Grid Guidelines and Overview

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Cessna Aircraft Company

Medium Density Mesh Characteristics

- Wing
  - Leading edge DS ~ 0.1% chord
  - TE base defined by 8 cells
  - Spanwise spacing at root ~1.0% semispan
  - Spanwise spacing at tip ~0.1% semispan
- Farfield located ~ 100 C_{REF} for all grid levels
- Viscous wall normal spacing
  - y+ = 1.0
  - Stretching ratio <= 1.25
- Fuselage
  - Cell size near nose and after-body ~2.0% C_{REF}
- Reference
  - Vassberg, DeHaan, Sclafani, "Grid Generation Requirements for Accurate Drag Predictions Based on OVERFLOW Calculations", AIAA 2003-4124

Suggested Grid Sizes

- WB 1.3M 4.0M 12.0M nodes
- WBNP 2.0M 6.0M 18.0M nodes

Supplied Meshes

- Unstructured
  - ICEM
  - NASA Langley/VGRID (5)
  - DLR/CENTAUR (2)
  - SWANSEA (1)
- Structured
  - ICEM (8)
  - Boeing/Seattle (2)
- Overset
  - Boeing/Long Beach (2)

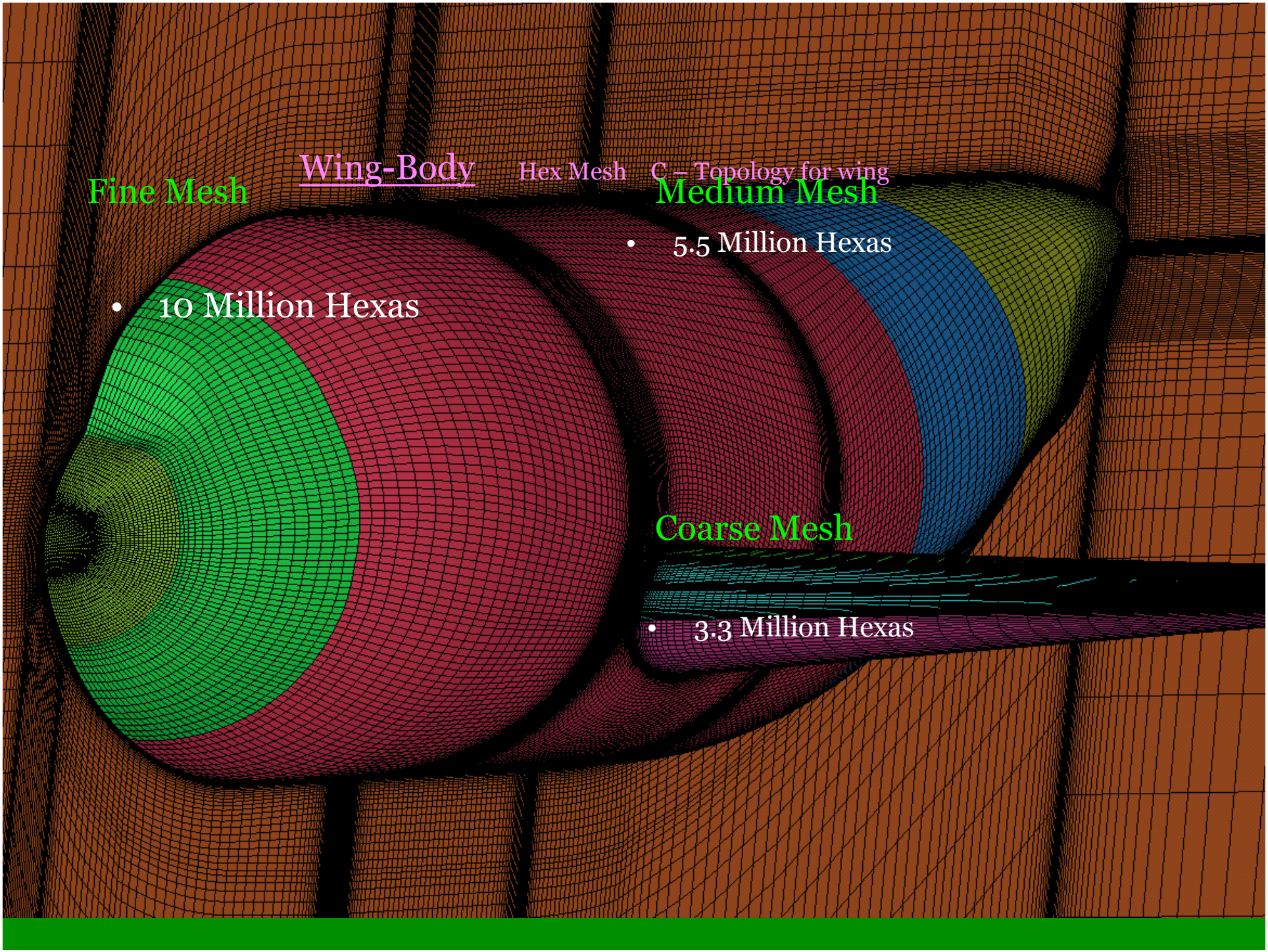
Other Meshes

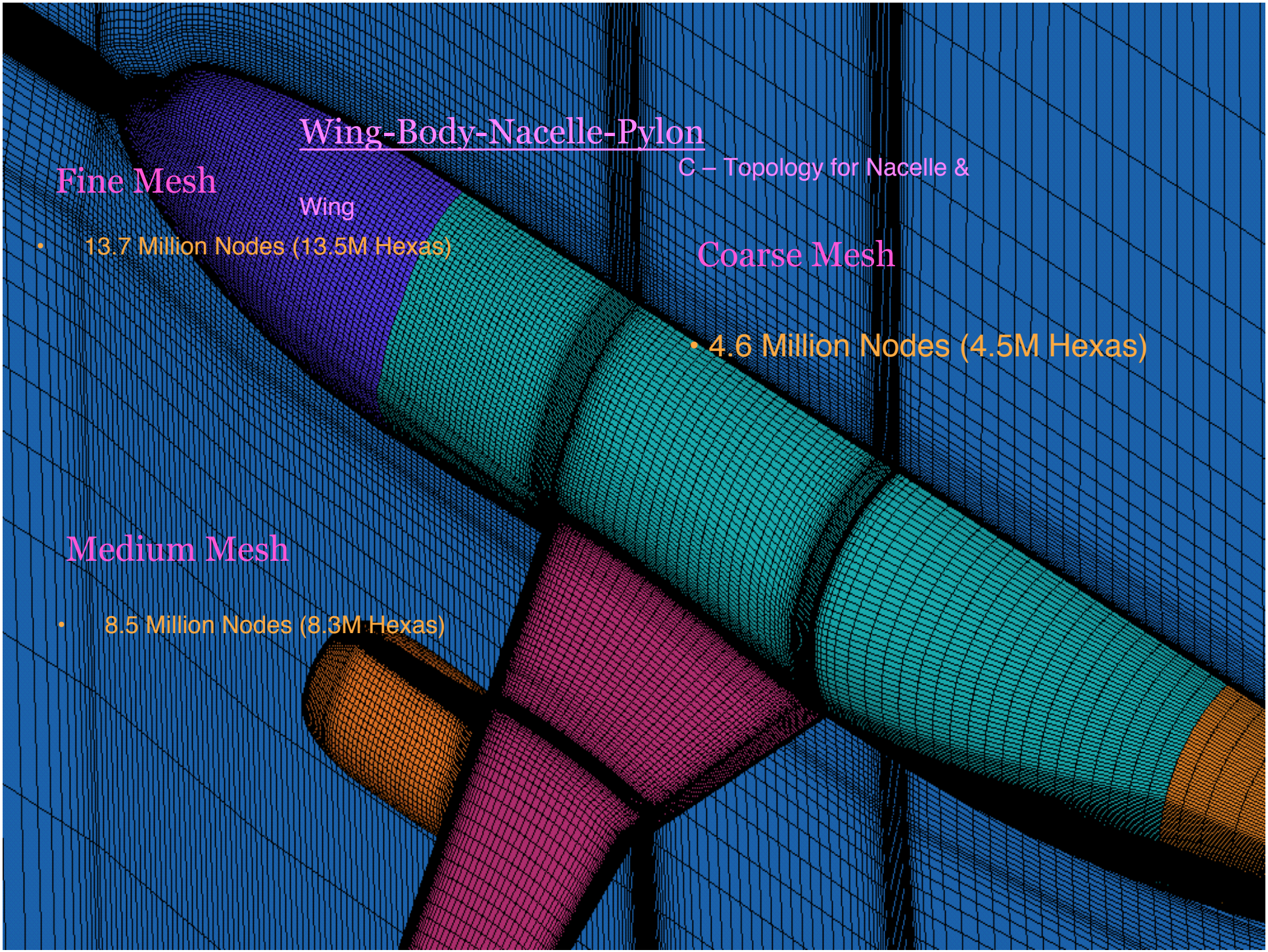
- SAUNA (1)
- ICEM tetra/prism (1)
- PUFGG (1)
- TAS-MESH(1)

Structured Multi-block Meshes
ICEM

ICEM Hexa Mesh Characteristics

- C – Topology around the wing
- Fine, Medium and Coarse grids
- 4 Levels of Multigrid (level 0, 1, 2 & 3) – Coarse mesh has only 3 levels (level 0, 1 & 2) of Multigrid
- Viscous Grid with Near wall Spacing = 0.001


Wing-Body Hex Mesh C – Topology for wing
Fine Mesh
• 10 Million Hexas
Medium Mesh
• 5.5 Million Hexas
Coarse Mesh
• 3.3 Million Hexas


Wing-Body-Nacelle-Pylon
C – Topology for Nacelle &
Wing
Fine Mesh
• 13.7 Million Nodes (13.5M Hexas)
Coarse Mesh
• 4.6 Million Nodes (4.5M Hexas)
Medium Mesh
• 8.5 Million Nodes (8.3M Hexas)

Structured Multi-block Meshes
Boeing/BCA-Advancing Front

Structured Multi-Block - Boeing

- H-H topology
- WB: 3.9M 13.2M nodes

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Tetrahedral Meshes
NASA Langley/VGRID

Tetrahedral Grids for DLR-F6 DPW2 Configuration

For Cell-Centered Codes with Wall Function - VGRIDns

	WB	WBNP
Coarse Avg. Δn_{c1}=0.020	**1,409,689 cells** Avg. y^+_{cell} = 13.1	**2,152,607 cells** Avg. y^+_{cell} = 12.9
Medium Avg. Δn_{c1}=0.013	**3,901,658 cells** Avg. y^+_{cell} = 8.9	**5,912,596 cells** Avg. y^+_{cell} = 8.7
Fine Avg. Δn_{c1}=0.009	**11,347,301 cells** Avg. y^+_{cell} = 5.9	**17,193,275 cells**

Grids generated by Jonathon Nehrbass, intern in the Configuration Aerodynamics Branch, NASA LaRC under direction of Neal Frink

neal.t.frink@nasa.gov

Tetrahedral Grids for DLR-F6 DPW2 Configuration

For Node-Centered Codes - VGRIDns

	WB	WBNP
Coarse Avg Δn_{n1}=0.00144	**1,121,301 nodes (6,558,758 cells)**	**1,827,470 nodes (10,715,204 cells)**
Medium Avg Δn_{n1}=0.001	**3,010,307 nodes (17,635,283 cells)**	**4,751,207 nodes (27,875,222 cells)**
Fine Avg Δn_{n1}=0.000695	**9,133,352 nodes (53,653,279 cells)**	**10,278,588 nodes (60,412,948 cells)**

Grids generated by Beth Lee-Rausch, Computational Modeling & Simulation Branch, NASA LaRC

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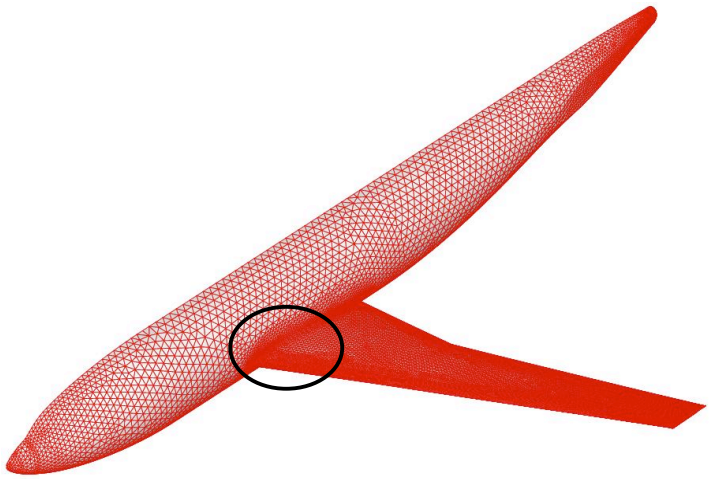
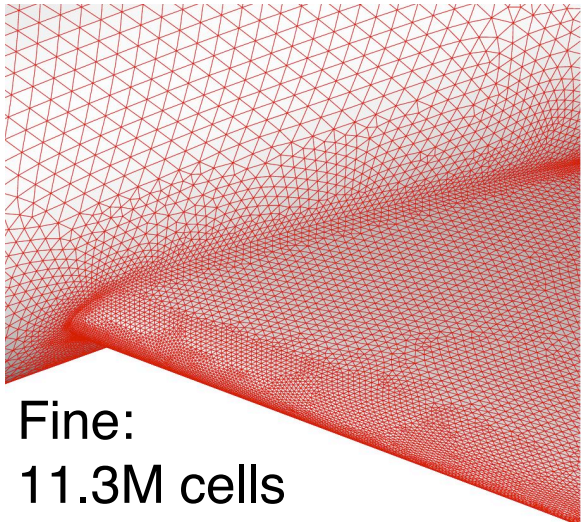
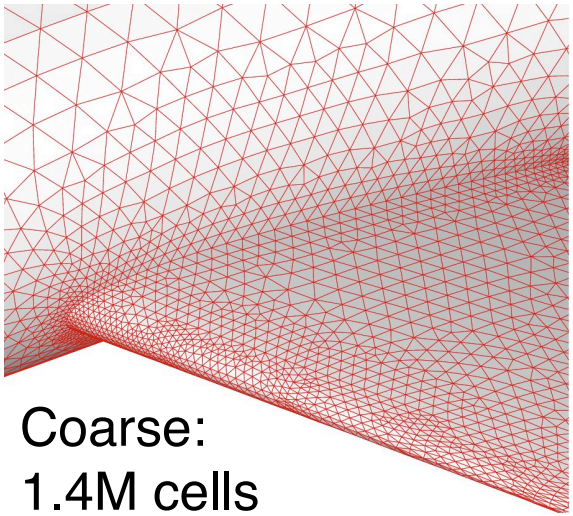
DLR-F6 WB Tetrahedral Viscous Grids for Cell-Centered Solvers

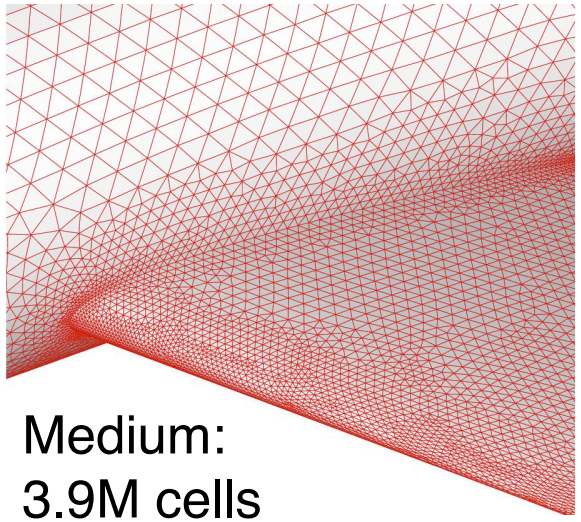




Fine:
11.3M cells



Coarse:
1.4M cells



Medium:
3.9M cells

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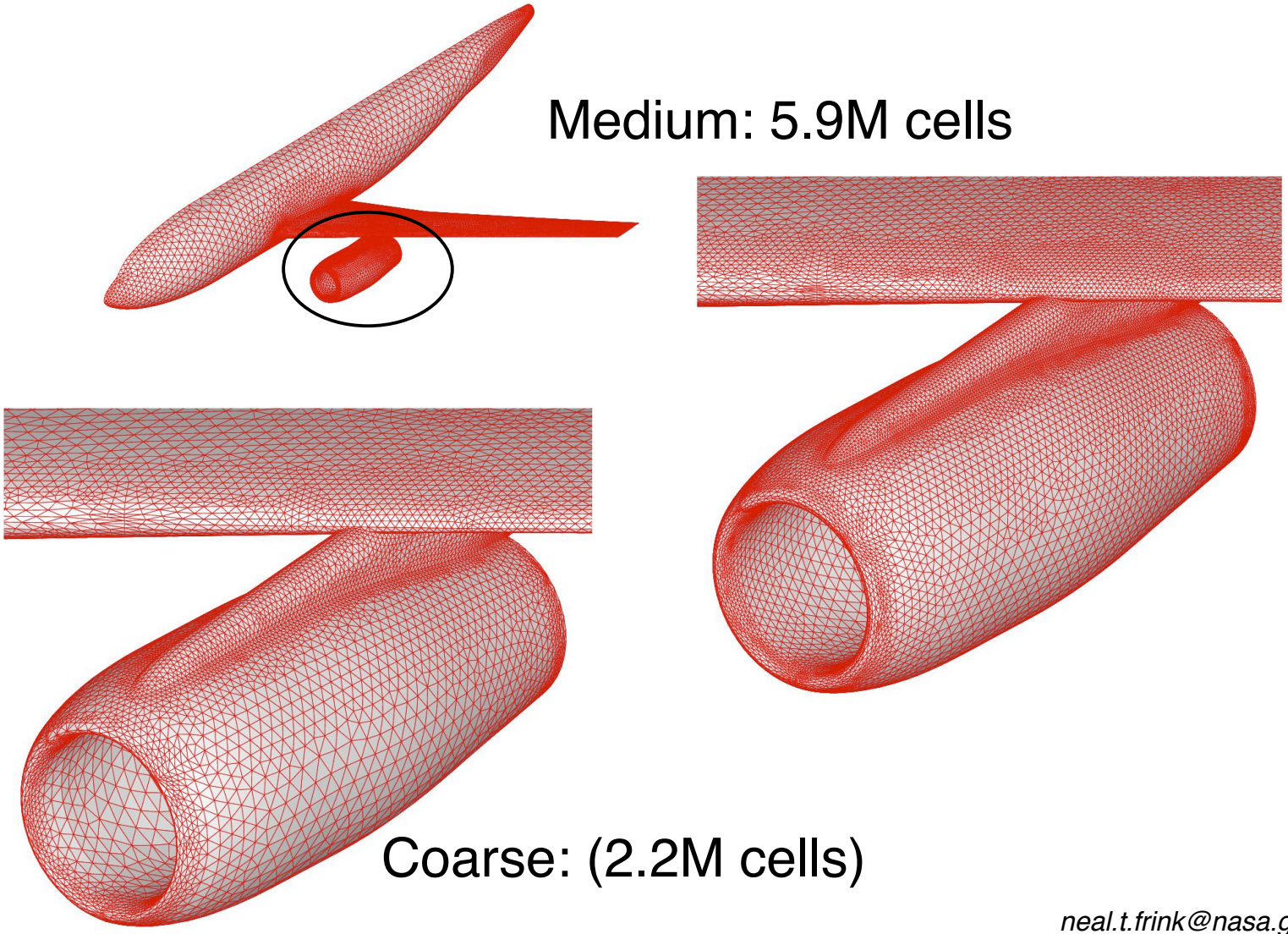
DLR-F6 WBNP Tetrahedral Viscous Grids for Cell-Centered Solvers



Medium: 5.9M cells

Coarse: (2.2M cells)

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Unstructured Meshes
DLR/CENTAUR

Unstructured - DLR/CENTAUR

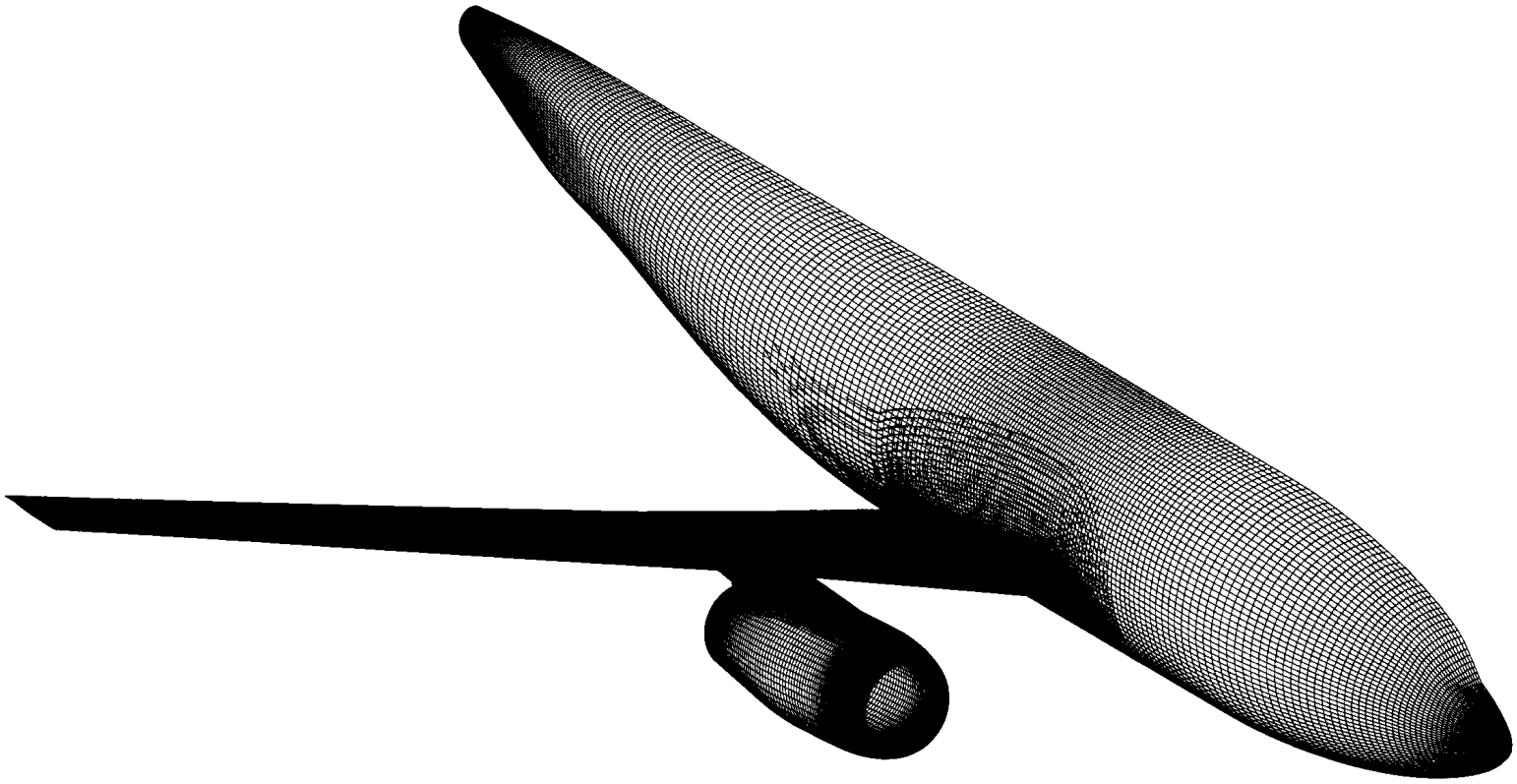
- WB: 2.4M 3.2M 4.1M (adapted)
- WBNP: 3.7M 4.8M 6.4M (adapted)

Overset Meshes
Boeing
ZONI3G-SURGRD-HYPGEN-LEGRID-PEGASUS5

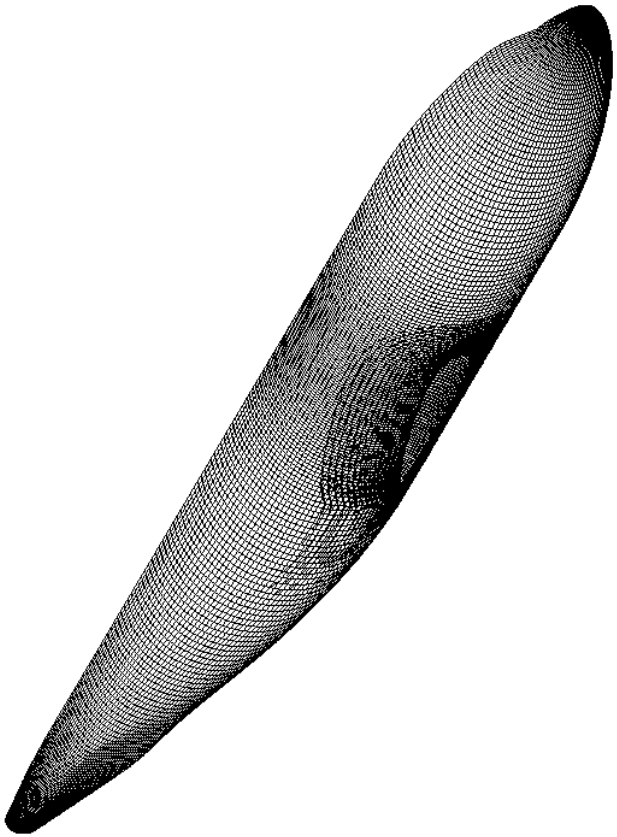
Overset Mesh Sizes

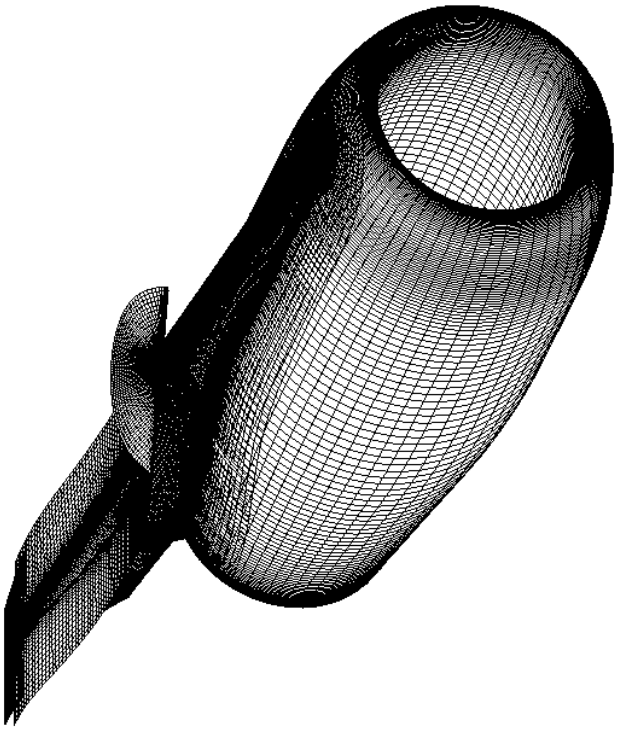
- WB: 1.97M 6.86M 23.15M nodes
- WBNP: 3.11M 10.78M 35.95M nodes

Overset Mesh

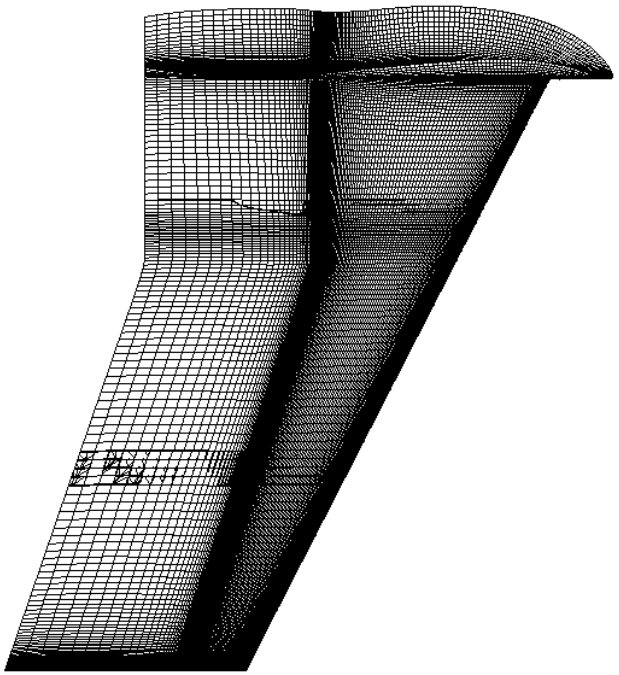


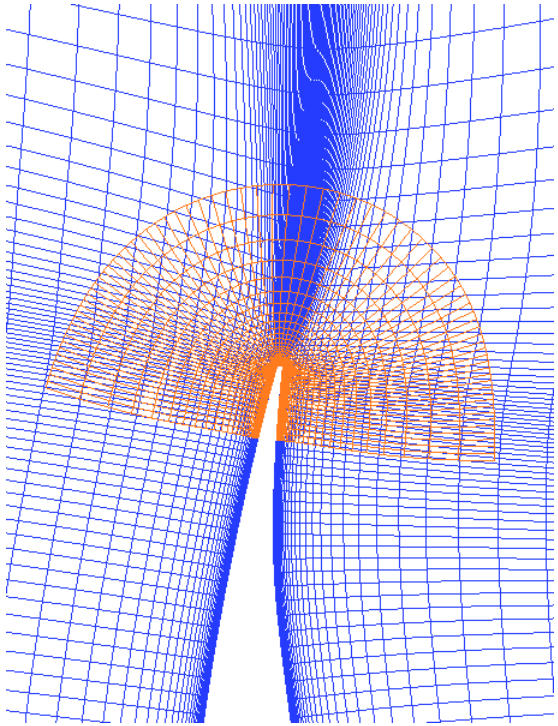
Overset Mesh Components





Overset Mesh Components





Summary

- 8 Gridsets provided for participants
  - 5 unstructured
  - 2 structured multi-block
  - 1 overset
- 4 Participants supplied their own meshes
- Wide variety of mesh sizes.
  - 3x step-up not strictly obeyed (machine limitations, etc.)

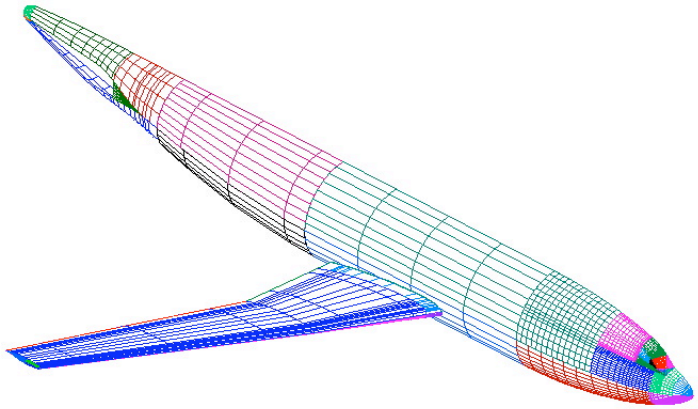
backup

Grid Generation System VGRIDns

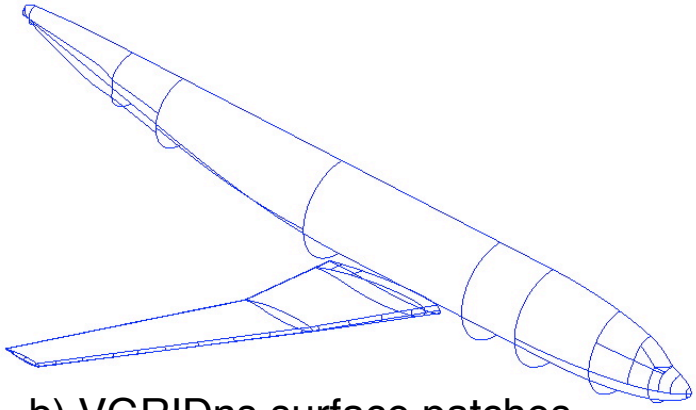
- Developed at the NASA LaRC
- Generates triangular surface and tetrahedral volume grids
- Based on marching techniques:
  - advancing-front method (AFM) for "Euler" grids (Löhner, 1988)
  - advancing-layers method (ALM) for "viscous" grids (Pirzadeh, 1993)
- Salient features:
  - smooth grids by means of sources and solving elliptic PDE
  - thin-layer "viscous" grids
  - anisotropic grid stretching
  - restart capability
  - local remeshing

} grid post-processing and adaptive refinement

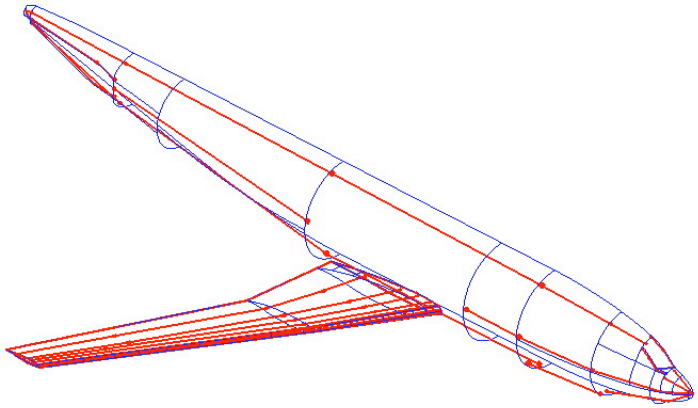
Grid Generation Process with VGRIDns on DLR-F6



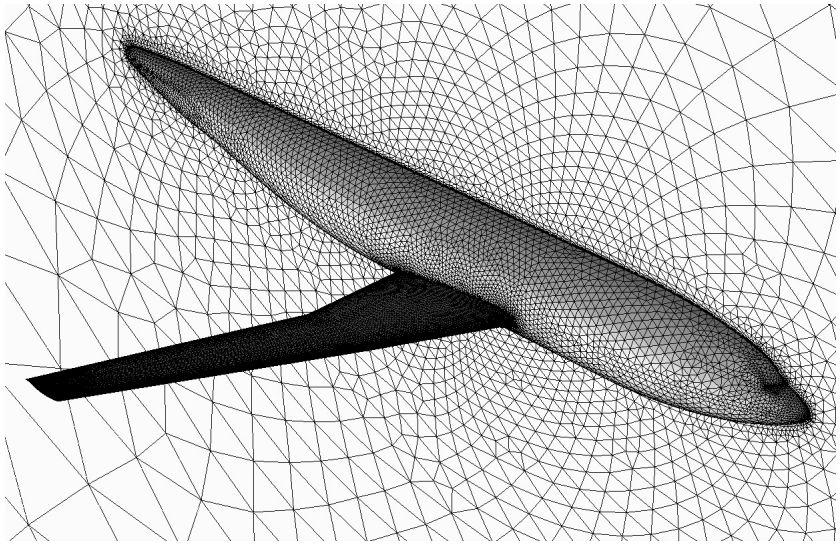
a) surface definition (IGES)



b) VGRIDns surface patches



c) background grid sources

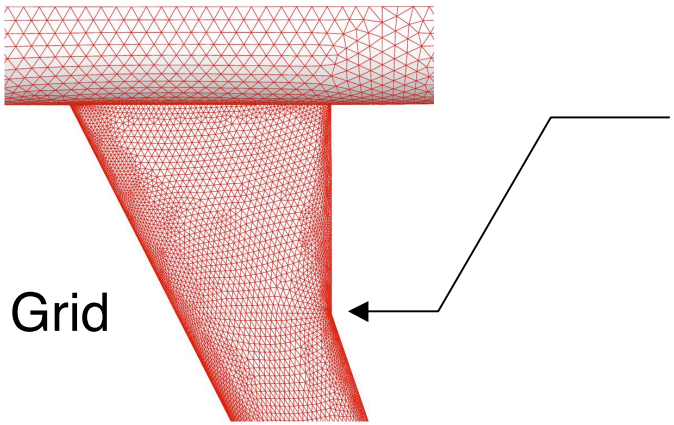


d) surface mesh

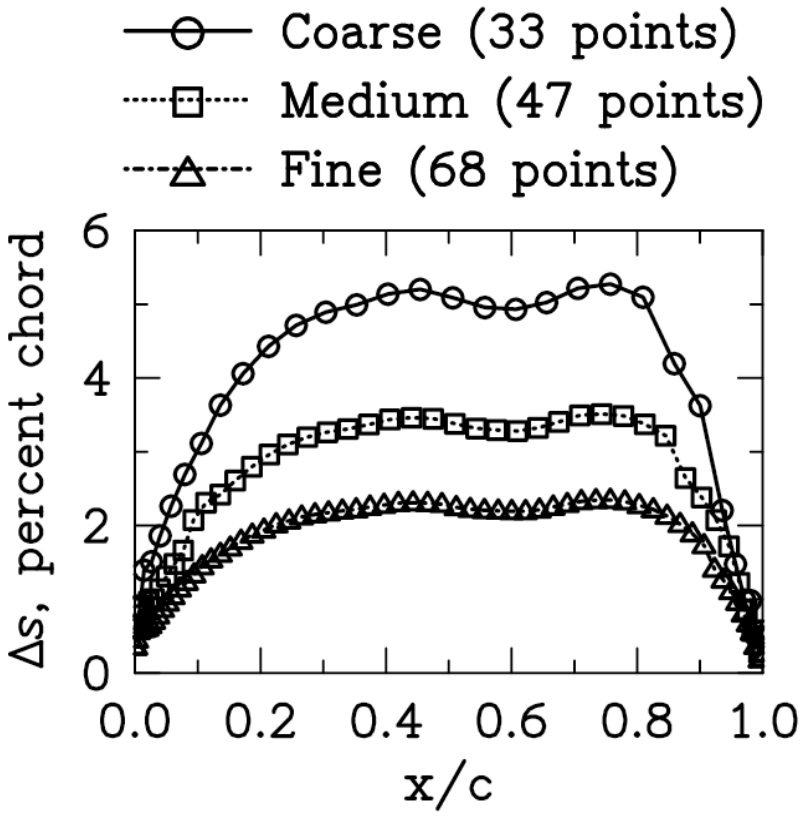
Chordwise Spacing at WB Crank Station

DLRF6: Tetrahedral Cell-Centered Grids

	WB	WBNP
C	1,409,689	2,152,607
M	3,901,658	5,912,596
F	11,347,301	---



WB
Medium Grid



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DLR-F6 Unstructured WB grids for Cell-Based Solvers

Grid Generation by VGRIDns

$$\Delta n_j = \Delta n_1(1+a(1+b)^{j-1})^{j-1}$$

Grid statistics:	Coarse	Medium	Fine
•**Tetrahedral cells**:	1,409,689	3,901,658	11,347,301
•Total grid nodes	246,020	675,946	1,954,524
•Total Bndry **triangles**	33,408	66,022	135,482
•**Triangles** on no-slip surfaces	24,638	49,919	104,180
•**Tet cells** in viscous layer	524,213	1,051,794	2,017,809
•Nodes in the viscous layers:	103,973	208,210	404,276
•T.E. patches	2	2	2

Grid spacings:	Coarse	Medium	Fine
% chordwise spacing at LE	0.90	0.60	0.35
% chordwise spacing at TE	0.494	0.29	0.185
Avg cell y^+ Avg node y^+ *(sized for wall function)*	13 52	9 36	6 24
Nominal BL **cells**	16	18	20
Init 'viscous' wall spacing (Δn_1)	0.0855	0.057	0.038
Geometric stretching rates *a* and *b*	0.456, 0.07	0.456, 0 07	0.456, 0.07
Outer boundary box	106 c_{ref}	106 c_{ref}	106 c_{ref}

Grids generated by Jonathon Nehrbass, intern in the Configuration Aerodynamics Branch, NASA LaRC under direction of Neal Frink

DLR-F6 Unstructured WB grids for Node-Based Solvers

Grid Generation by VGRIDns

$$\Delta n_j = \Delta n_1 (1 + a(1+b)^{j-1})^{j-1}$$

Grid statistics:	**Coarse**	**Medium**	**Fine**
Total grid **nodes**	1,121,301	3,010,307	9,133,352
Tetrahedral cells:	6,558,758	17,635,283	53,653,279
Nodes on no-slip boundaries	25,104	55,069	118,903
Nodes in viscous layers:	674,338	1,462,475	3,975,437
Tet cells in viscous layer	3,826,019	8,313,126	22,866,866
T.E. patches	2	4	6

Grid spacings:	**Coarse**	**Medium**	**Fine**
Nominal BL **nodes**	26	26	33
Init 'viscous' wall spacing (Δn_1)	0.00144	0.001	0.000695
Geometric stretching rates *a* and *b*	0.2, 0.02	0.2, 0.02	0.13, 0.02
Outer boundary box	106 c_{ref}	106 c_{ref}	106 c_{ref}

Grids generated by Beth Lee-Rausch, Computational Modeling & Simulation Branch, NASA LaRC