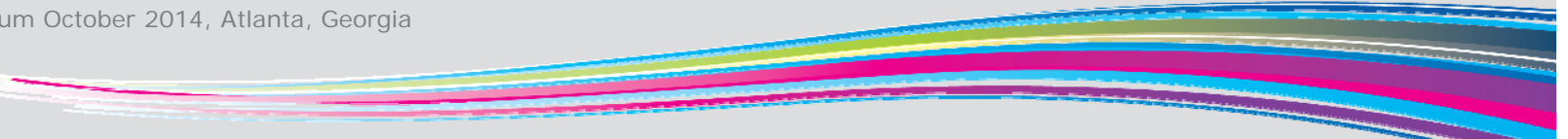


Integrated Overset Mesh Generation and Assembly with Pointwise

Nick Wyman
nwyman@pointwise.com

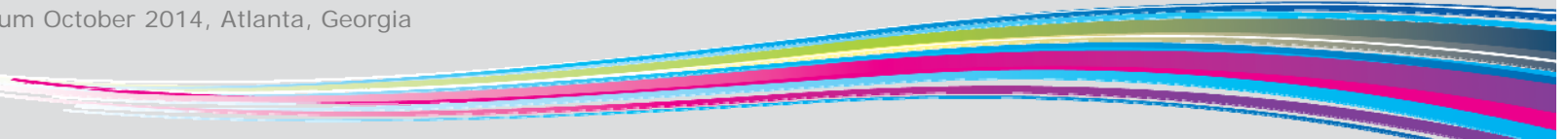
Overset Grid Symposium October 2014, Atlanta, Georgia



Overview

- Overset grid simulation popularity on the rise
- Mesh generation and assembly still a challenge
- Integration has several key advantages

Overset Grid Symposium October 2014, Atlanta, Georgia



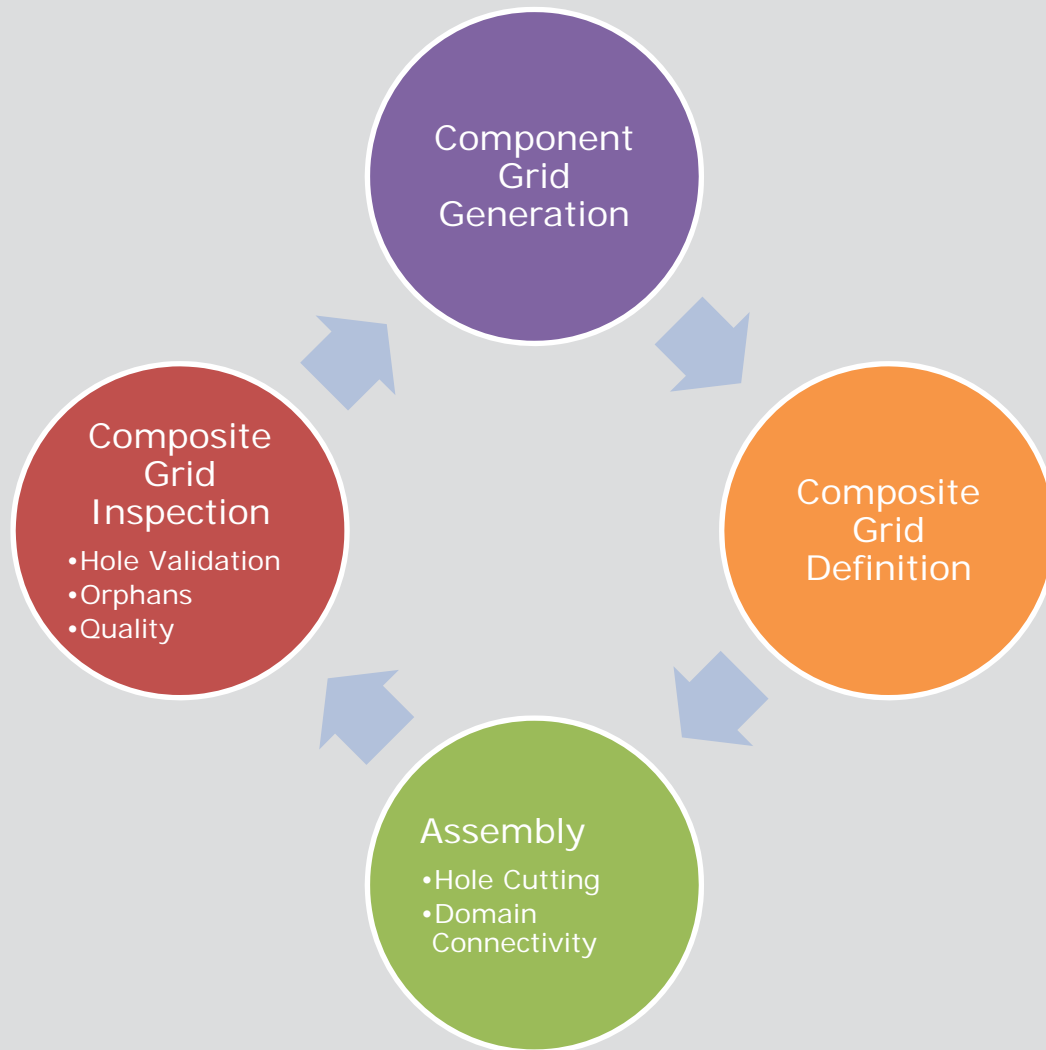
Overset on the Rise

- Government codes being improved/maintained
 - ARC3DC
 - CFL3D
 - DPLR
 - FUN3D
 - Kestrel
 - Neptune
 - OVERFLOW
 - OVERGRID
 - OVERTURE
 - PEGASUS5
 - SAMARC
 - SIERRA
 - TAU
 - USM3D
 - X-RAYS
- University codes being improved/maintained
 - Penn State ARL – NPHASE, UNCLE-M, UNCLE-REL, CFD-SHIP, UNCLE-TF
 - U of Iowa – CFDShip-Iowa
 - U of Wyoming – NSU3D, PUNDIT
- Commercial vendors now offering overset functionality
 - Celeritas Simulation Technology
 - SUGGAR++ Version 2.2
 - CD-adapco
 - Craft Tech
 - MetaComp Technologies
 - Cobalt Solutions
 - Tecplot
 - Intelligent Light



Overset Grid Symposium October 2014, Atlanta, Georgia

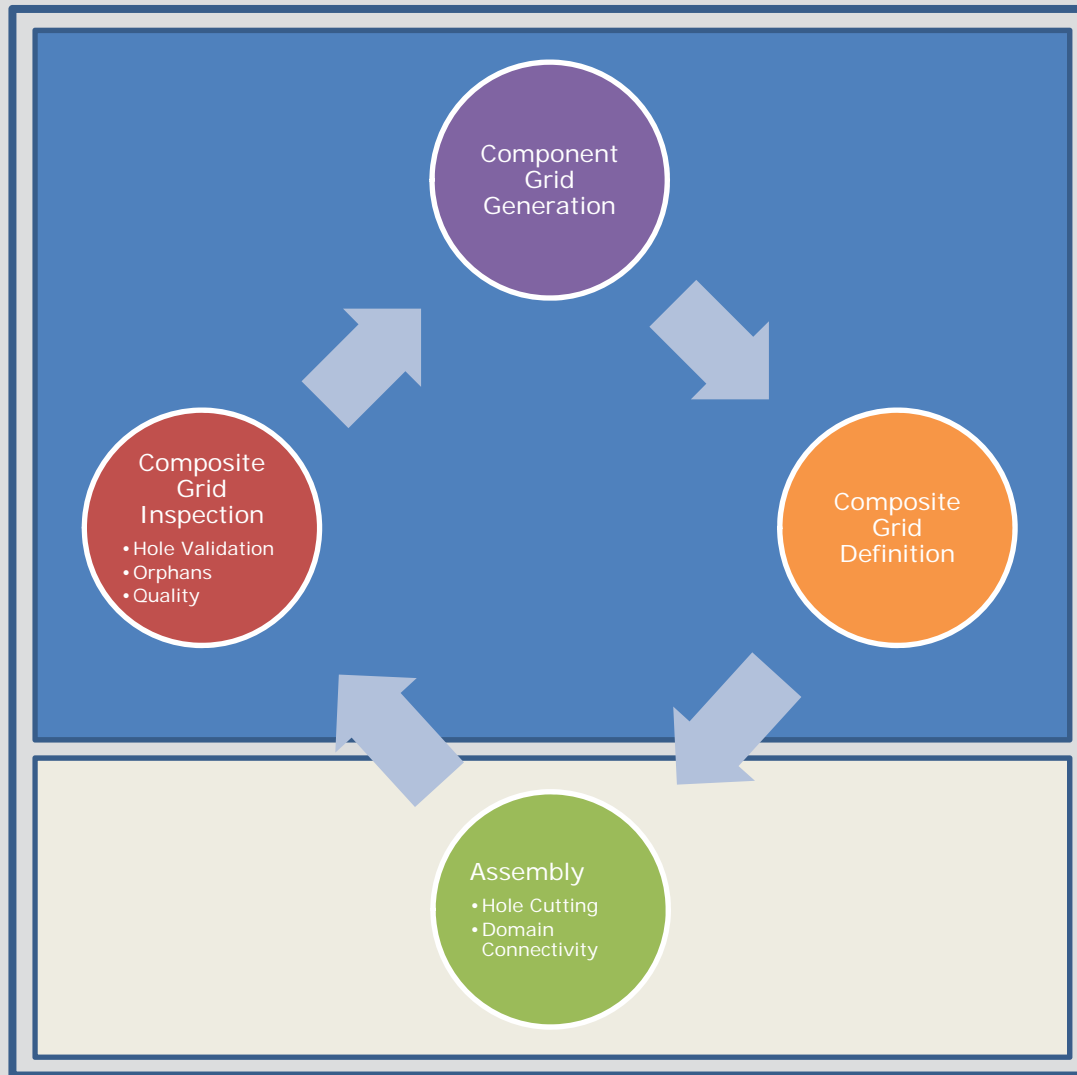
Workflow Issues



- 4 distinct phases
 - repeat until satisfactory composite grid system is generated
- 4+ distinct software tools
 - Data manipulation
 - Format translation
- Toolset changes with simulation technology

Overset Grid Symposium October 2014, Atlanta, Georgia

An Integrated Environment



Pointwise

- Component grids
- Composite definition
- Composite inspection

} Tight Coupling

Assembly Software

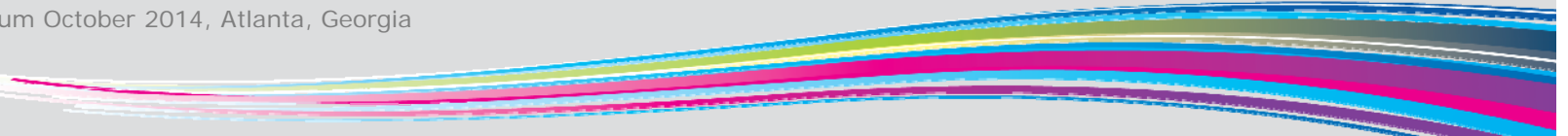
- Domain expertise
- Dynamic assembly

Overset Grid Symposium October 2014, Atlanta, Georgia

Overset Features

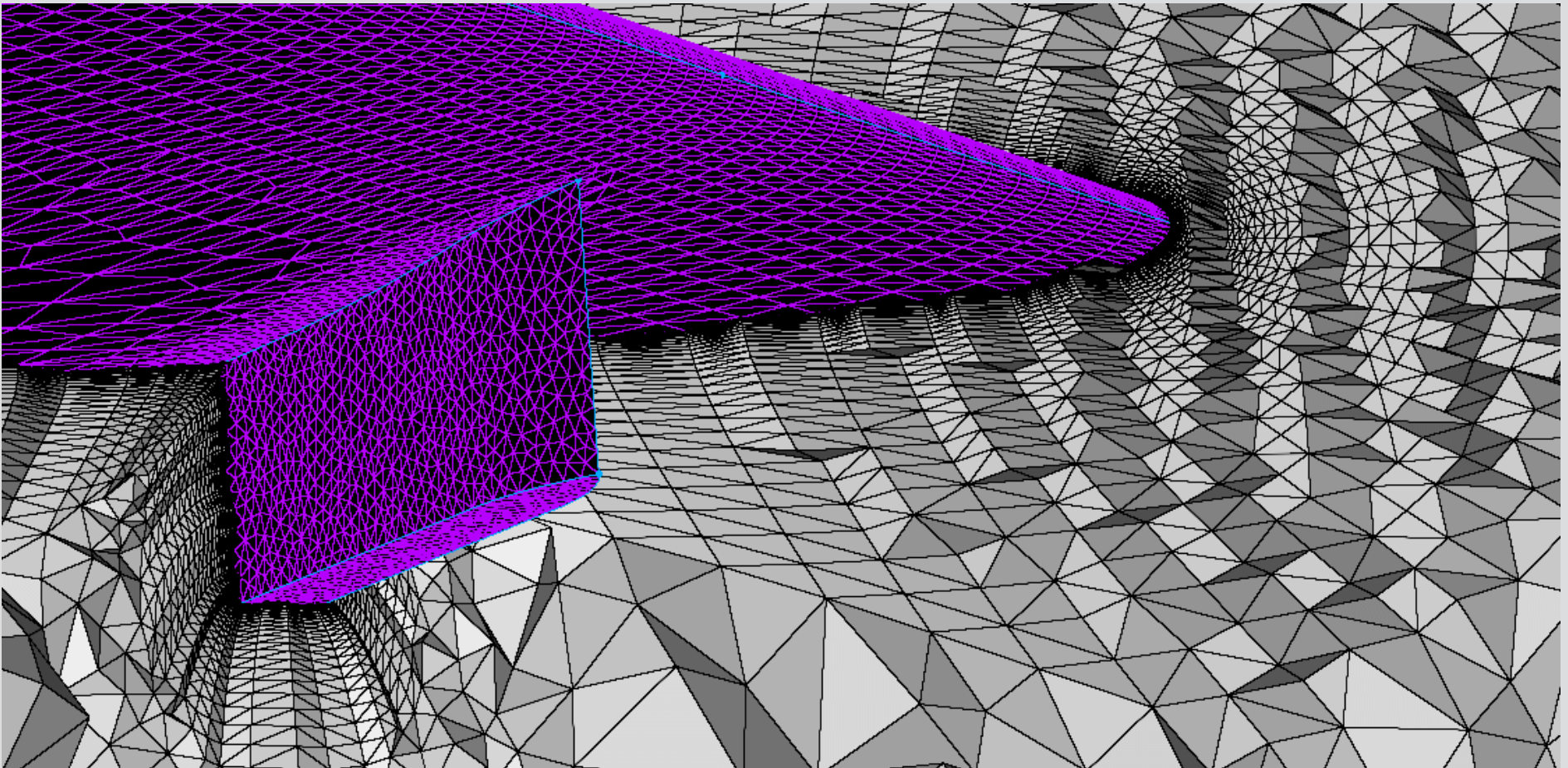
- Structured / Unstructured / Hybrid Grids
- Supported Assembly Software
 - PEGASUS version 5.2
 - Structured blocks
 - SUGGAR++ version 2.2
 - Str/Uns/Hybrid blocks
 - Native file support
 - Local and remote assembly
- Composite Grid Inspection
 - Import domain connectivity data
 - Display connectivity markers
 - Display derived data (fringe/donor volume ratio)

Overset Grid Symposium October 2014, Atlanta, Georgia



Component Grid Generation

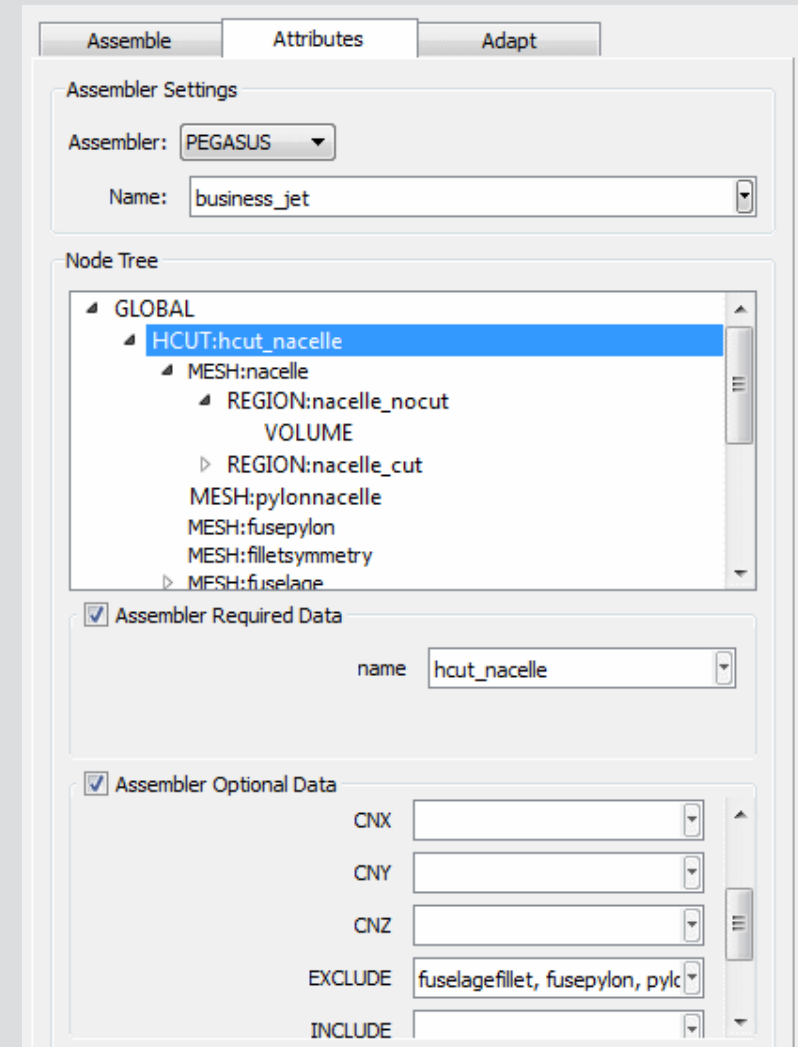
- Structured and Unstructured grid extrusion



Overset Grid Symposium October 2014, Atlanta, Georgia

Composite Grid Definition

- Present a unified interface
- 3rd party software input definition
 - XML DTD provides legal syntax
 - Parsed at run-time
 - Dynamic GUI
- Tree-based UI facilitates organization of complex configurations
 - Pointwise grid blocks assigned to appropriate nodes on the tree
 - Assembly boundary conditions applied using common UI



Overset Grid Symposium October 2014, Atlanta, Georgia

Composite Grid Definition

Assemble Attributes Adapt

Assembler Settings

Assembler: **PEGASUS**

Name: **business_jet**

Node Tree

- GLOBAL
 - HCUT:hcut_nacelle**
 - MESH:nacelle
 - REGION:nacelle_nocut
 - VOLUME
 - REGION:nacelle_cut
 - MESH:pylonnacelle
 - MESH:fusepylon
 - MESH:filletsymmetry
 - MESH:fuselage

☒ Assembler Required Data

name: **hcut_nacelle**

☒ Assembler Optional Data

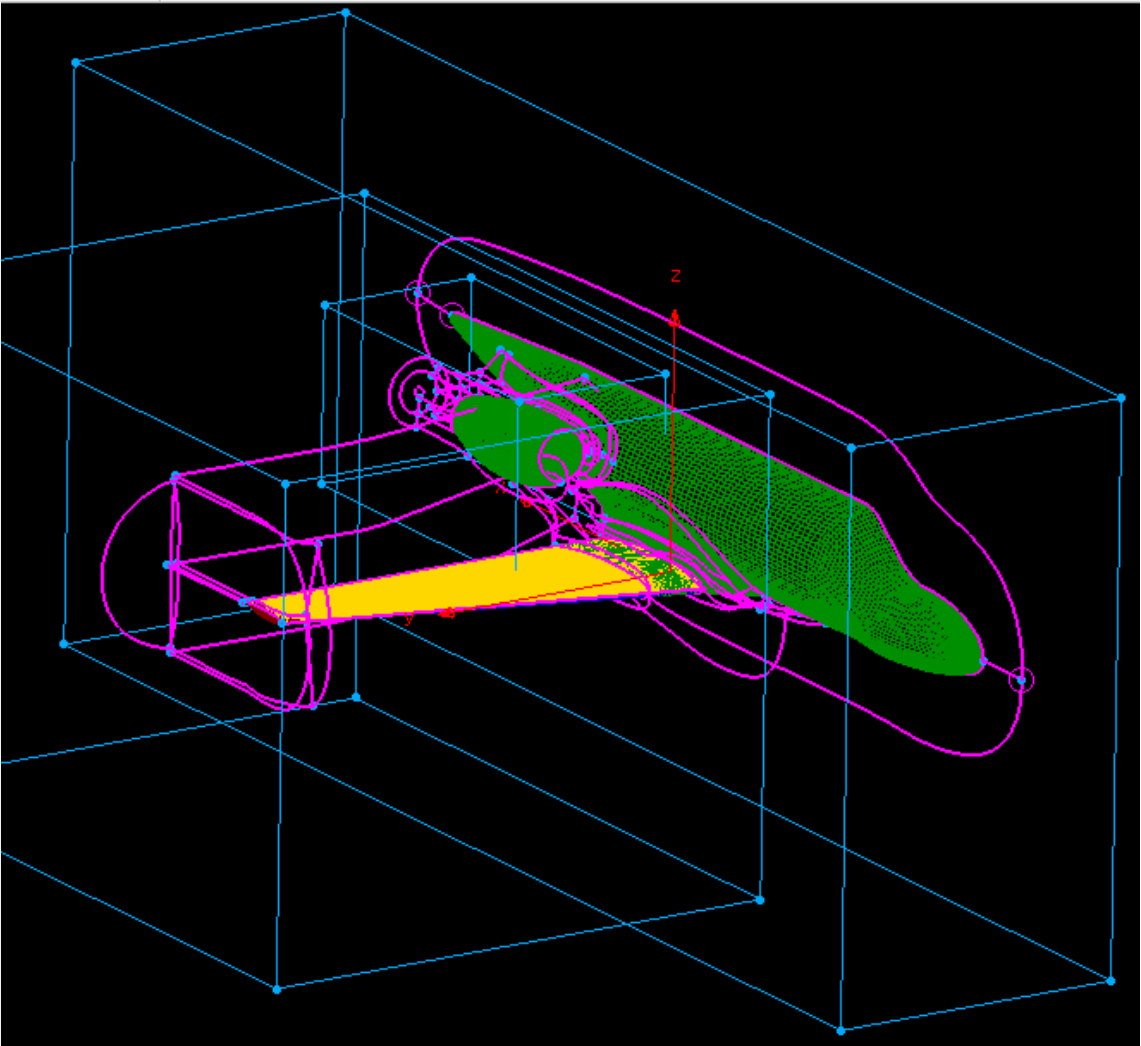
CNX:

CNY:

CNZ:

EXCLUDE: **fuselagefillet, fusepylon, pylc**

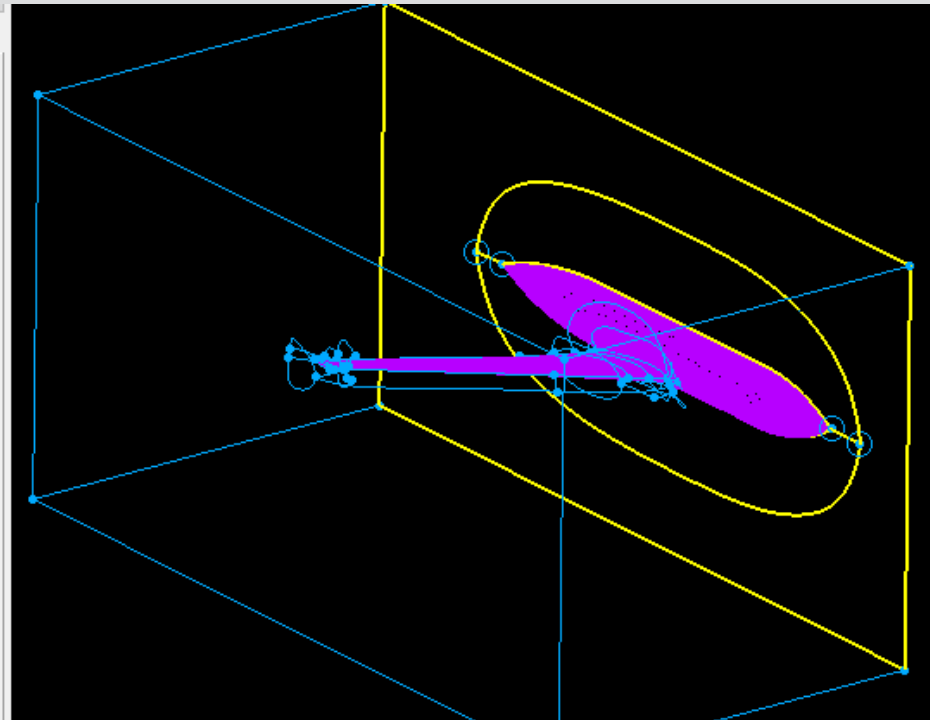
INCLUDE:



Overset Grid Symposium October 2014, Atlanta, Georgia

Composite Grid Definition

List	Layers	Defaults	Set BC	
Set	#	Name	CAE Type	Overset Type
<input type="checkbox"/>	8	Connection	Connection	Connection
<input checked="" type="checkbox"/>	22	Unspecified	Unspecified	Unspecified
<input checked="" type="checkbox"/>	13	wall	Vis Ad Wall (P extrp)	Vis Ad Wall (P extrp)
<input checked="" type="checkbox"/>	3	Symmetry	Symmetry in Y	Symmetry in Y
<input checked="" type="checkbox"/>	2	axis	Axis (J around)	Axis (J around)
<input checked="" type="checkbox"/>	5	Farfield	Characteristic	Impose Freestream



Overset Grid Symposium October 2014, Atlanta, Georgia

Grid Assembly

- Performed within Pointwise
- Parse Definition Tree
 - Export grids in req'd format
 - Export input file
- Local or Remote Assembly
 - Automatic file management
- Composite Data Import
- Domain Connectivity Statistics
 - Marked out-of-date on grid modification

Assemble	Attributes	Adapt
----------	------------	-------

Assembler Statistics

Name	Fringe	Hole	Orphan	Up to Date
outerbox	869	1175	0	Yes
fusebox	23425	15039	0	No
wingbox	20616	2977	0	Yes
fuselage	13056	24053	0	No
wing	39826	76834	0	No
wingcap	20251	0	0	Yes
fuselagefillet	8829	0	0	Yes
wingfillet	30711	0	0	Yes
filletsymmetry	3717	0	0	Yes
nacellebox	42403	58310	0	No
nacelle	27277	16536	0	Yes
pylonnacelle	22735	0	0	Yes
fusepylon	22214	0	1	Yes

Show

☐ Fringe ☐ Hole ☐ Orphan

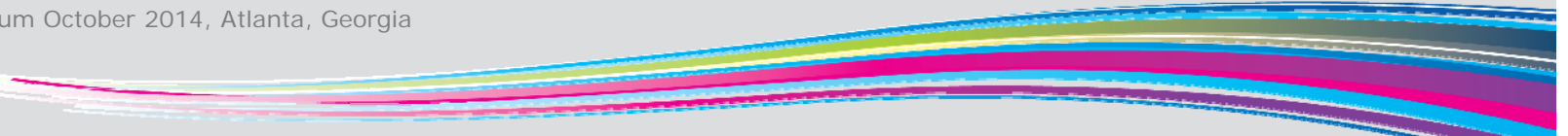
Release Assembly Data

Show Assembly Report

Overset Grid Symposium October 2014, Atlanta, Georgia

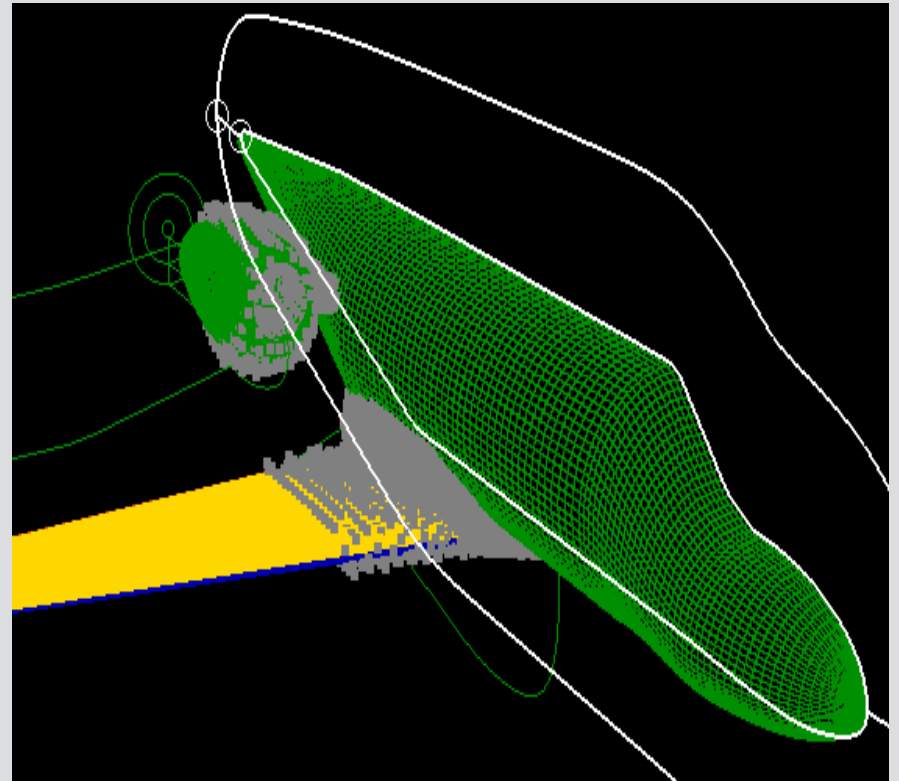
Domain Connectivity

- Assembler writes composite mesh and connectivity info
 - **FRINGE** = location (pt or cell) on block boundary (can be internal) which is not solved, but rather receives interpolated values from another mesh after each time step
 - **DONOR** = cell in foreign block which encapsulates fringe pt (or cell ctr) and is a suitable match for providing data to the fringe
 - **DONOR CANDIDATE** = cell in foreign block which encapsulates fringe. A quality metric is calculated for each fringe-donorCand pair
 - **ORPHAN** = fringe location in block which does not have a suitable donor. This must be remedied by mesh improvement, assembler input change, or flow solver
 - **HOLE** = location in block which is not solved due to being outside the flow domain
- Pointwise imports
 - Fringe, hole, orphan, donor, donor cands as “overset objects”
 - Rendered as colored markers
 - Stored with cached grid data (XYZ, volume)
 - IBLANK array
 - Used in Examine cut planes to skip rendering of cells marked as HOLE
 - Stored with the block
 - Marked “Out of Date” when block is modified



Composite Grid Inspection

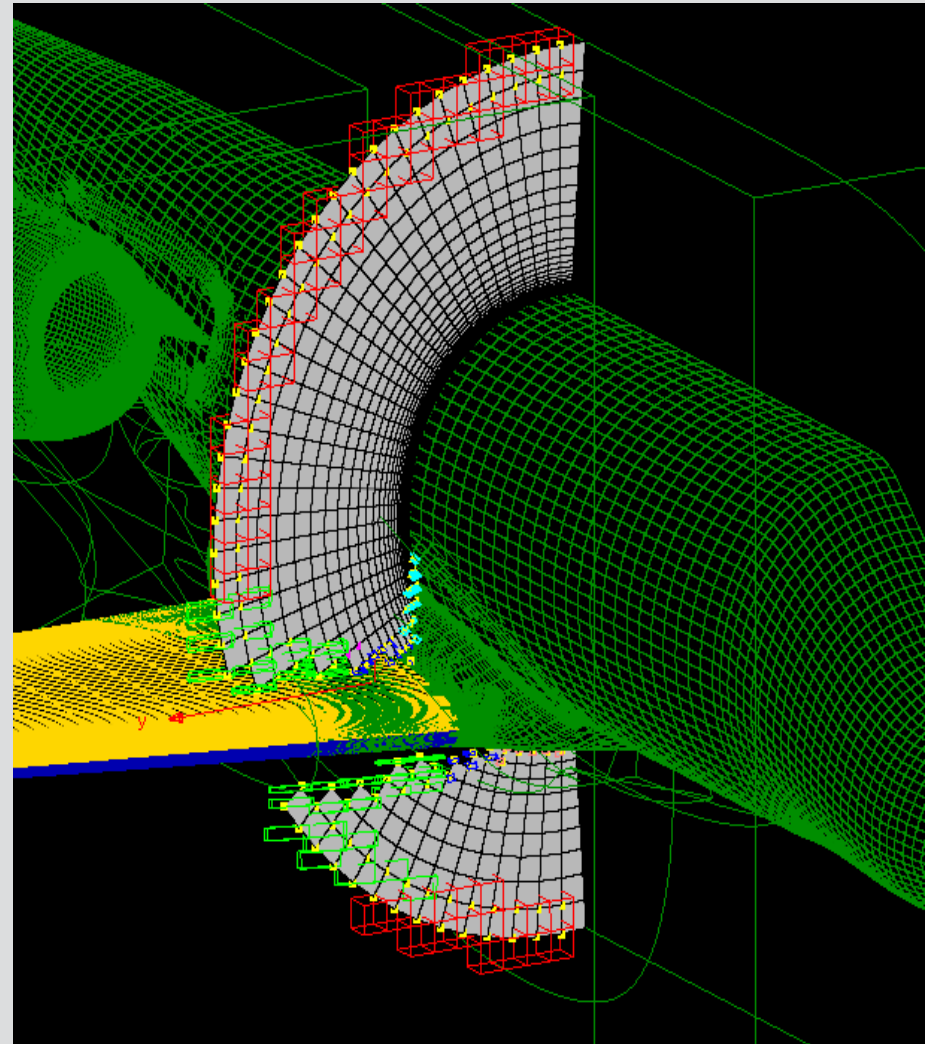
- Fringe / Hole / Orphan markers
- Cached data
- Remain visible during/after grid modification



Overset Grid Symposium October 2014, Atlanta, Georgia

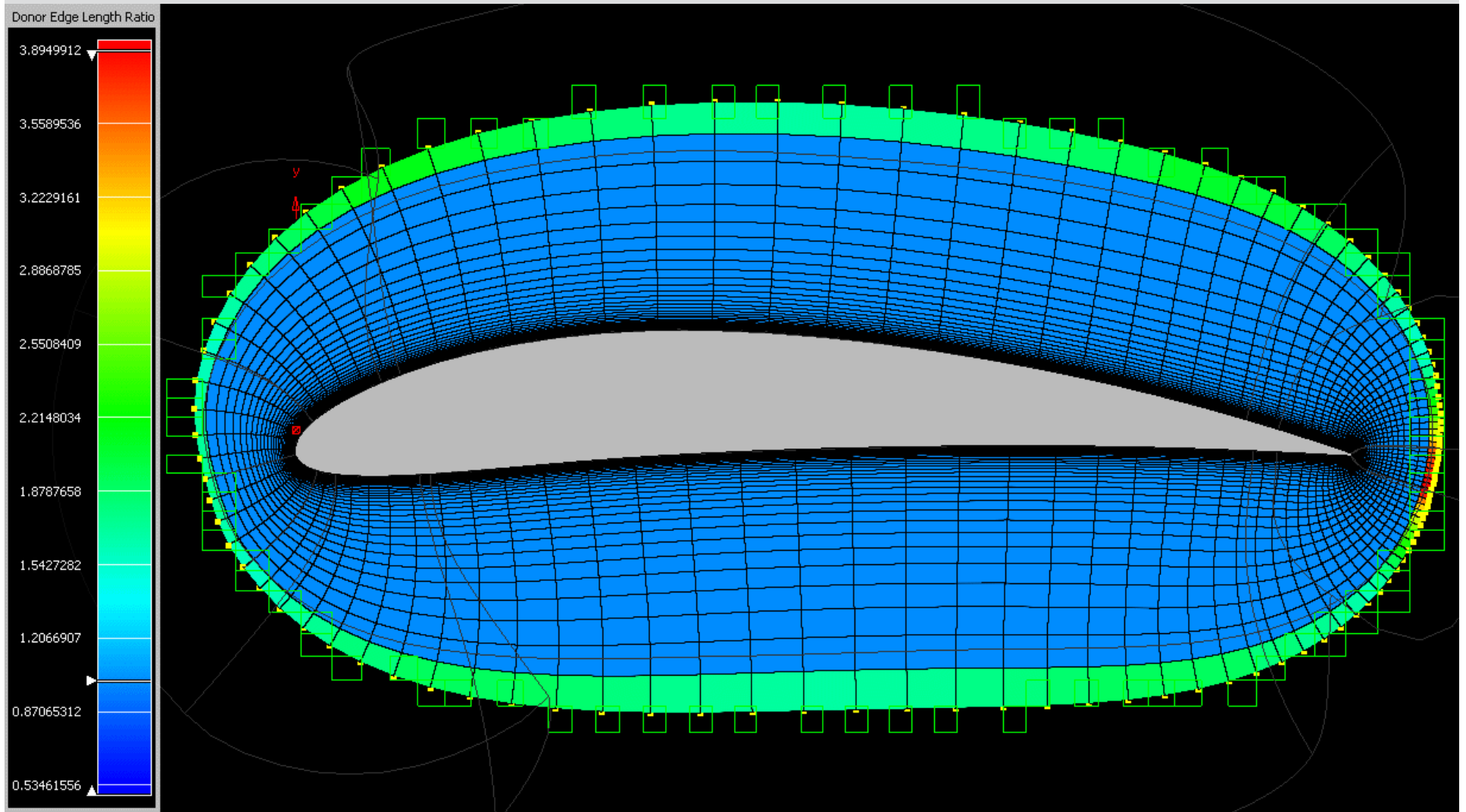
Composite Grid Inspection

- Grid Examine for detailed inspection
- Cut planes blanked by IBLANK
- Fringe donor cells
- Orphan donor candidate cells
- Fringe/Donor edge length and volume ratio



Overset Grid Symposium October 2014, Atlanta, Georgia

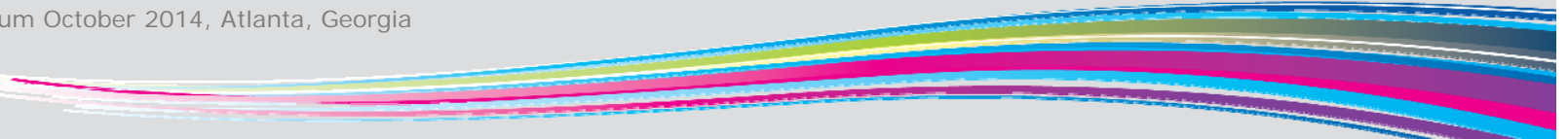
Composite Grid Inspection



Overset Grid Symposium October 2014, Atlanta, Georgia

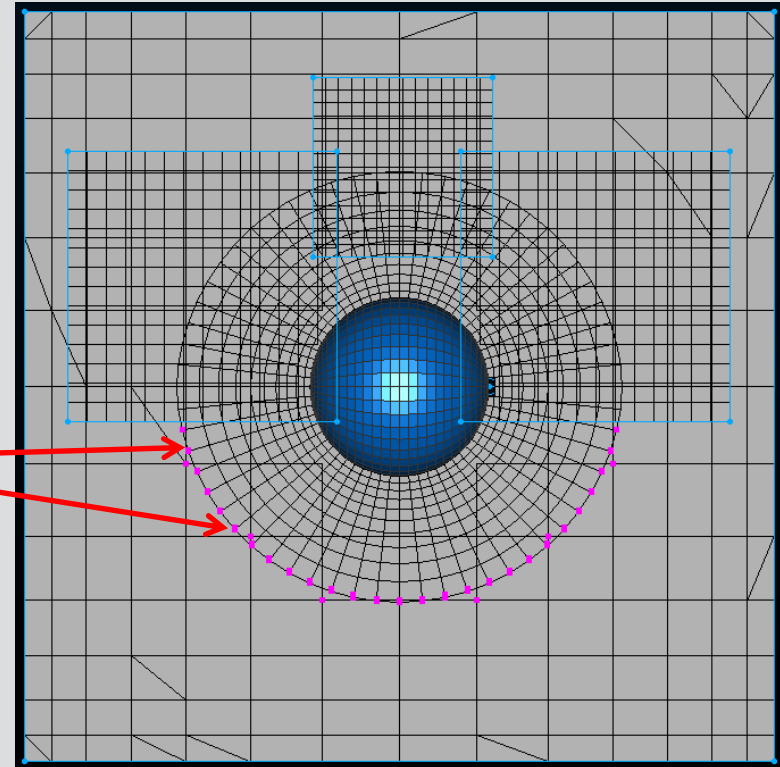
Domain Connectivity Improvement

Overset Grid Symposium October 2014, Atlanta, Georgia



Problem Statement

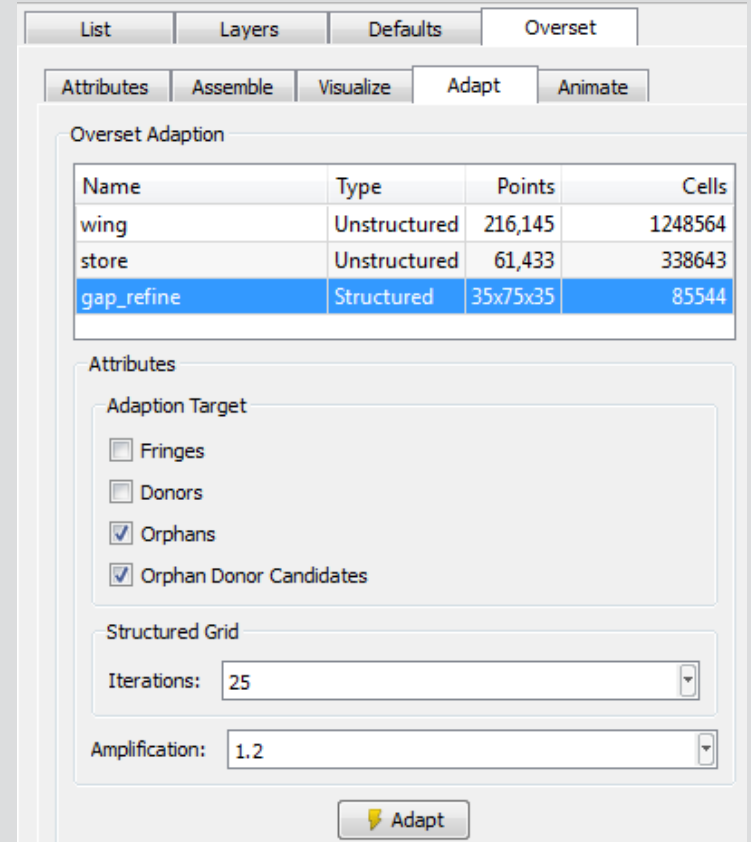
- Interpolation Errors in Overset Meshes
 - Large differences in size between donor and fringe cells reduce connection quality or produce **orphan points** - fringe points without a valid donor
 - Orphan points significantly impede solution accuracy and convergence



Overset Grid Symposium October 2014, Atlanta, Georgia

Orphan Remediation

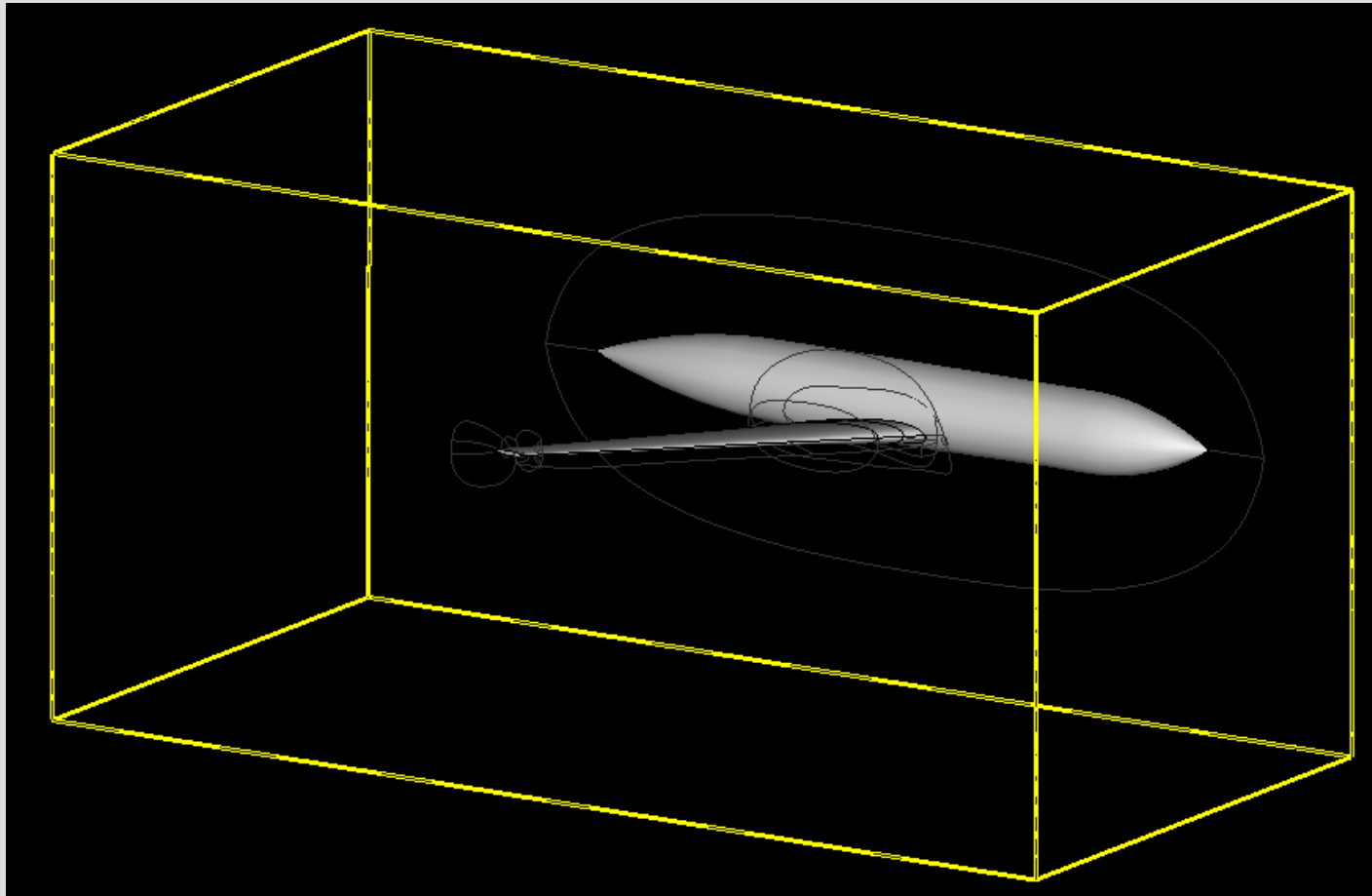
- Adapt grid to local interpolation length scale
 - Structured Grid
 - Parametric elliptic smoothing technique
 - Constant mesh dimensions
 - Unstructured Grid
 - Local point insertion
- Use composite grid assembly data
 - Orphan donor candidate cell as source location
 - Foreign mesh orphan provides target length scale
 - Amplification allows user control
- Repeat composite grid assembly



Overset Grid Symposium October 2014, Atlanta, Georgia

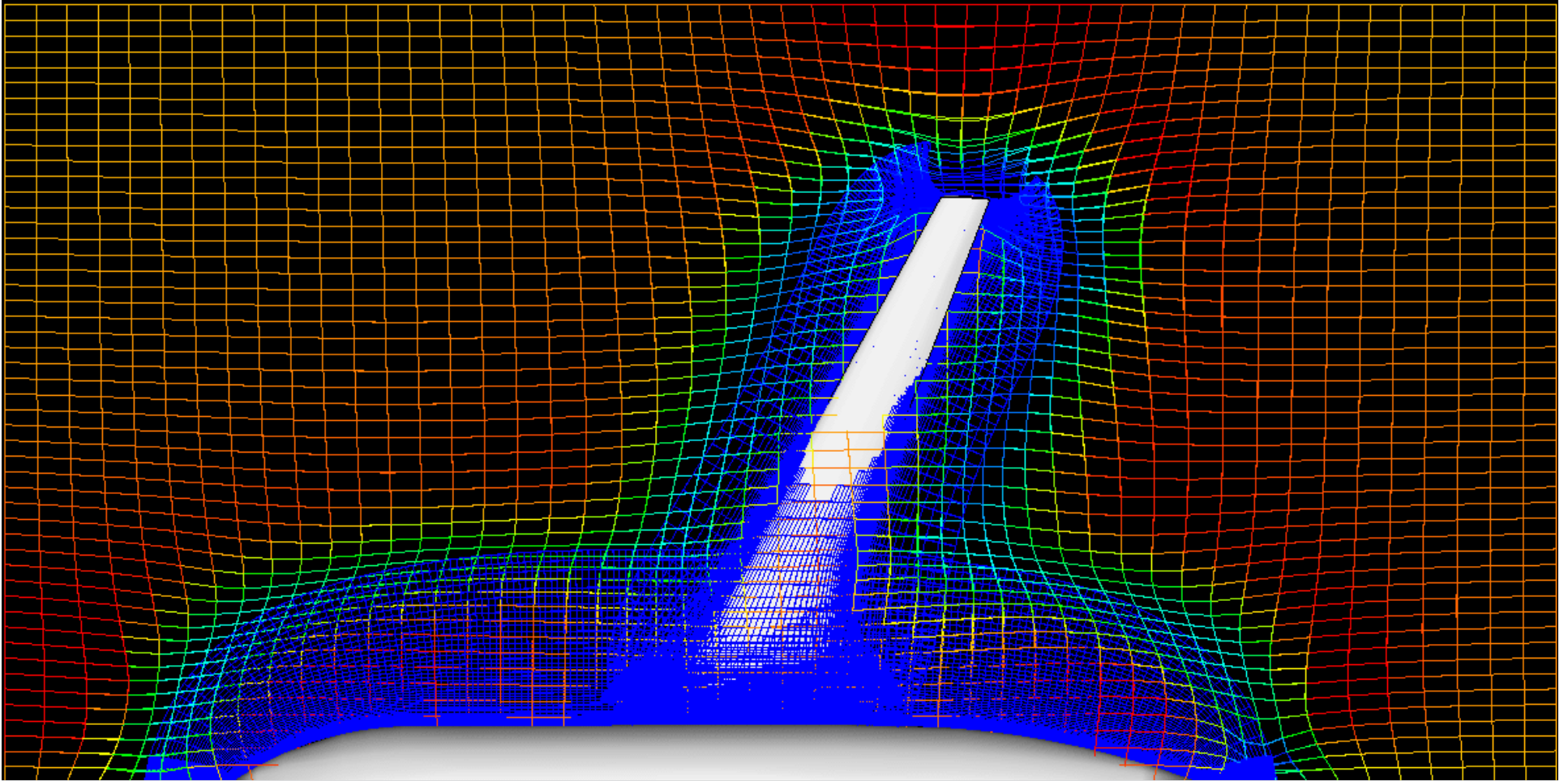
Structured Mesh Example

- Wing-Body composite grid
- Adapt inviscid block donors to fringe length scale



Overset Grid Symposium October 2014, Atlanta, Georgia

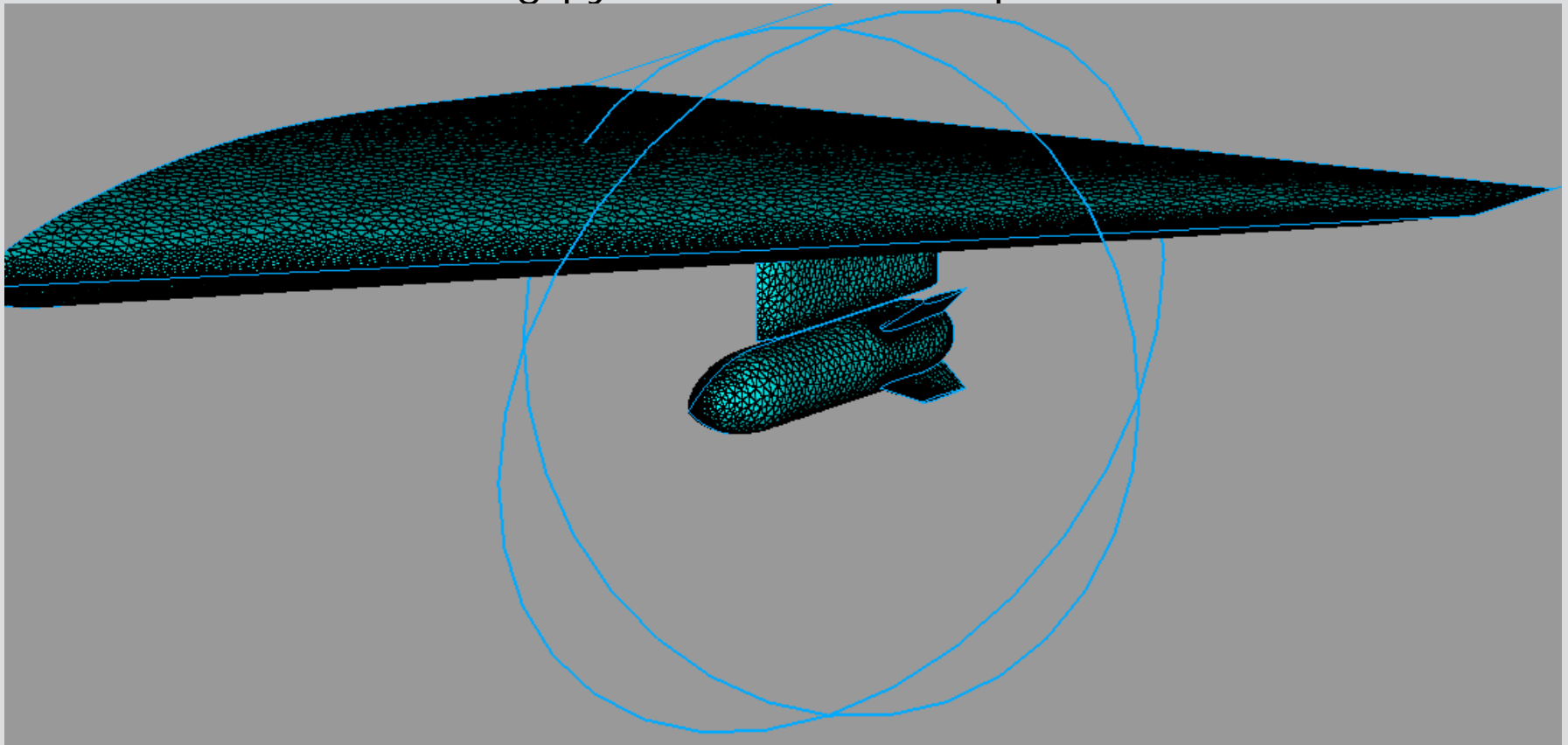
Structured Mesh Example



Overset Grid Symposium October 2014, Atlanta, Georgia

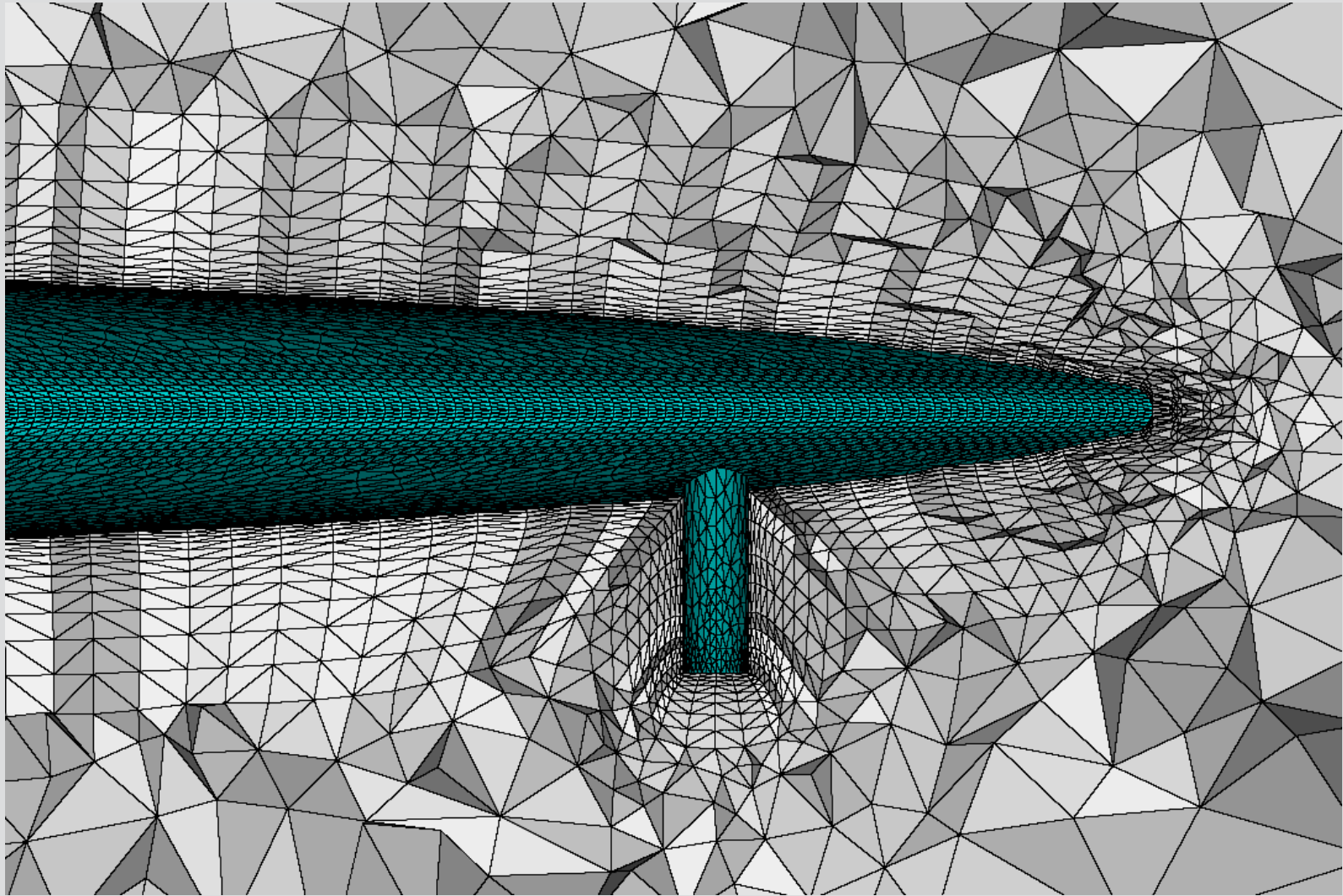
Hybrid Mesh Example

- Generic wing-pylon-store
 - Anisotropic unstructured viscous T-Rex mesh created in isolation for wing-pylon and store components

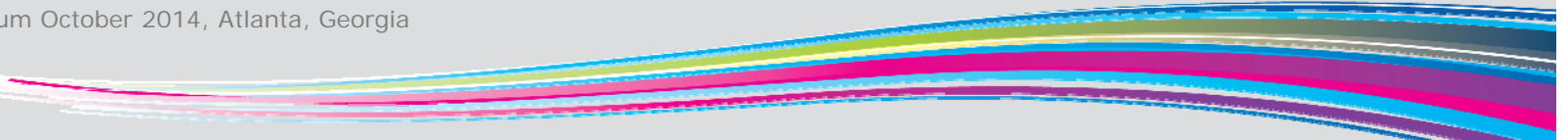


Overset Grid Symposium October 2014, Atlanta, Georgia

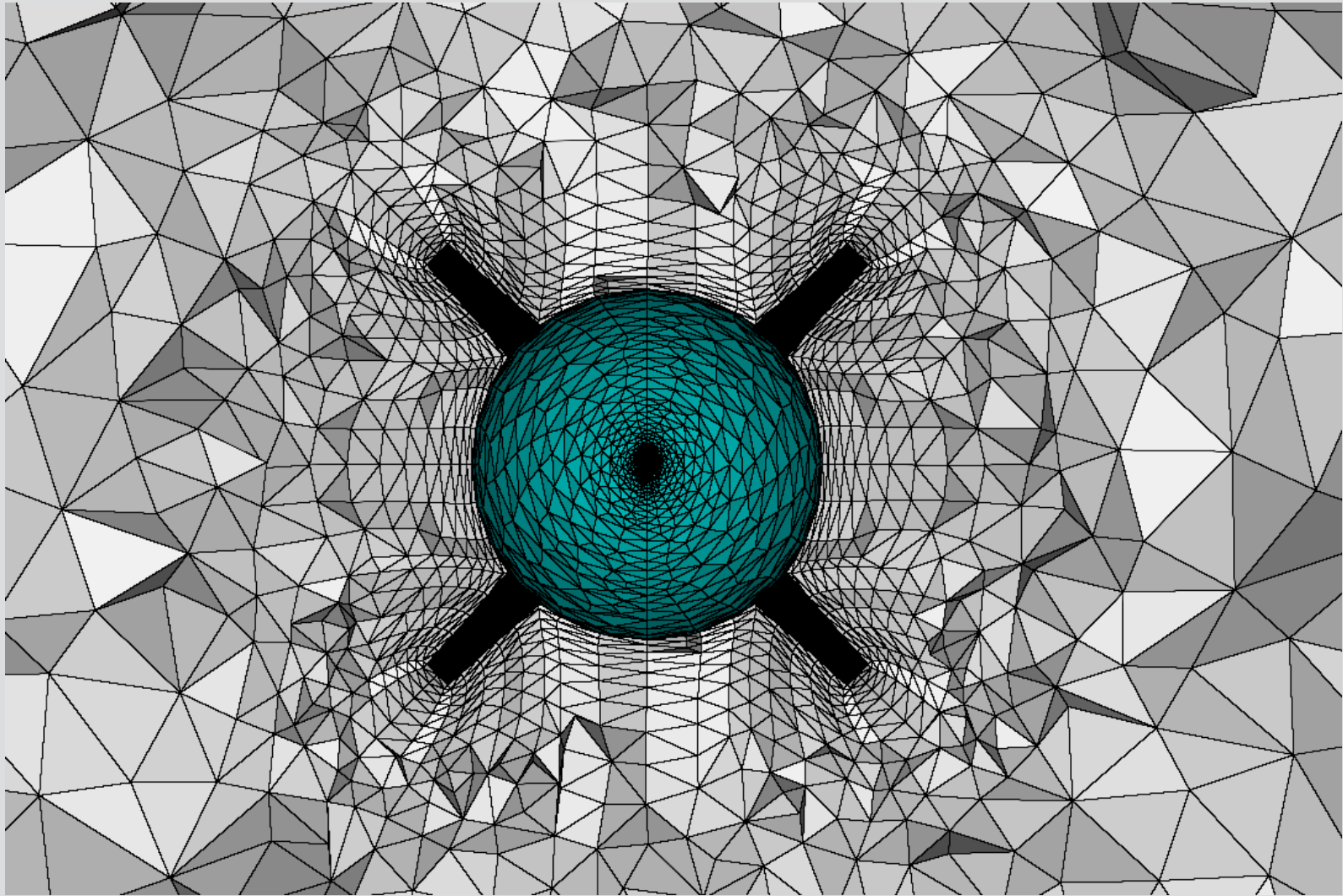
Wing-Pylon Mesh



Overset Grid Symposium October 2014, Atlanta, Georgia



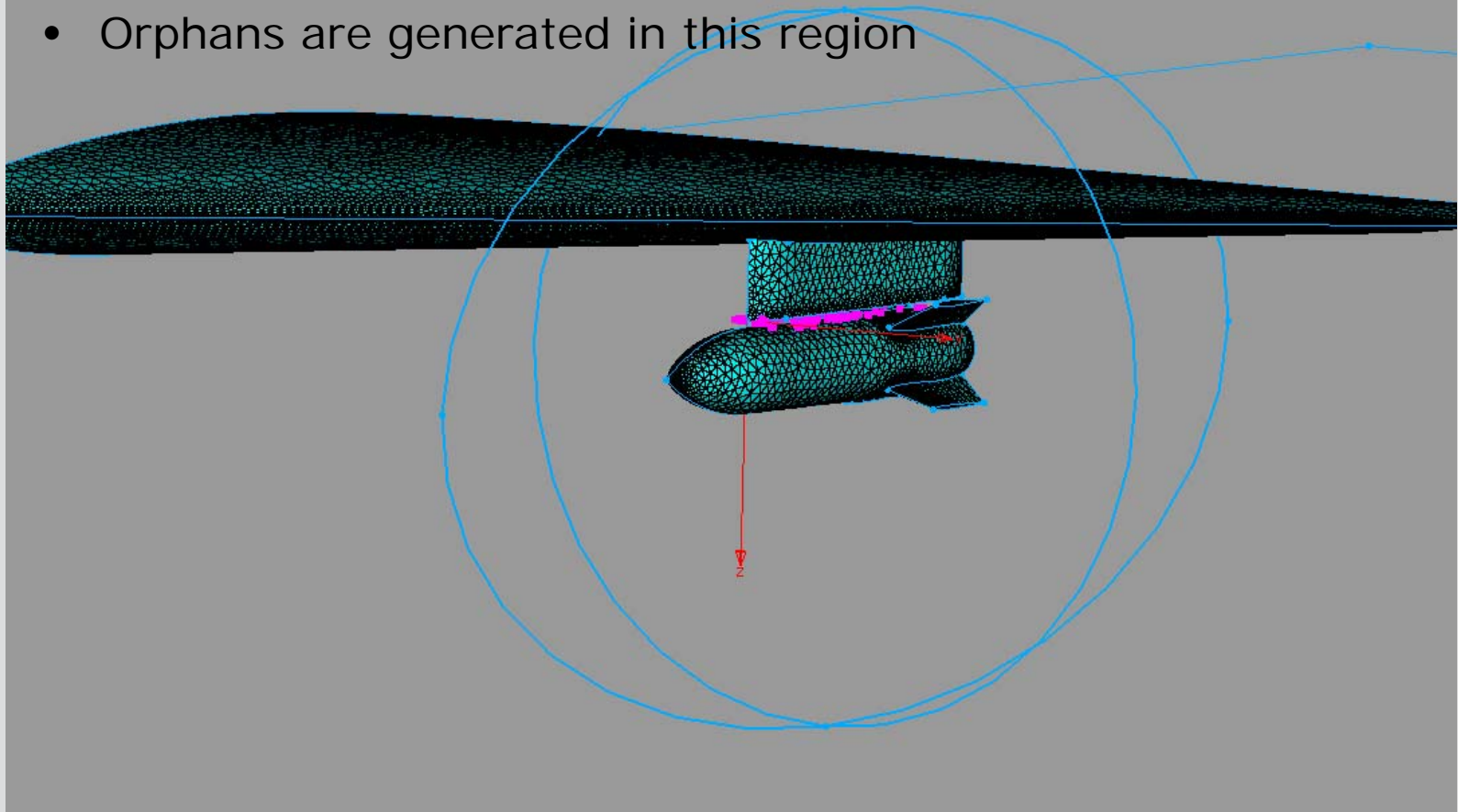
Store Mesh



Overset Grid Symposium October 2014, Atlanta, Georgia

Composite Mesh

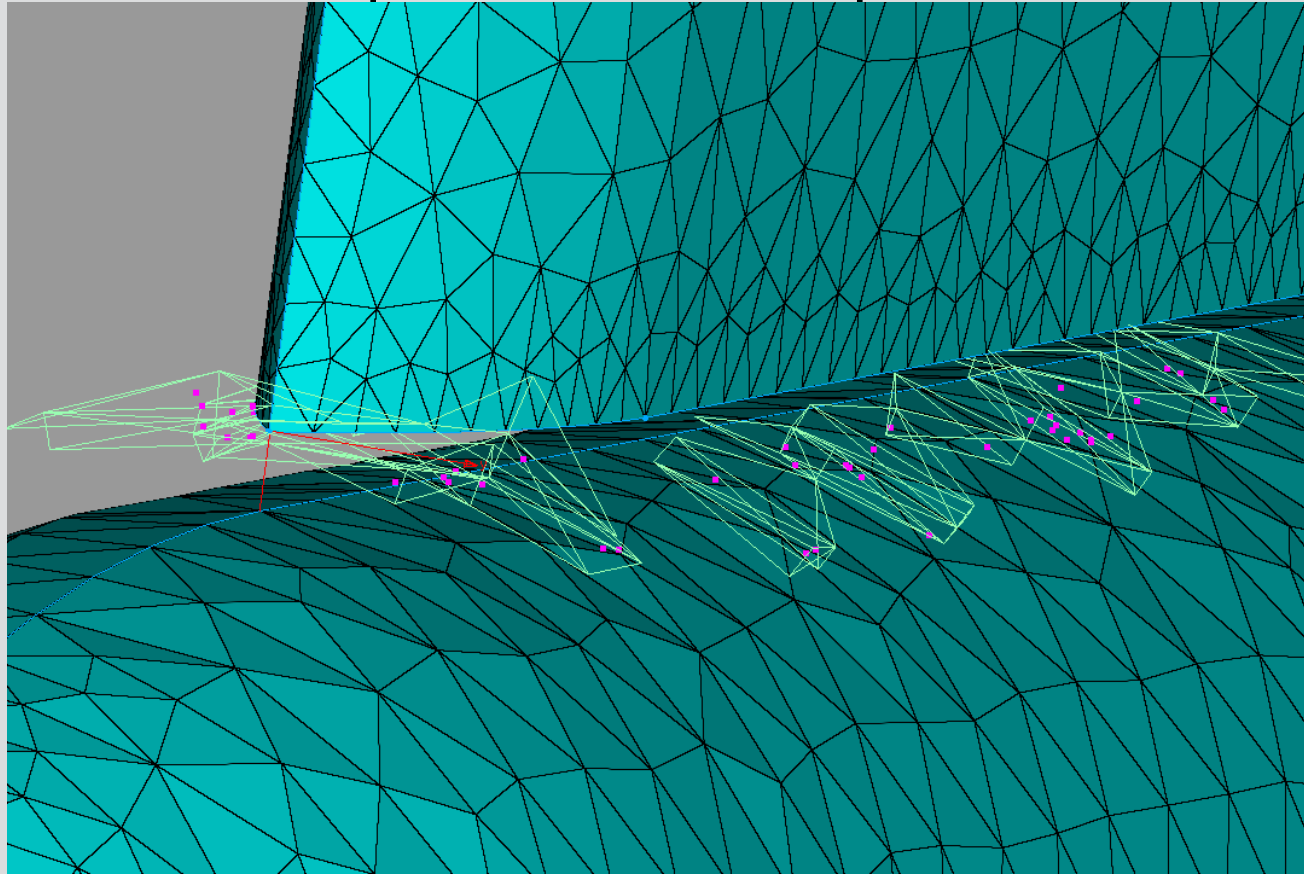
- Pylon-Store gap insufficiently resolved by component meshes
 - Orphans are generated in this region



Overset Grid Symposium October 2014, Atlanta, Georgia

Pylon-Store Gap Orphans

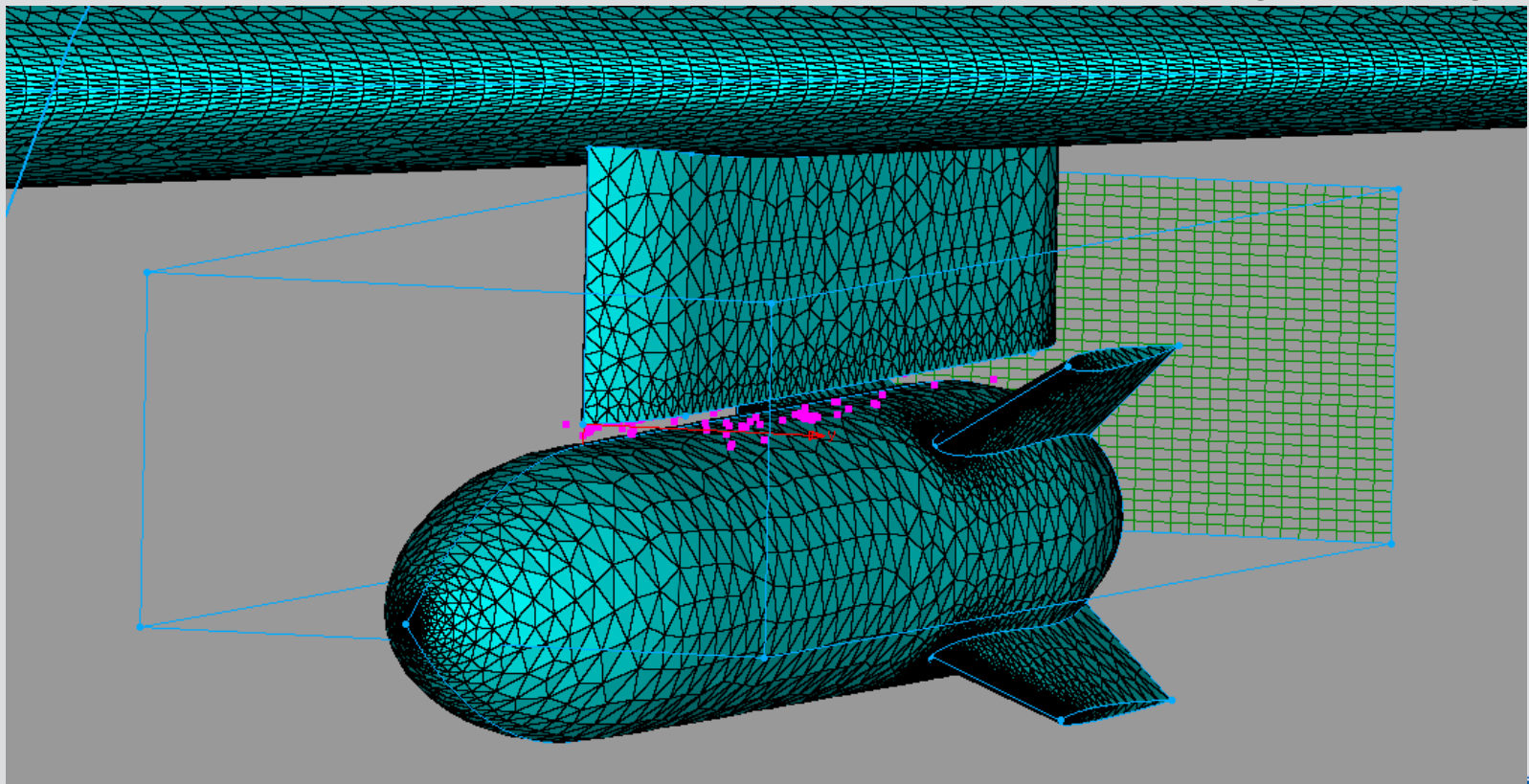
- Orphan donor candidates are anisotropic cells ill-suited for interpolation or adaption



Overset Grid Symposium October 2014, Atlanta, Georgia

Orphan Remediation

- Addition of uniform Cartesian mesh in gap region only moderately successful at eliminating orphans
- 5X further refinement needed – but only locally



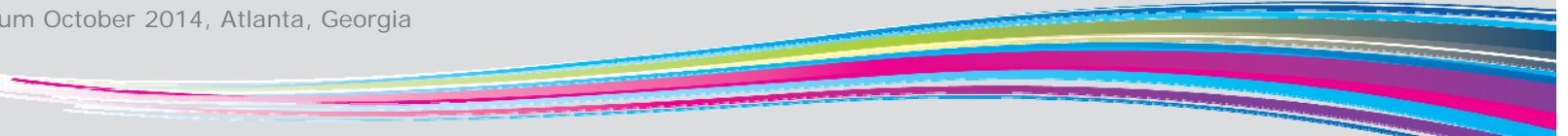
Overset Grid Symposium October 2014, Atlanta, Georgia

Orphan Remediation

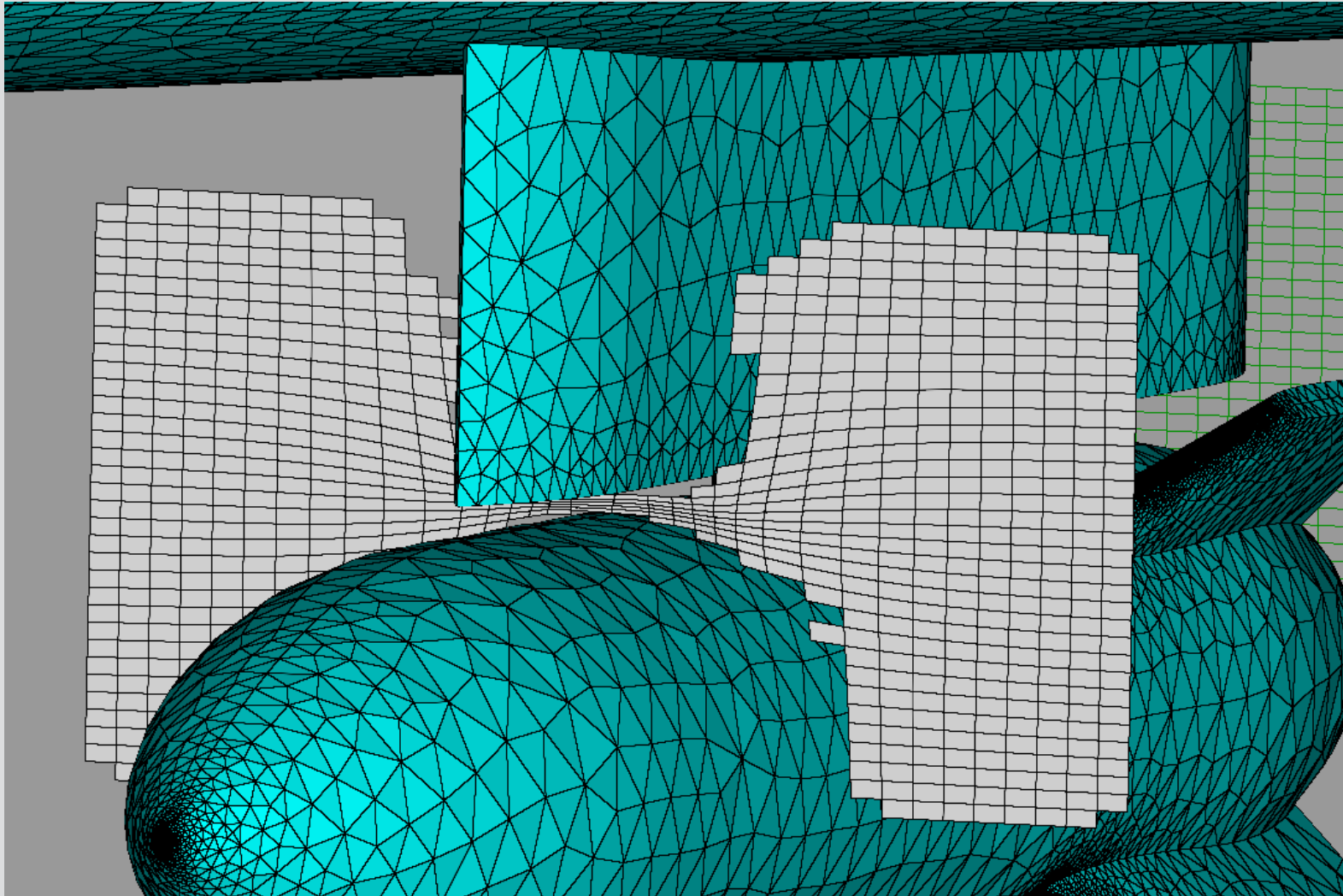
- Initial adapt-assembly cycle rarely successful in removing all orphans
 - Often produces orphans in new locations
- Repeat adapt-assemble cycle to resolve interpolation locations
- Too many cycles can be unstable

Adapt-Assemble Iteration	Composite Mesh Orphans	Orphan Reduction
Baseline	146	
0	106	27%
1	13	91%
2	8	95%
3	1	99%
4	1	99%

Overset Grid Symposium October 2014, Atlanta, Georgia



Final Remediation Mesh



Overset Grid Symposium October 2014, Atlanta, Georgia

Conclusion

- Overset Assembly successfully integrated with Pointwise mesh generation software
 - Improved workflow
 - Common UI
 - Consistent toolset
 - Automated domain connectivity improvement
- Available in Version 17.3

Overset Grid Symposium October 2014, Atlanta, Georgia

