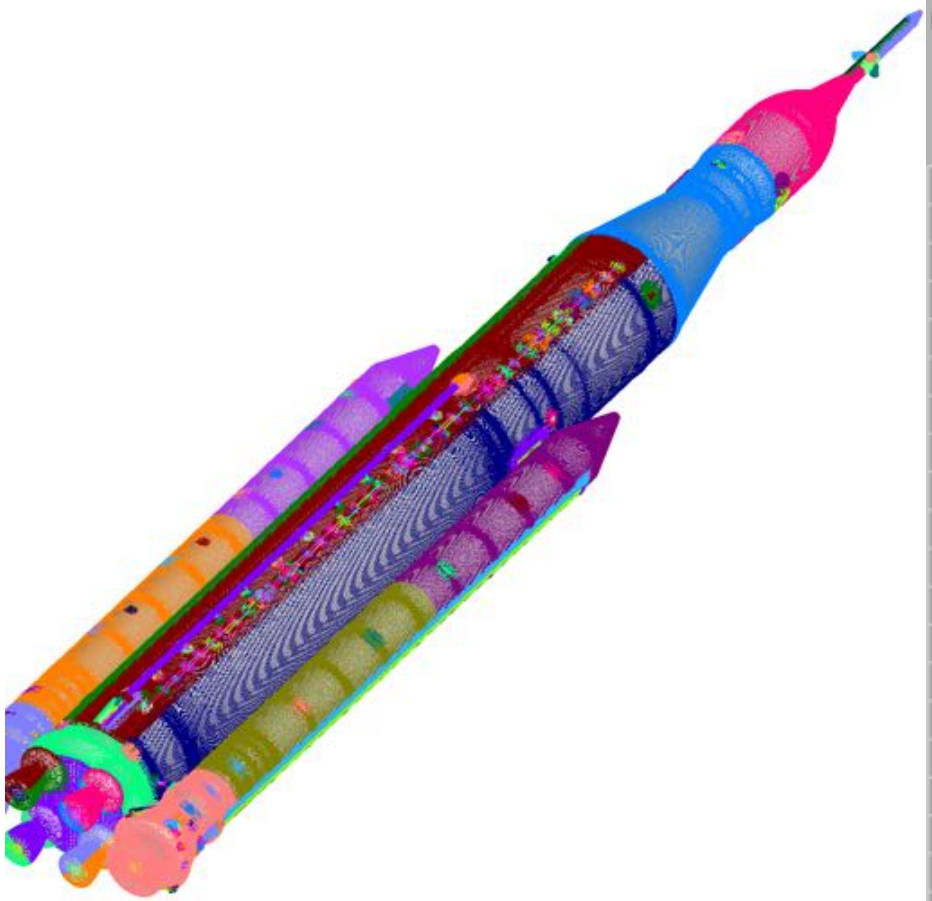
- Need visual check of grid indices used to define components for forces/moments computation





Toggle display of each component in different colors

OVERGRID: VISUALIZATION OF COMPONENTS DEFINED FOR FORCES/MOMENTS COMPUTATION (BIG CASE)



Fomoco Components Definition

FOMOCO Input Filename: mixsur.i [Read]

	Surfaces	Components
Total	142	147
Show	•	○

ALL	CORE_LOXLineSeal	CORE_PressLineBracketG02
CORE_No_Base	CORE_LOXLineFwdFairing	CORE_PressLineBracketG03
LSRB_No_Base	CORE_LOX1Brackets	CORE_PressLineBracketG04
RSRB_No_Base	CORE_LOX2Brackets	CORE_PressLineBracketG05
STACK_No_Base	CORE_LOXLineAftFairing1	CORE_PressLineBracketG06
MPCV_Body	CORE_LOXLineAftFairing2	CORE_PressLineBracketG07
CORE_Body	CORE_PressLineLong	CORE_PressLineBracketG08
CORE_SystemTunnel	CORE_PressLineShort	CORE_PressLineBracketG09
CORE_Base	CORE_PressLineBracketA01	CORE_PressLineBracketG10
MPCV_AbortNoz1	CORE_PressLineBracketB01	CORE_PressLineBracketG11
MPCV_AbortNoz2	CORE_PressLineBracketB02	CORE_PressLineBracketG12
MPCV_AbortNoz3	CORE_PressLineBracketB03	CORE_PressLineBracketG13
MPCV_AbortNoz4	CORE_PressLineBracketB04	CORE_PressLineBracketG14
ICPS_Tunnel1	CORE_PressLineBracketB05	CORE_PressLineBracketG15
ICPS_Tunnel2	CORE_PressLineBracketB06	CORE_PressLineBracketG16
ICPS_UmbConnector	CORE_PressLineBracketB07	CORE_PressLineBracketG17
MPCV_Umbilical_ramp	CORE_PressLineBracketC01	CORE_PressLineBracketG18
MPCV_Umbilical	CORE_PressLineBracketE01	CORE_PressLineBracketG19
CORE_FwdCamera	CORE_PressLineBracketE02	CORE_PressLineBracketG20
CORE_Stabilizer	CORE_PressLineBracketE03	CORE_PressLineBracketG21
MPCV_PanelHinge	CORE_PressLineBracketE04	CORE_PressLineBracketG22
MPCV_Camera	CORE_PressLineBracketE05	CORE_PressLineBracketG23
MPCV_TowerTunnel	CORE_PressLineBracketD01	CORE_PressLineBracketH01
CORE_LOXLine1	CORE_PressLineBracketF01	CORE_PressLineBracketH02
CORE_LOXLine2	CORE_PressLineBracketG01	CORE_PressLineBracketI01

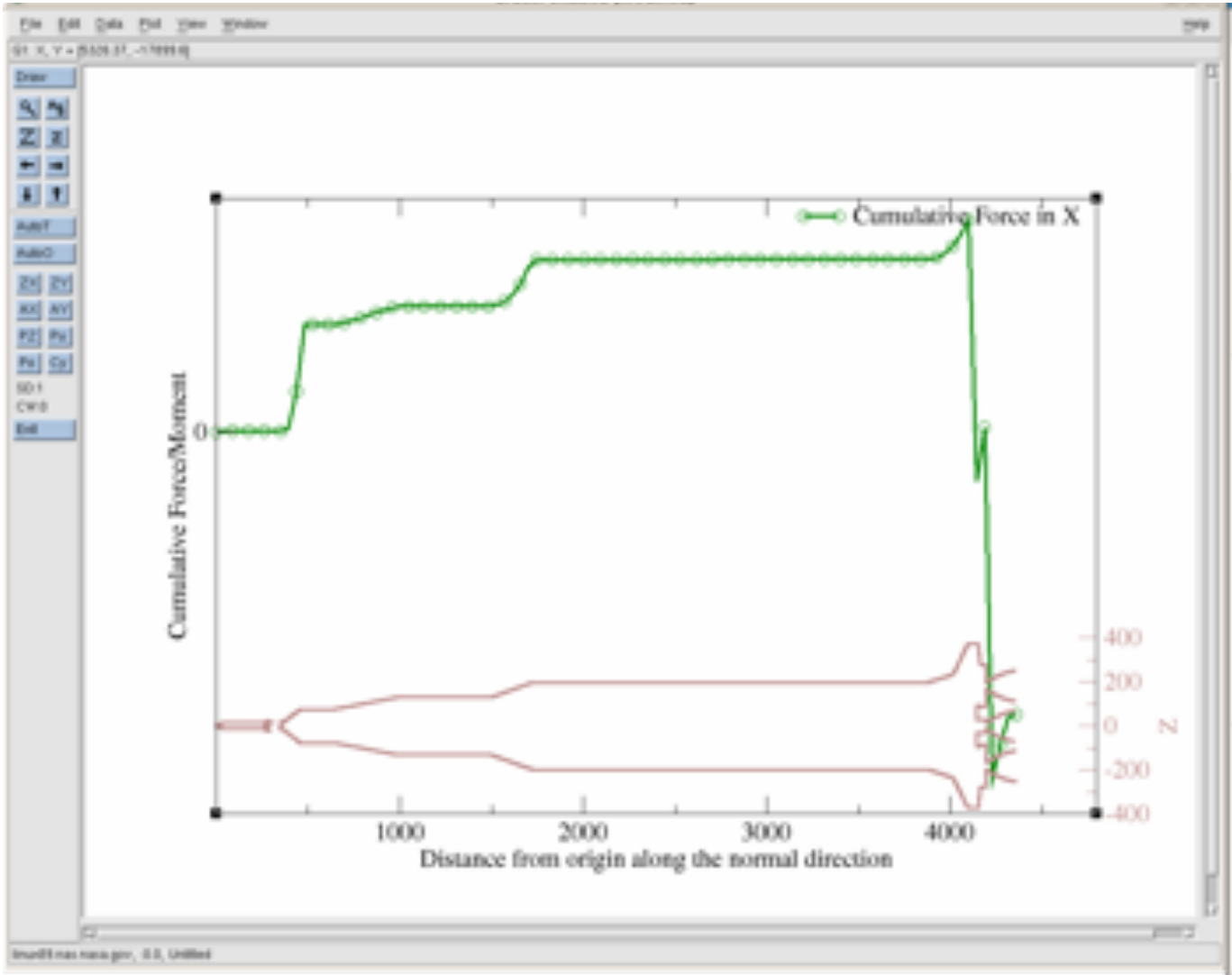
< 1 - 75 >

Select All | Toggle Select | Clear All | Show Ref Surfaces | Help | Quit

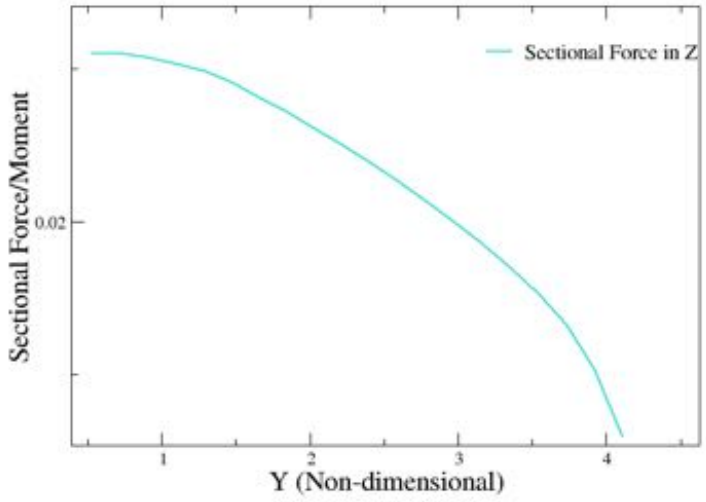
Click to second panel to see components 76-147

LINE LOADS COMPUTATION AND Cp CUTS IN TRILOAD (1)

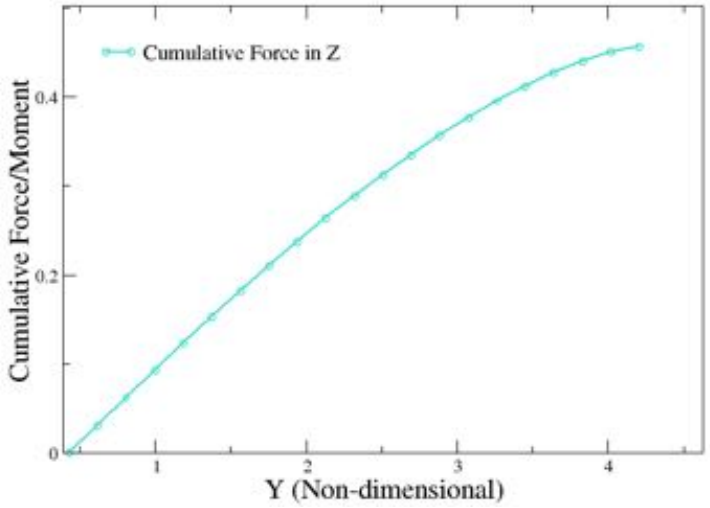
- Computation of sectional loads and Cp along specified cuts
- Modes of operation
  - command line
  - GUI



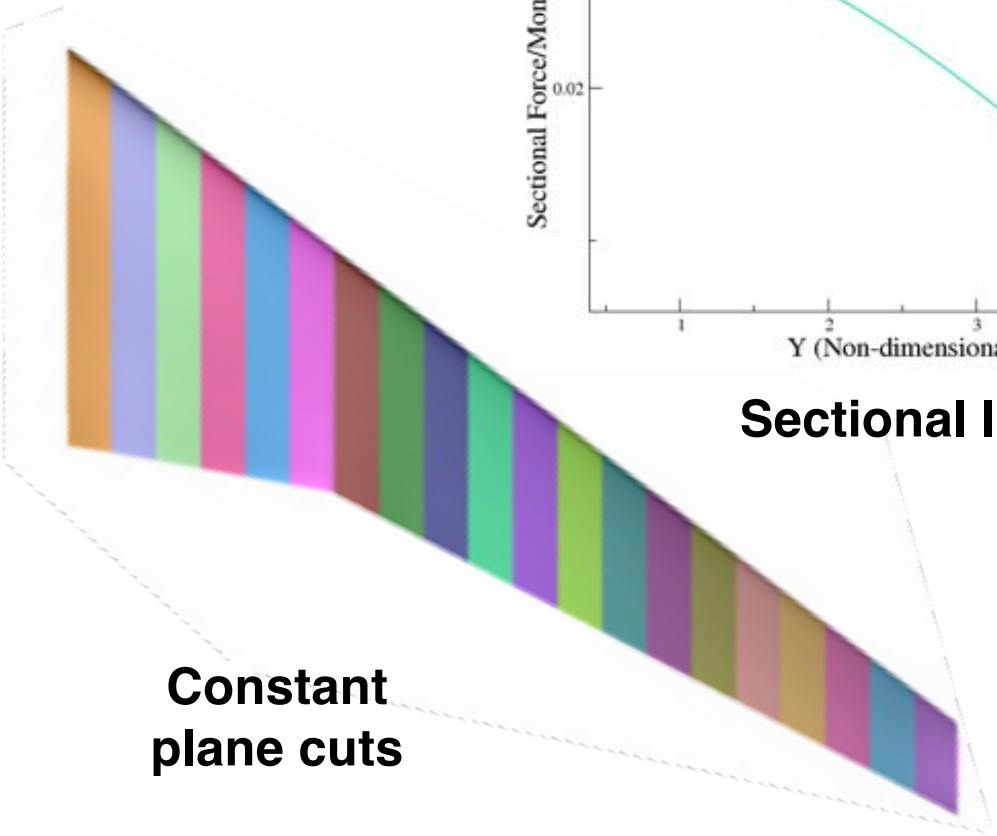
LINE LOADS COMPUTATION AND Cp CUTS IN TRILOAD (2)



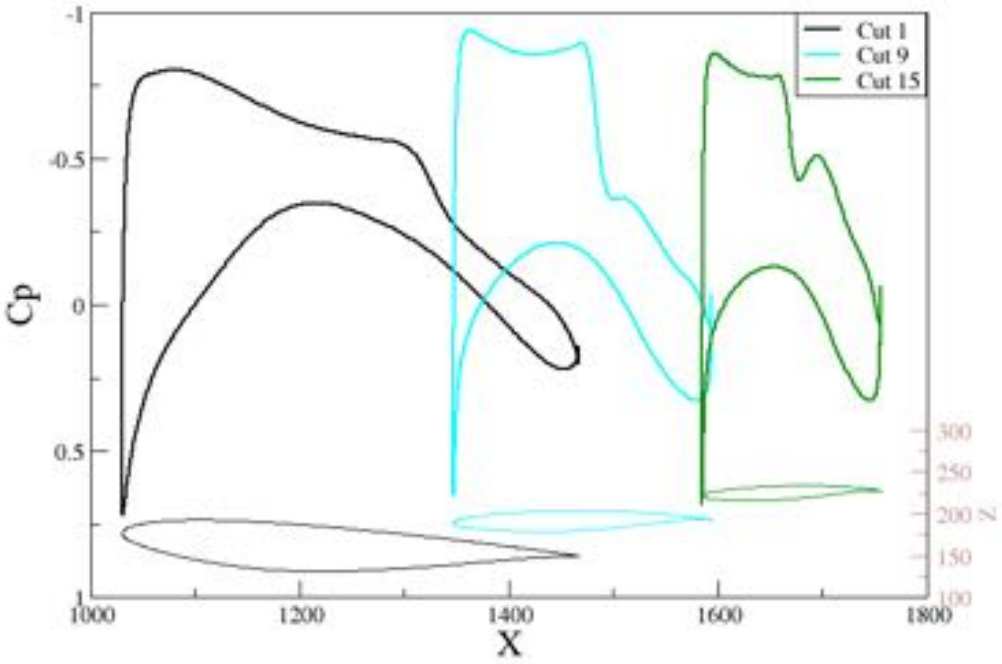
Sectional loads



Cumulative loads



Constant plane cuts



Cp on various cut planes

MISCELLANEOUS MODULES AND TUTORIALS

FORTRAN FILE I/O (FFIO) LIBRARY AND OVERCONVERT

Auto detection of type and attributes of files encountered in overset CFD analysis process using number and size of record markers

File types

- **PLOT3D grid, solution, and function**
- **OVERFLOW solution (one or two time levels)**
- **CART3D grid and solution files (.tri, .i.tri, .triq)**
- **X-ray map**
- **Interpolation stencil data (INTOUT/XINTOUT)**

File attributes

- **ASCII / unformatted single / unformatted double**
- **Big / little endian**
- **PLOT3D grid (single/multiple grid, with/without iblanks, 2D/3D)**
- **Solution (PLOT3D/OVERFLOW, with/without 2nd order restart)**

FORTRAN FILE I/O (FFIO) LIBRARY AND OVERCONVERT

Large grids

- Traditional Record marker limit=2^31 bytes sets maximum record size
- Depending on number of flow variables, grid size is limited
  - E.G. 8 double precision flow variables = nPts*8*8 < 2^31 => nPts ≈ 33M
- Sub-record markers supported in FFIO to allow for larger grids
- Auto-detection of sub-records and associated properties

Commonly used FFIO enabled CGT modules

- GRIDED, TRIGED, SRAP, SURGRD, HYPGEN, BOXGR, GEN_X, GRIDINF MINMAX, LSECT, COMBINEMX, COMBINEMQ, TRILOADCMV, QINFO

Use overConvert to report/check file type and attributes, and to convert between different attributes

OVERCONVERT SAMPLE OUTPUT

overConvert -i filename -v -h -s

```
unformatted file
Machine is Little Endian
File is Big Endian
74 records found in input file
Number of Grids in multiple grid file: 72
Double Precision, no IBlanks
Data is 3D

Grid 3: 15x27x59 (23.9K Points)
Grid 25: 17x41x54 (37.6K Points)
Grid 13: 35x19x59 (39.2K Points)
Grid 20: 17x43x54 (39.5K Points)
...
Grid 69: 289x159x117 (5.4M Points)
Grid 58: 386x153x98 (5.8M Points)
Grid 72: 381x181x115 (7.9M Points)
Grid 30: 215x538x97 (11.2M Points)

Total points in file: 72.92M
Total cells in file: 70.93M
```

MISCELLANEOUS NEW FEATURES FROM DIFFERENT MODULES

DIFFXQ – compute differences between two structured mesh files in
- **grid coordinates**
- **solution values**
- **iblank values (connectivity)**

TRIGED – triangulation editing tool
- **read .stl, .fro files (in addition to .tri, .triq, .ucd, .fst)**
- **report bounding box and edge length statistics**
- **fast search for duplicated vertices**
- **perturb vertices along local surface normal by specified distance**
- **compute differences between two .triq files (different nvert, ntri)**

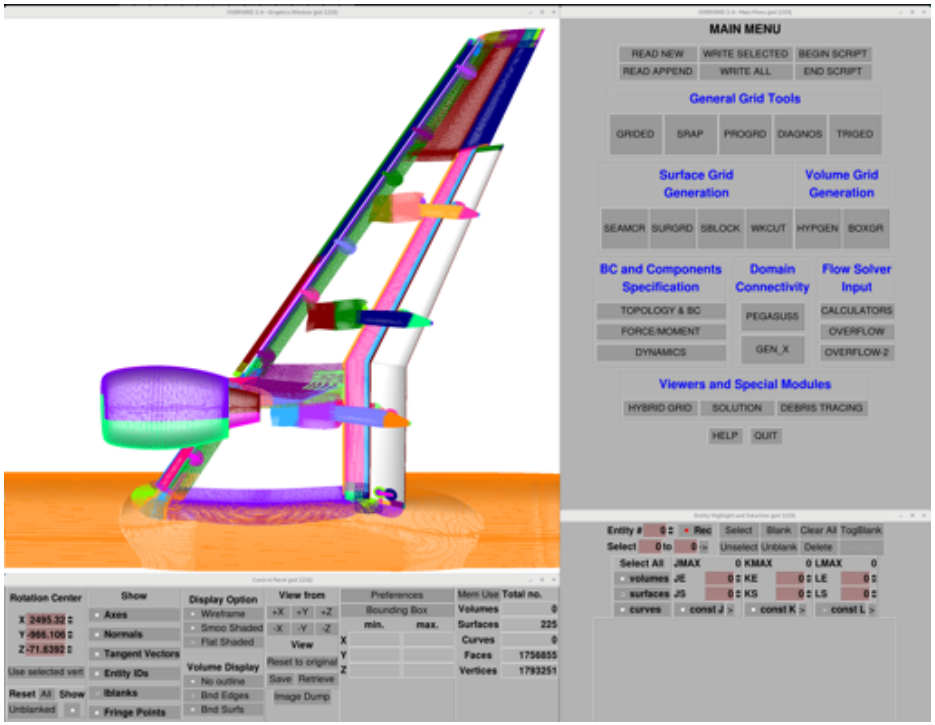
QINFO - solution file header info tool
- **report min/max of each Q**

QED – perform editing of solution files
- **swap J/K, K/L, J/L indices**
- **reverse J, K, K indices**
- **mirror velocity vector about x/y/z=0 plane**
- **rotate velocity vector**

TUTORIALS IN CGT 2.2: OVERGRID

- Under chimera2.2/tutorials/gui

- Updated for OVERGRID version 2.4



A detailed OVERGRID demo is available at:
The OVERGRID Graphical User Interface in Chimera Grid Tools (Parts 1, 2, 3)
http://www.nas.nasa.gov/publications/ams/2014/05-13-14.html
http://www.nas.nasa.gov/publications/ams/2014/05-20-14.html
http://www.nas.nasa.gov/publications/ams/2014/05-29-14.html

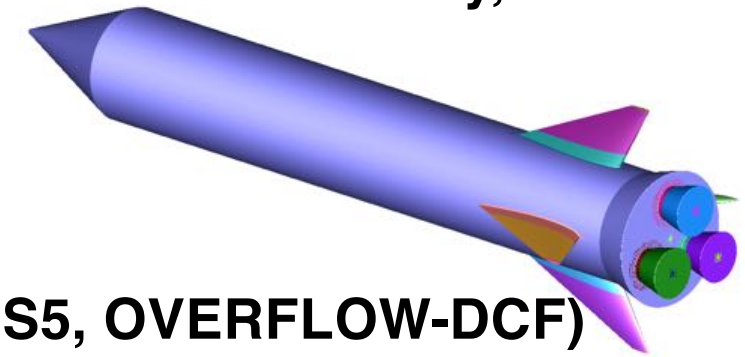
TUTORIALS IN CGT 2.2: SCRIPTING

- General Script Library procedures (chimera2.2/tutorials/scriptlib)

- Script development using the configuration (Build) scripts (chimera2.2/tutorials/scripts)

- James' rocket (JCLV) scripting example (chimera2.2/tutorials/jclv)

  - Complete process includes geometry creation, surface and volume mesh generation, input preparation for domain connectivity, flow solution, forces/moments computation



  - Grid-centric approach (Build scripts)
    - Each grid file contains 1 grid
    - Domain connectivity options (PEGASUS5, OVERFLOW-DCF)

  - Component-centric approach
    - Each grid file contains all grids for 1 component
    - Domain connectivity options (OVERFLOW-DCF, PEGASUS5, C3P)

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