

Unstructured Grids for DPW3

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DPW Committee

General Gridding Guidelines

- Grid Convergence Cases:
 - DLR F6 WBF
 - 3 grid levels required
 - DLR F6 WB
 - Medium grid required, coarse/fine optional
 - Wing1 and Wing2
 - Four grid levels required

General Gridding Guidelines

- Grid Resolution Guidelines
 - BL Region
 - $Y^+ < 1.0, 2/3, 4/9, 8/27$ (Coarse,Med,Fine,VeryFine)
 - 2 cell layers constant spacing at wall
 - Growth rates < 1.25
 - Far Field: 100 chords
 - Local Spacings (Medium grid)
 - Chordwise: 0.1% chord at LE/TE
 - Spanwise spacing: 0.1% semispan at root/tip
 - Cell size on Fuselage nose, tail: 2.0% chord
 - Trailing edge base:
 - 8,12,16,24 cells across TE Base (Coarse,Med,Fine,Veryfine)

General Gridding Guidelines

- Grid Convergence Sequence
 - Grid size to grow $\sim 3X$ for each level refinement
 - 1.5X in each coordinate direction (structured)
 - Maintain same family of grids in sequence
 - Same relative resolution/topology/growth factors
 - Sample sizes (DLR F6 WBF):
 - 2.7M, 8M, 24M pts (structured grids)
 - Unstructured grids should be similar
 - Cell based vs. Node Based Unstructured solvers
 - 5 to 6 times more tetrahedra per nodes
 - 2 times more prisms than nodes

Available (Posted) Unstructured Grids

- VGRID (NASA Langley)
 - Cell Centered Grids Raytheon (WB,WBF)
 - Node-Based grids Cessna (W1,W2)
 - Node-Based grids NASA(W1,W2,WB,WBF)
- ANSYS Hybrid Meshes
- Centaur (DLR, adapted) (Node Based)
- AFLR3 (Boeing) (Cell Centered)
- TAS (JAXA) (Node Based)
- GridPro (Block-Structured/Unstructured)

VGRID Cell Centered (Raytheon)

- WB:
 - Medium: 1.1M pts 6.5M cells
- WBF:
 - Coarse: 0.54M pts 3.1M cells
 - Medium: 1.0M pts 6.3M cells
 - Fine: 2.0M pts 11.5M cells

VGRID Cell Centered (Raytheon)

AIAA DPW-3 (Drag Prediction Workshop), June 2006

DLR-F6 Wing Body

$S_{ref} = 145400 \text{ mm}^2$, $c_{ref} = 141.2 \text{ mm}$, $b/2 = 585.647 \text{ mm}$.

Coarse Grid : Tetrahedra = 3,142,285; Surface triangles = 59,660

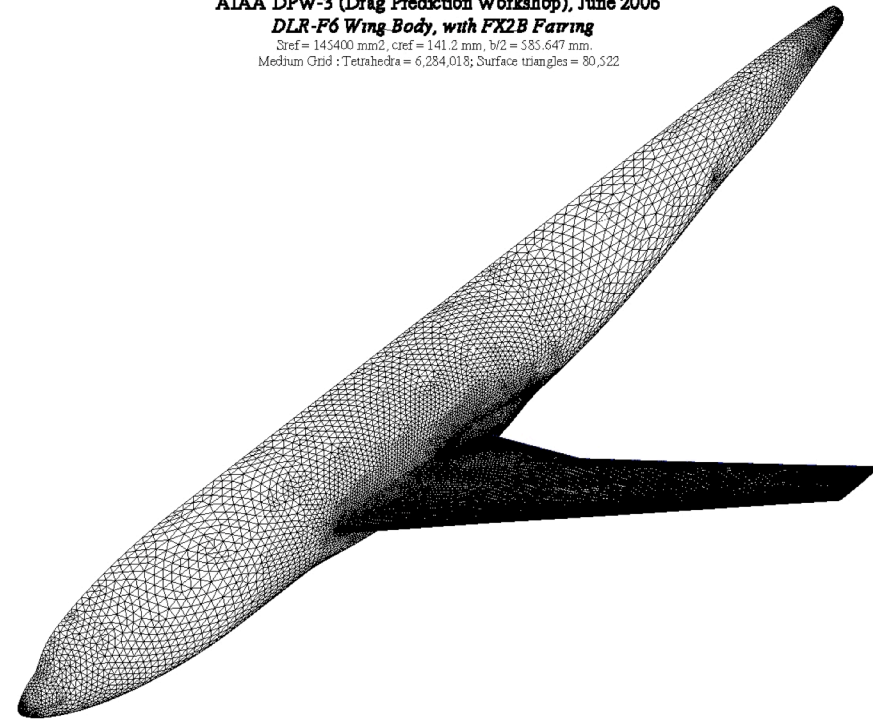


AIAA DPW-3 (Drag Prediction Workshop), June 2006

DLR-F6 Wing Body, with FX2B Faring

$S_{ref} = 145400 \text{ mm}^2$, $c_{ref} = 141.2 \text{ mm}$, $b/2 = 585.647 \text{ mm}$.

Medium Grid : Tetrahedra = 6,284,018; Surface triangles = 80,522



VGRID Cell Centered (Raytheon)

AIAA DPW-3 (Drag Prediction Workshop), June 2006

DLR-F6 Wing Body

Sref = 145400 mm², cref = 141.2 mm, b/2 = 585.647 mm.

Coarse Grid : Tetrahedra = 3,142,285; Surface triangles = 59,660

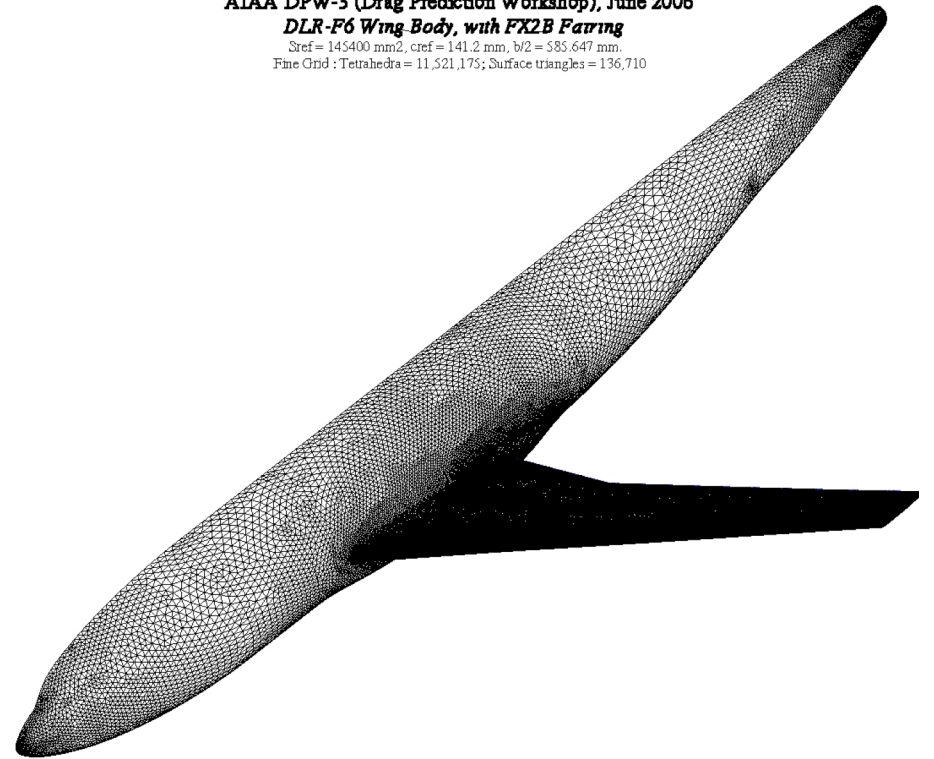


AIAA DPW-3 (Drag Prediction Workshop), June 2006

DLR-F6 Wing Body, with FX2B Faving

Sref = 145400 mm², cref = 141.2 mm, b/2 = 585.647 mm.

Fine Grid : Tetrahedra = 11,521,175; Surface triangles = 136,710



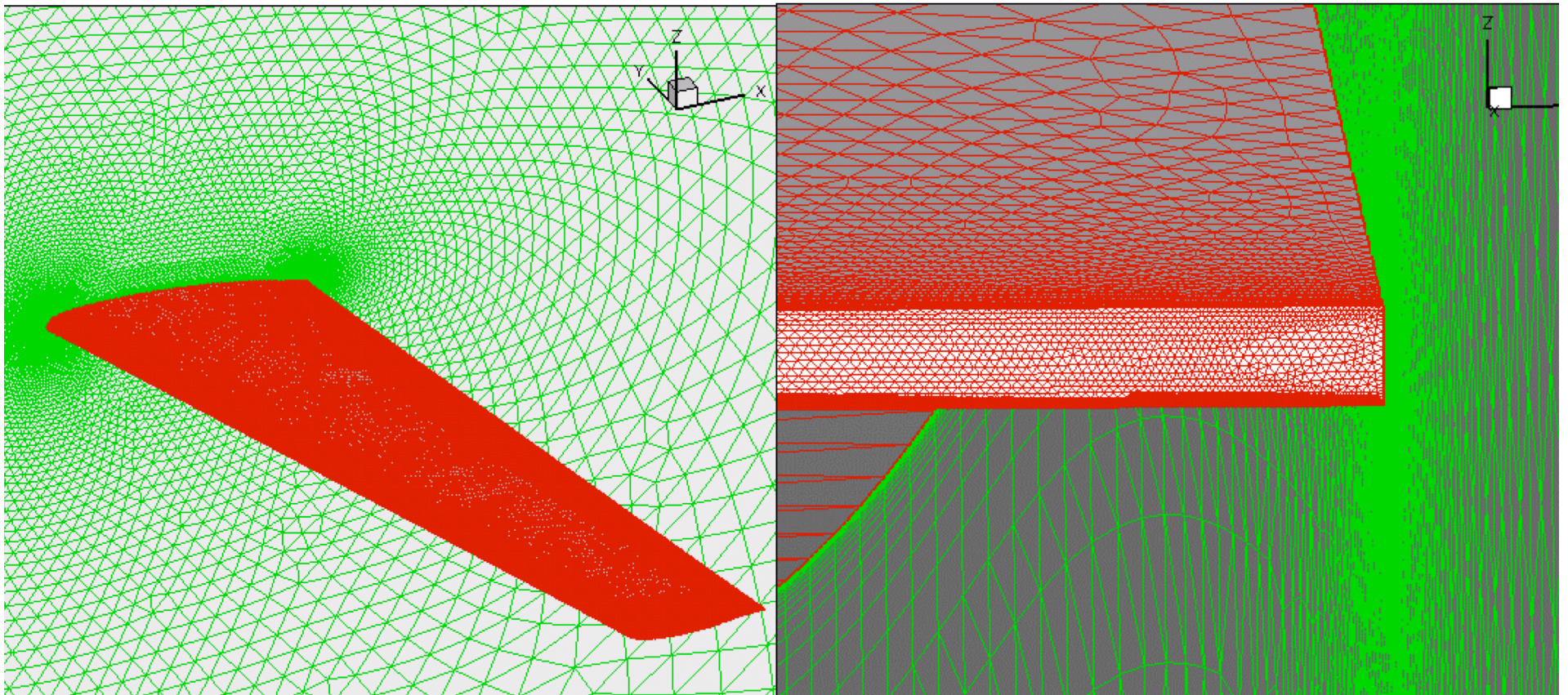
VGRID NASA (Cessna)

- W1:
 - Coarse : 0.98M pts
 - Medium: 2.4M pts
 - Fine: 6.1M pts
 - SuperFine: 12.7M pts
- W2:
 - Coarse: 0.95M pts
 - Medium: 2.3M pts
 - Fine: 5.9M pts
 - SuperFine: 12.4M pts

VGRID NASA (Node Based)

- W1:
 - Coarse : 1.8M pts
 - Medium: 4.5M pts
 - Fine: 11.5M pts
 - SuperFine: 36.9M pts
- W2:
 - Coarse: 1.9M pts
 - Medium: 4.7M pts
 - Fine: 11.9M pts
 - SuperFine: 38.5M pts

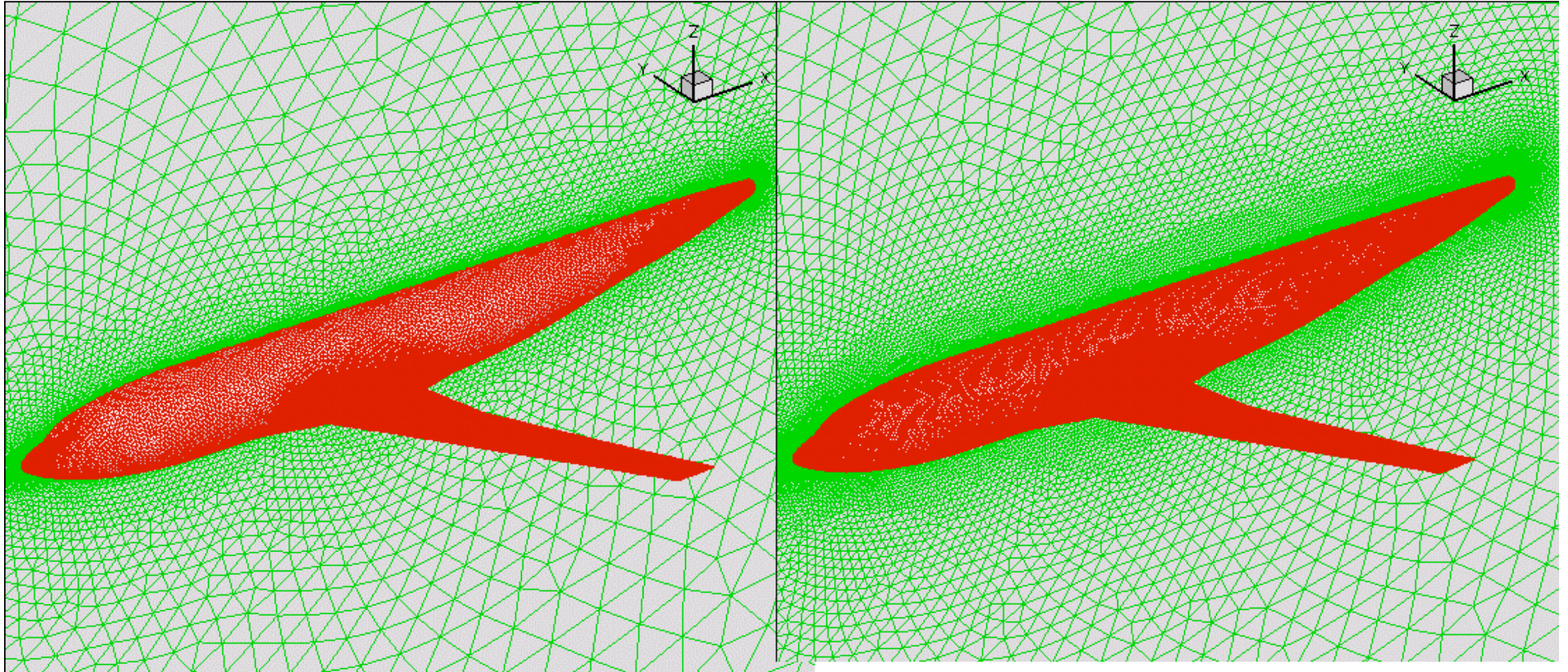
VGRID Node Centered (NASA)



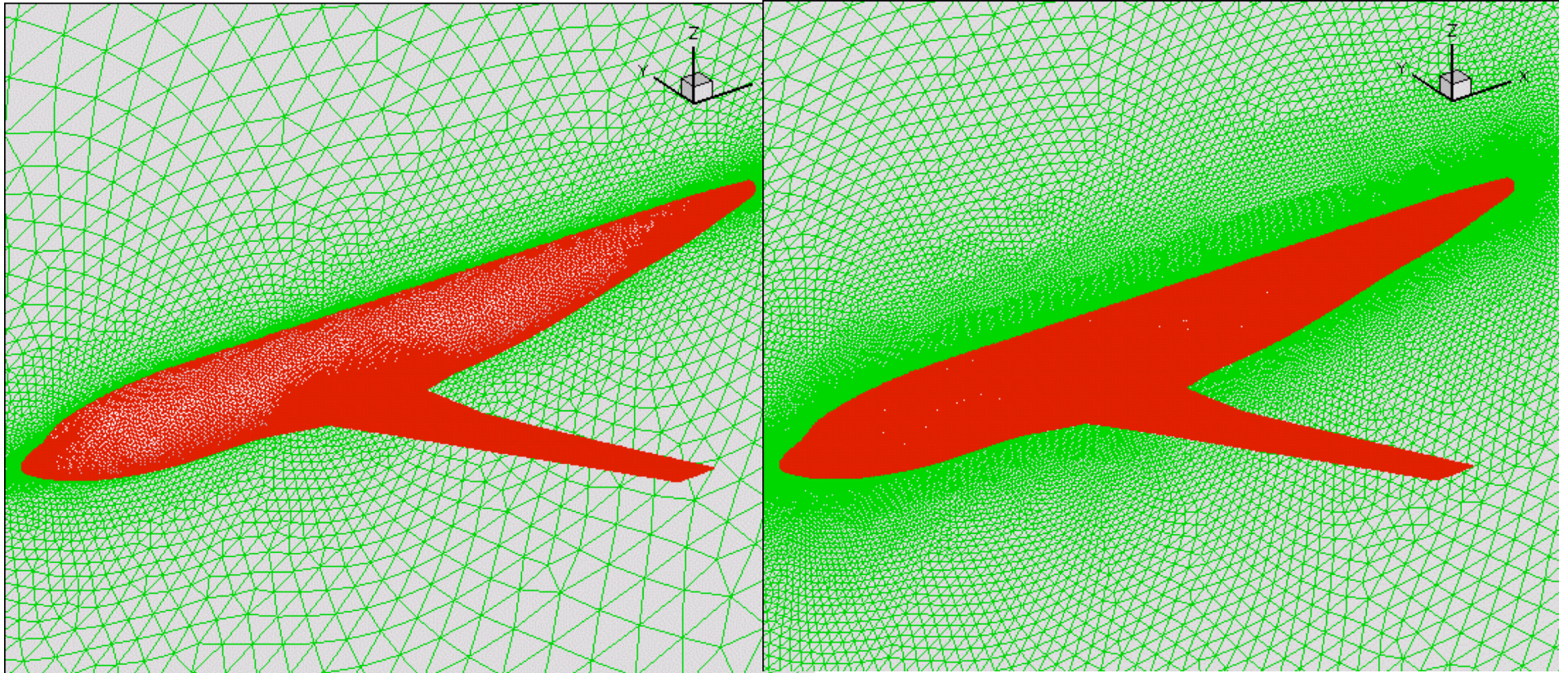
VGRID NASA (Node Based)

- **WB:**
 - Coarse : 5.3M pts
 - Medium: 14.3M pts
 - Fine: 40.0M pts (> 200 M cells)
- **WBF:**
 - Coarse: 5.6M pts
 - Medium: 14.6M pts
 - Fine: 41.1M pts (> 200 M cells)

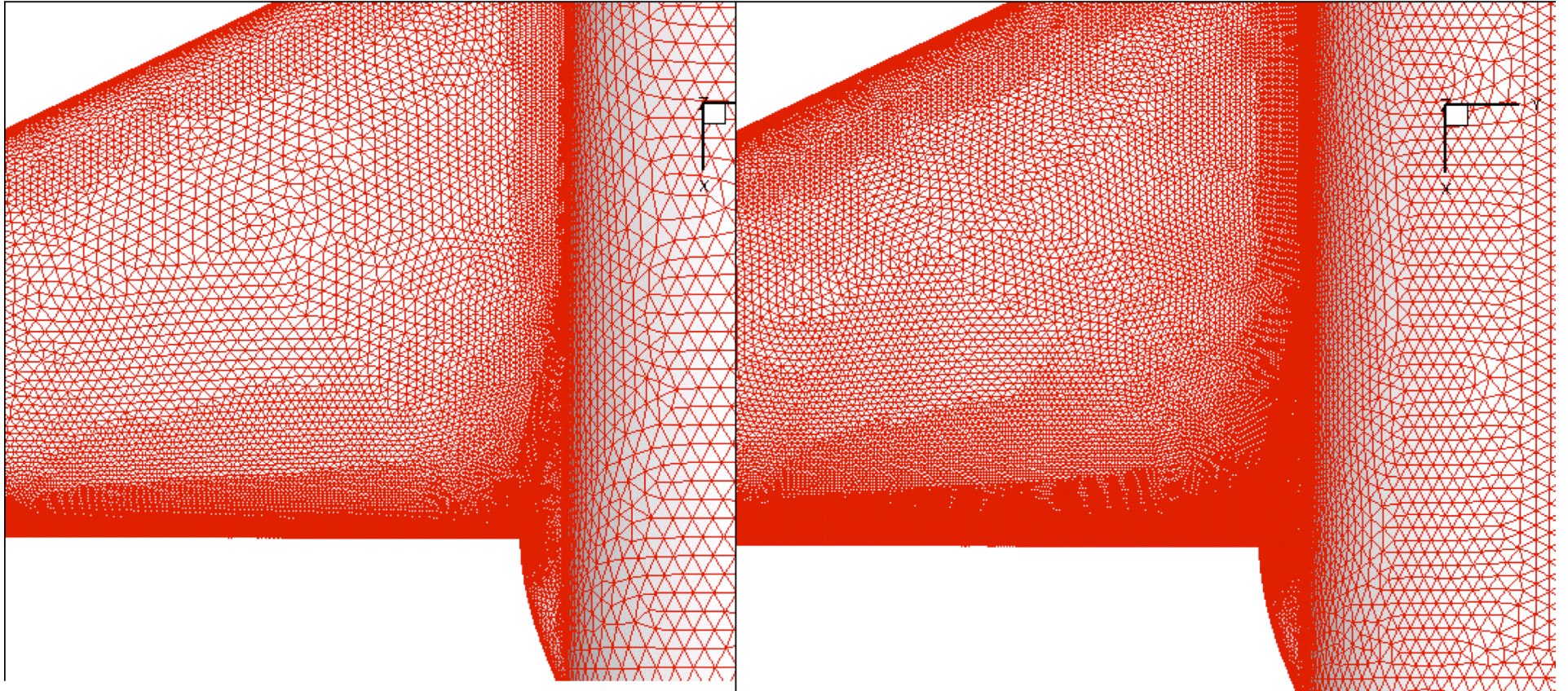
VGRID Node Centered (NASA)



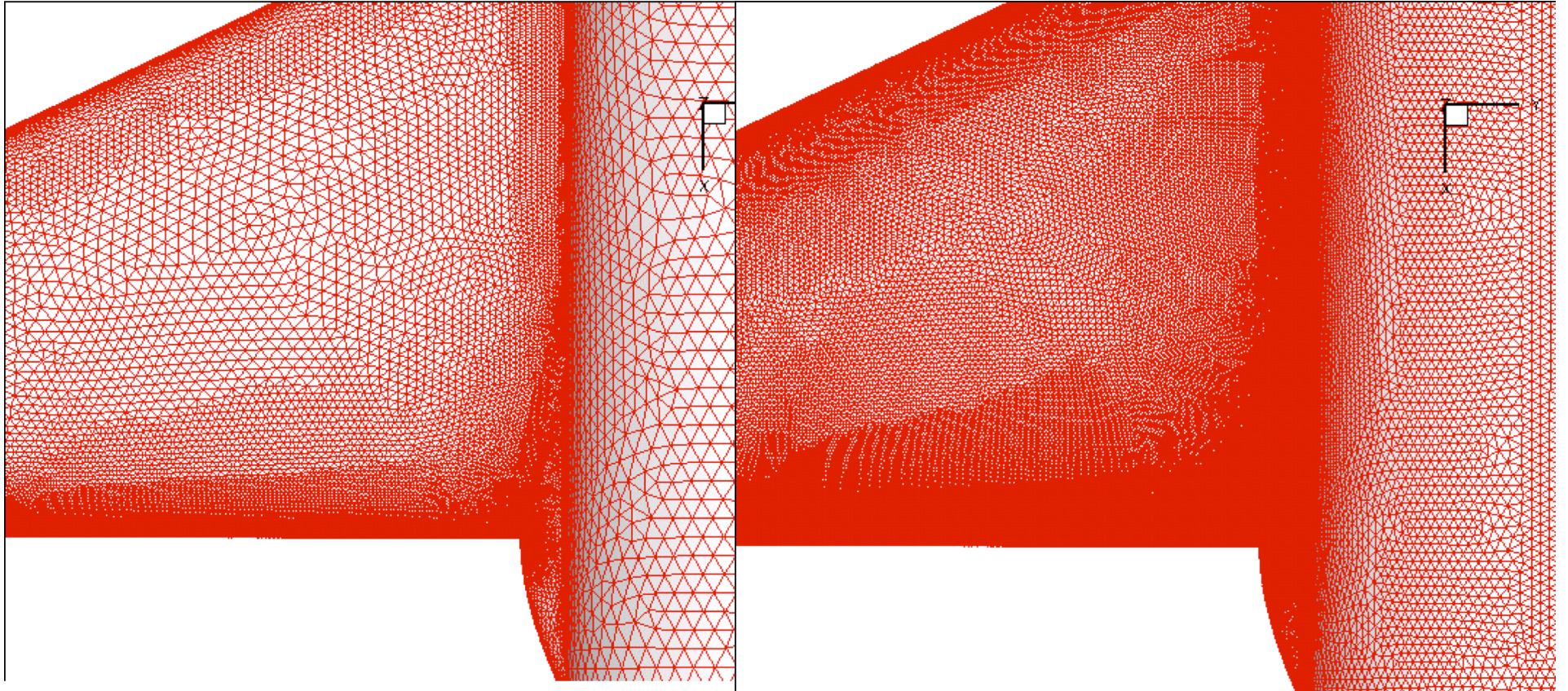
VGRID Node Centered (NASA)



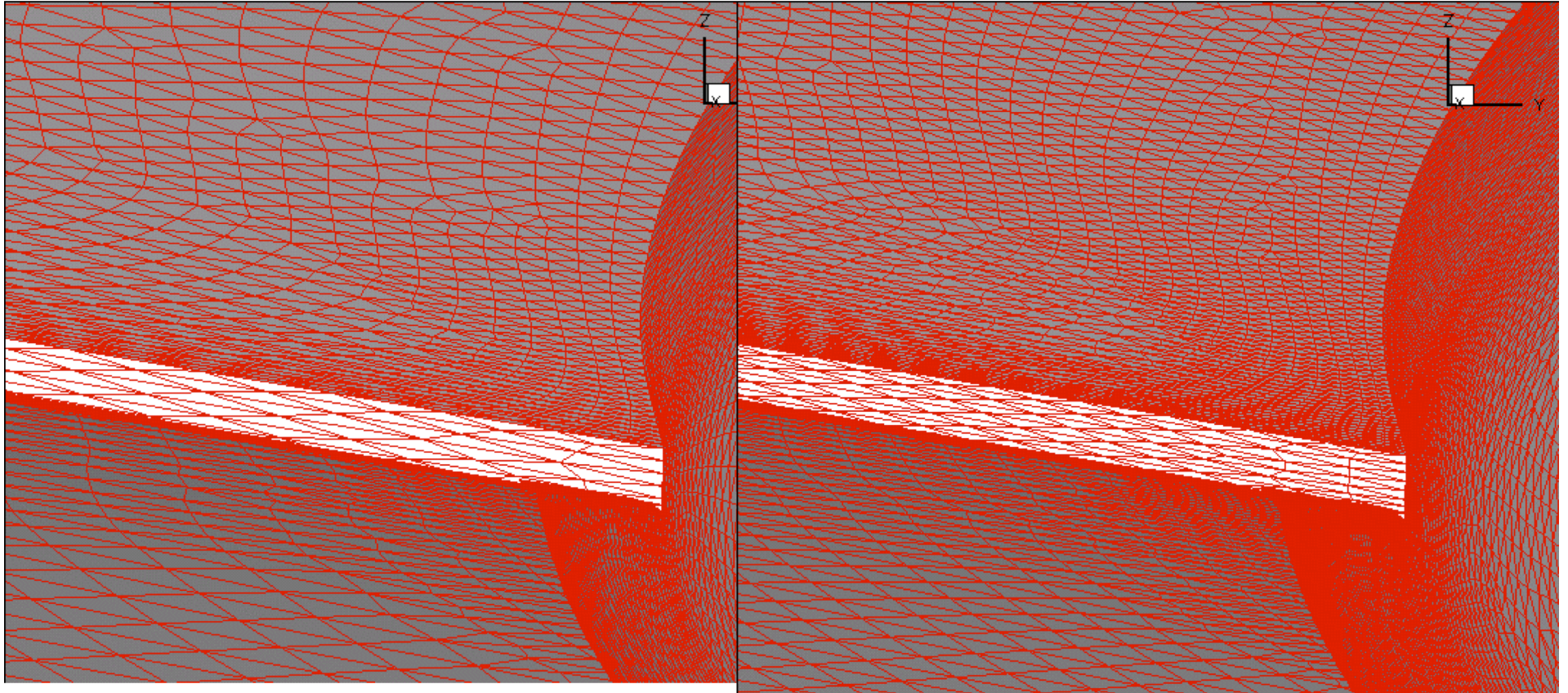
VGRID Node Centered (NASA)



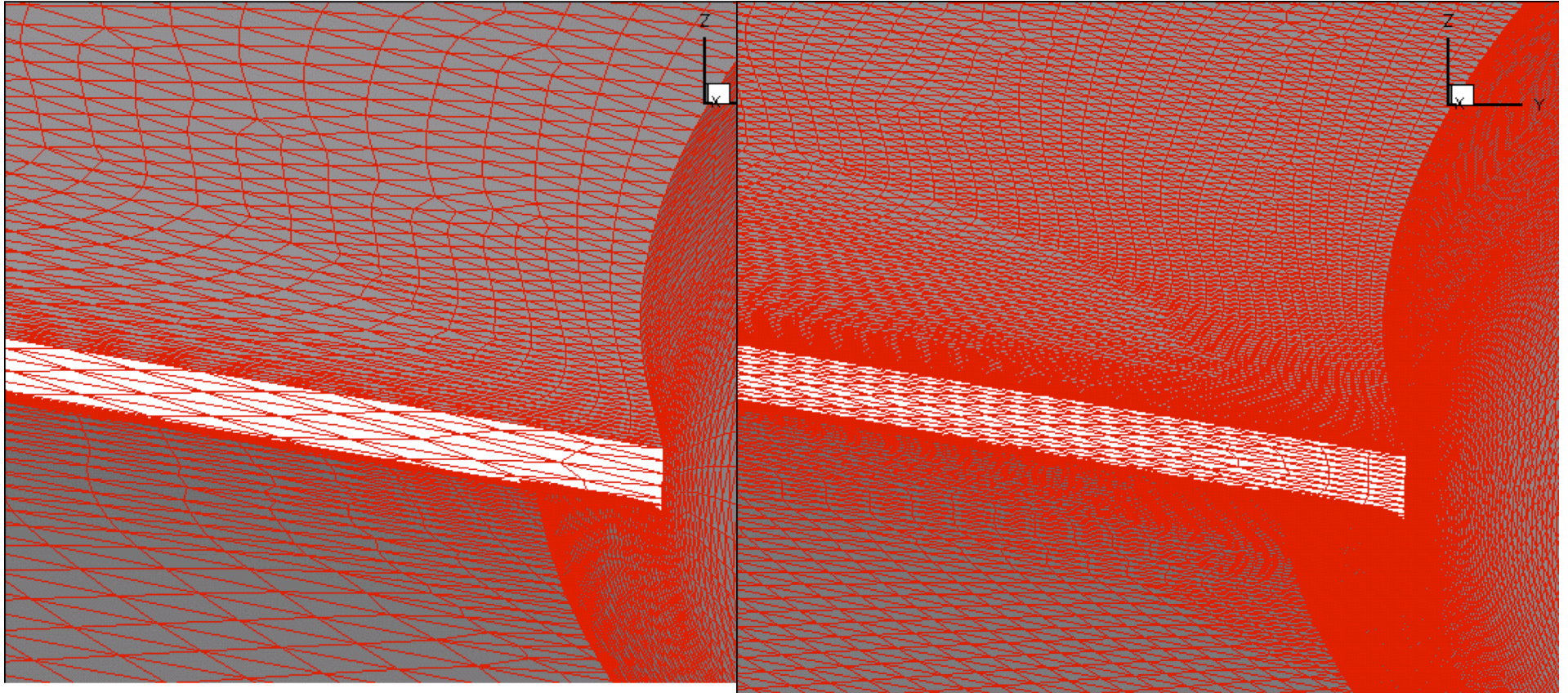
VGRID Node Centered (NASA)



VGRID Node Centered (NASA)



VGRID Node Centered (NASA)



Centaur - DLR (Node Based)

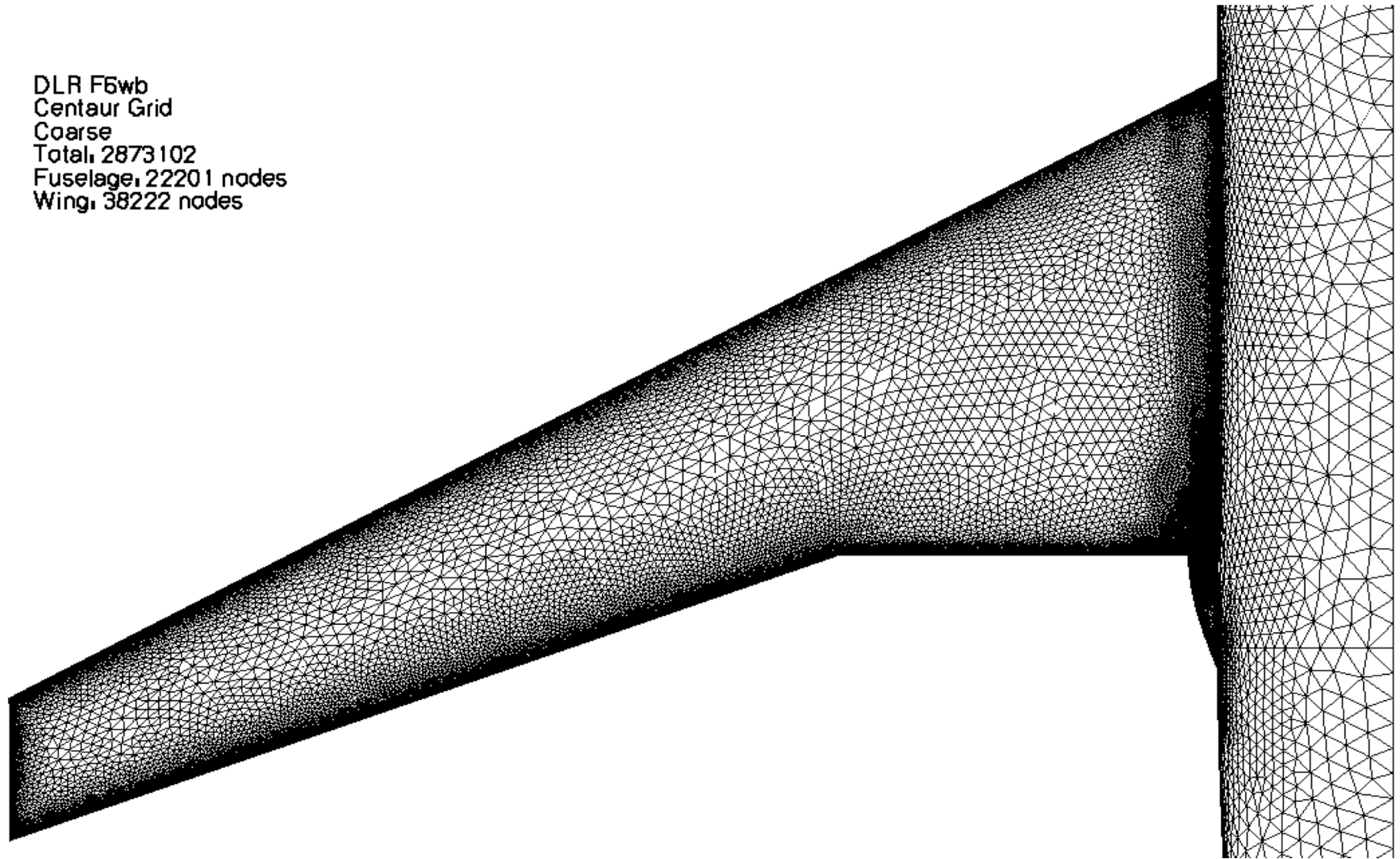
- **WB:**
 - Coarse : 2.5M pts
 - Medium: 5.1M pts
 - Fine: 8.5M pts
- **WBF:**
 - Coarse: 2.9M pts
 - Medium: 6.1M pts
 - Fine: 10.3M pts

Centaur - DLR (Node Based)

- W1:
 - Coarse : 2.2M pts
 - Medium: 5.3M pts
 - Fine: 10.3M pts
 - SuperFine: 17.0M pts (adaptive refinement)
- W2:
 - Coarse: 1.9M pts
 - Medium: 5.1M pts
 - Fine: 9.9M pts
 - SuperFine: 16.6M pts (adaptive refinement)

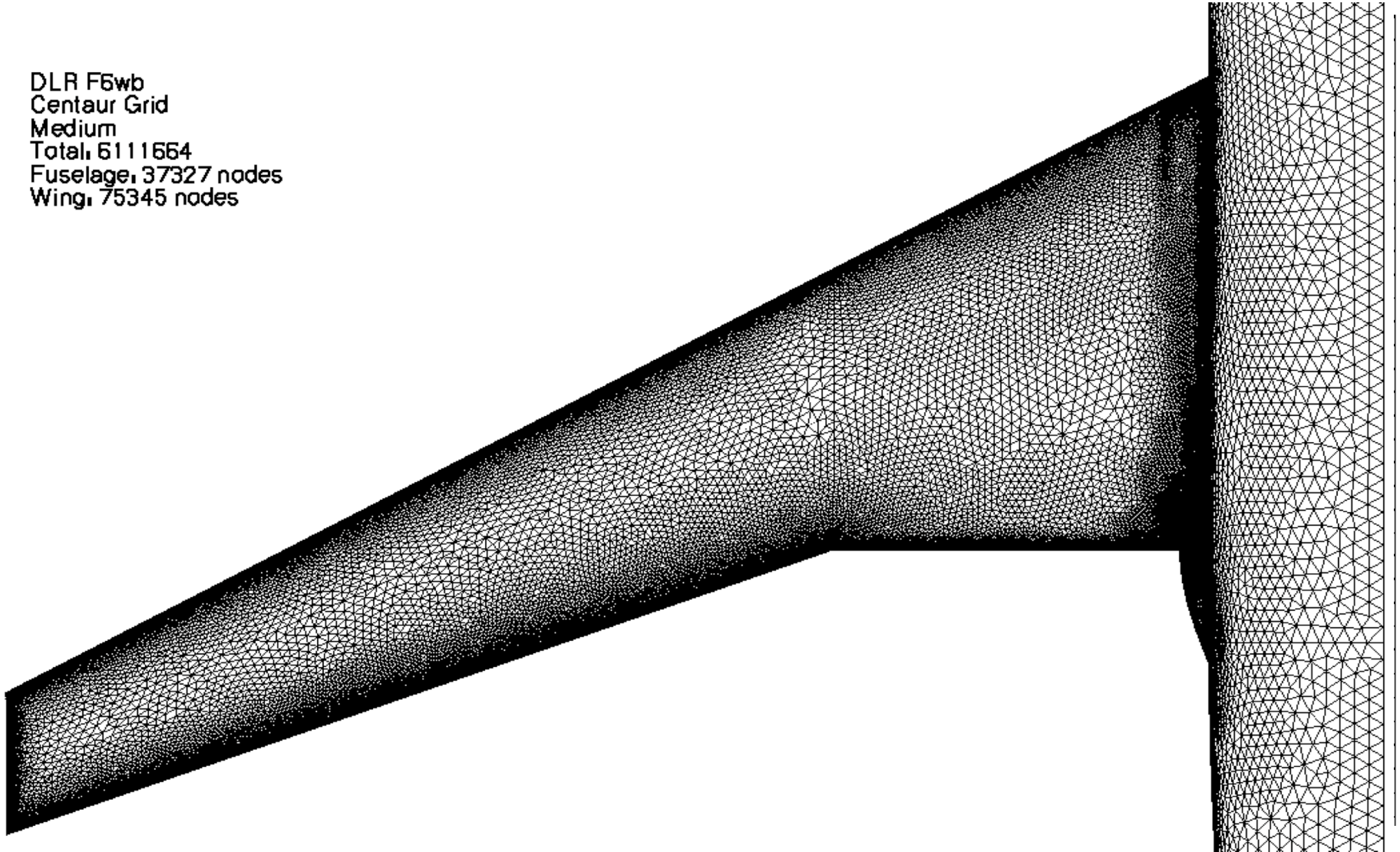
Centaur - DLR (Node Based)

DLR F5wb
Centaur Grid
Coarse
Total, 2873102
Fuselage, 22201 nodes
Wing, 38222 nodes



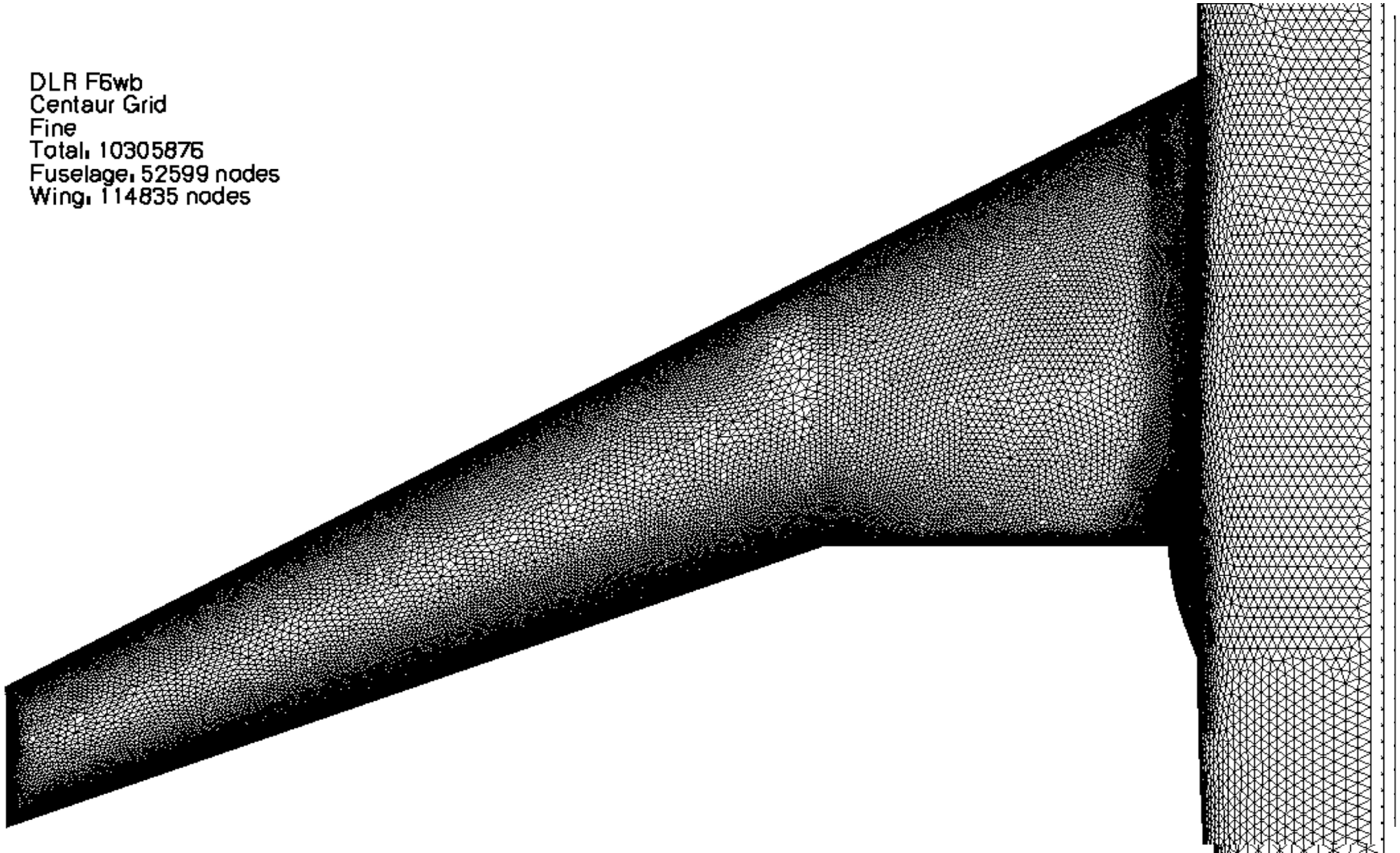
Centaur - DLR (Node Based)

DLR F6wb
Centaur Grid
Medium
Total, 6111664
Fuselage, 37327 nodes
Wing, 75345 nodes

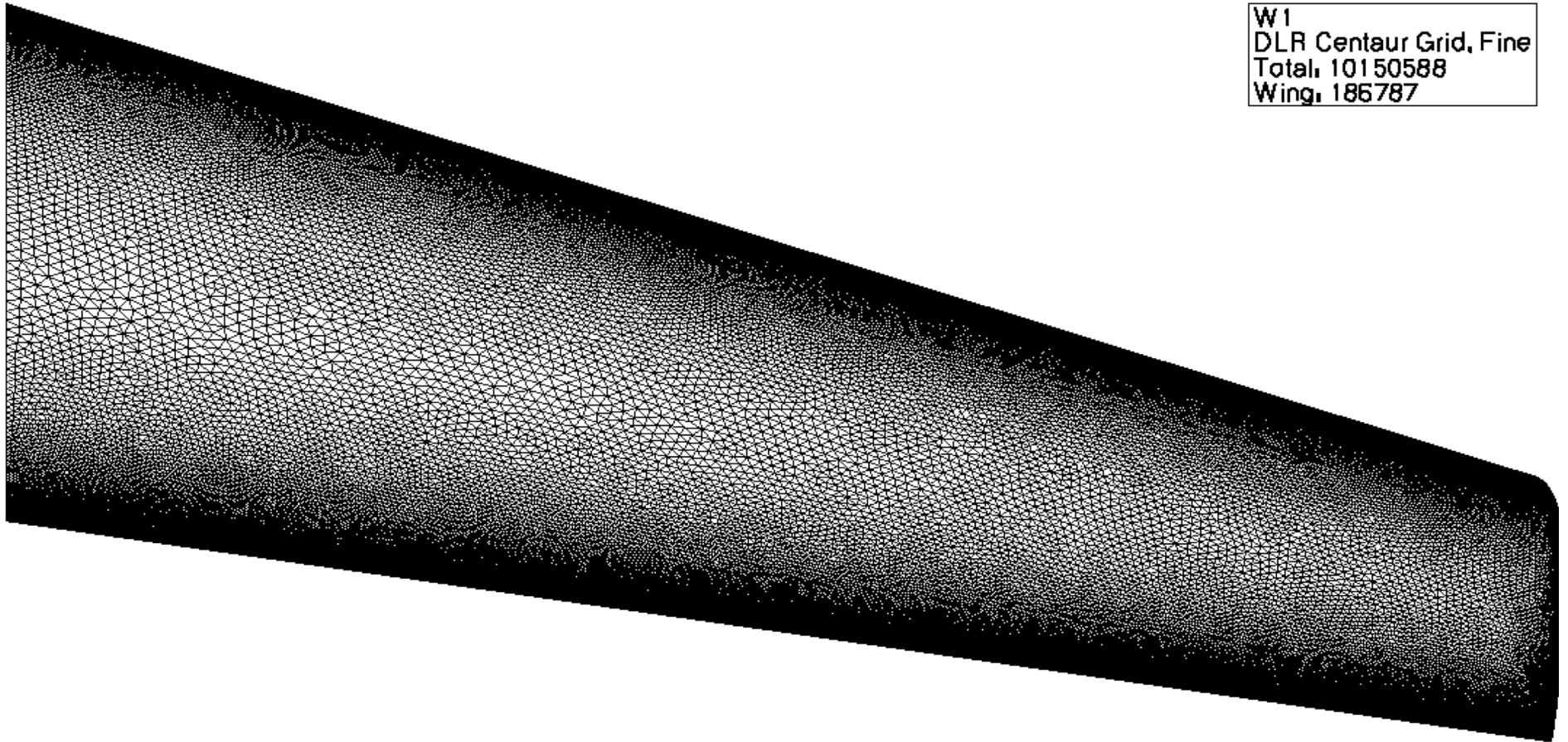


Centaur - DLR (Node Based)

DLR F6wb
Centaur Grid
Fine
Total, 10305875
Fuselage, 52599 nodes
Wing, 114835 nodes

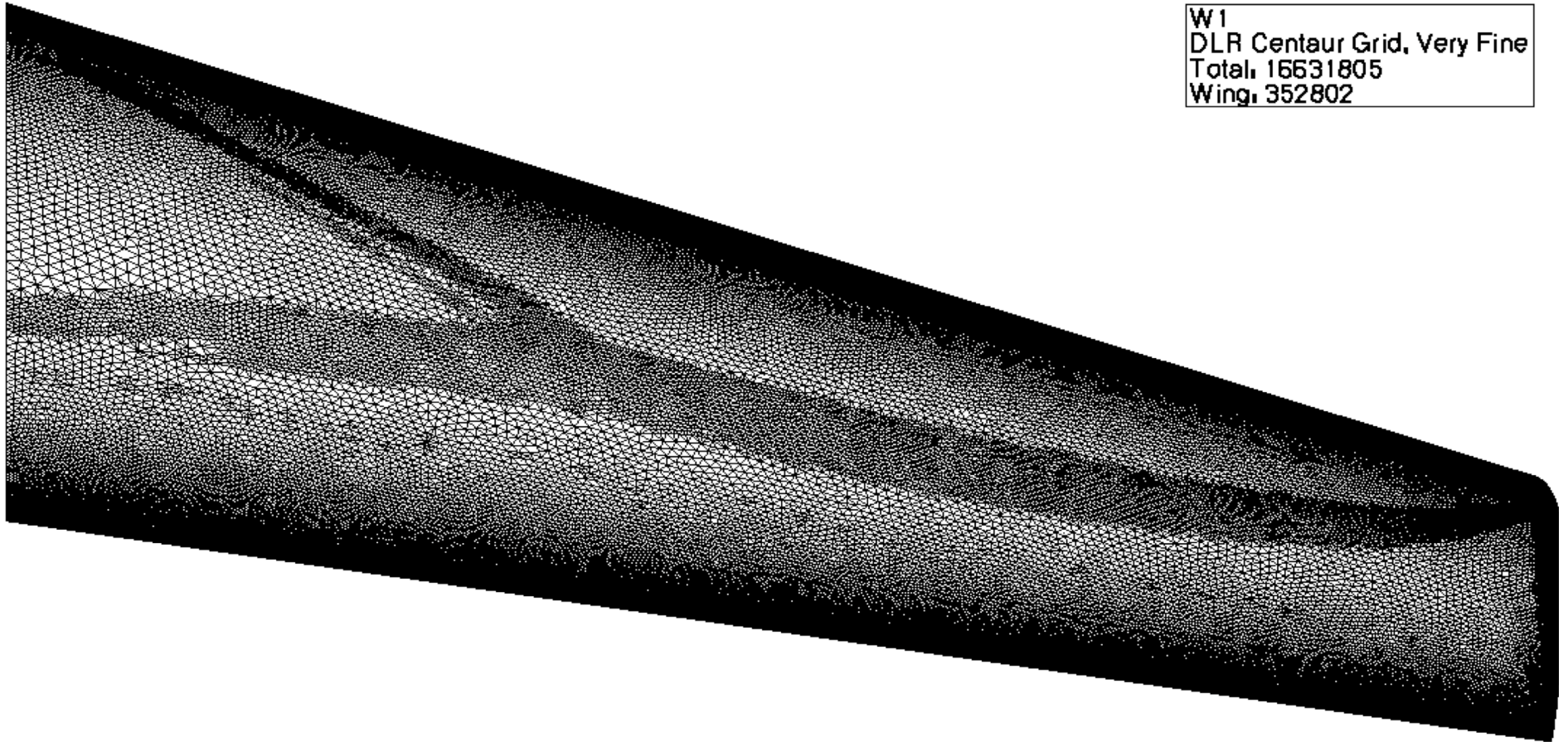


Centaur - DLR (Node Based)



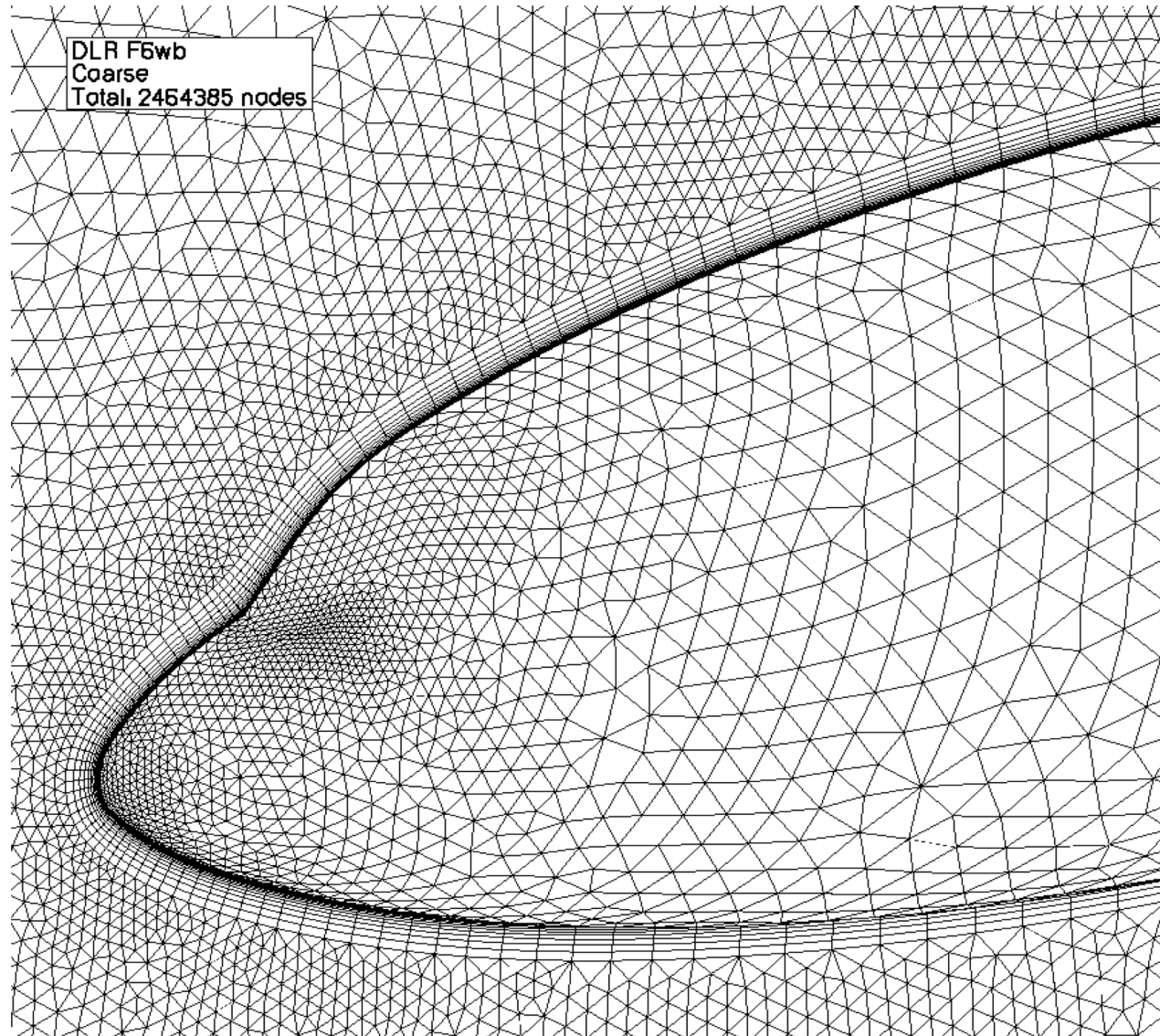
W1
DLR Centaur Grid, Fine
Total, 10150588
Wing, 186787

Centaur - DLR (Node Based)

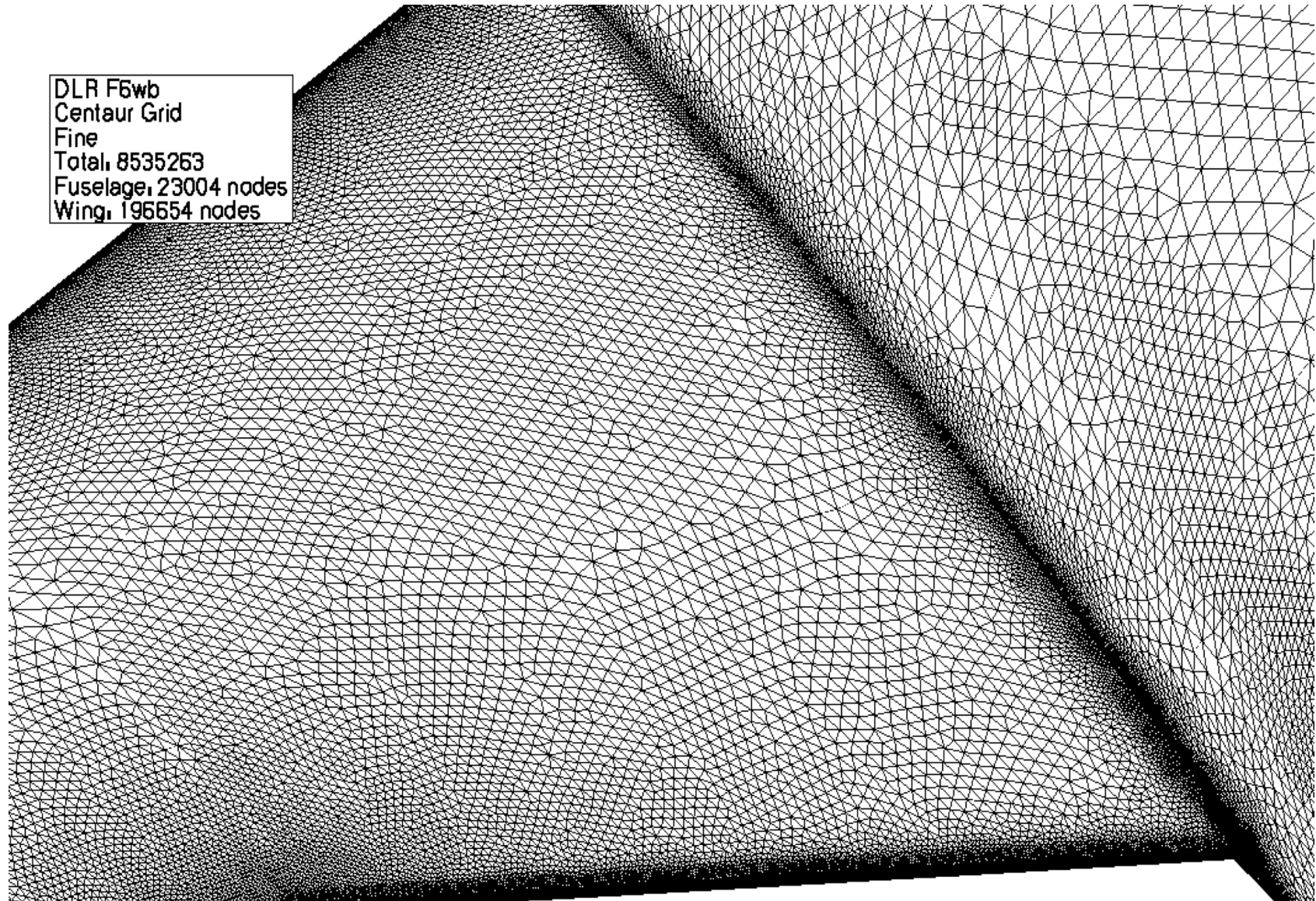


W1
DLR Centaur Grid, Very Fine
Total: 16631805
Wing: 352802

Centaur - DLR (Node Based)



Centaur - DLR (Node Based)



Point-matched multi-block structured grids

- Generated using a commercial software, Gridgen

Near the model surface:

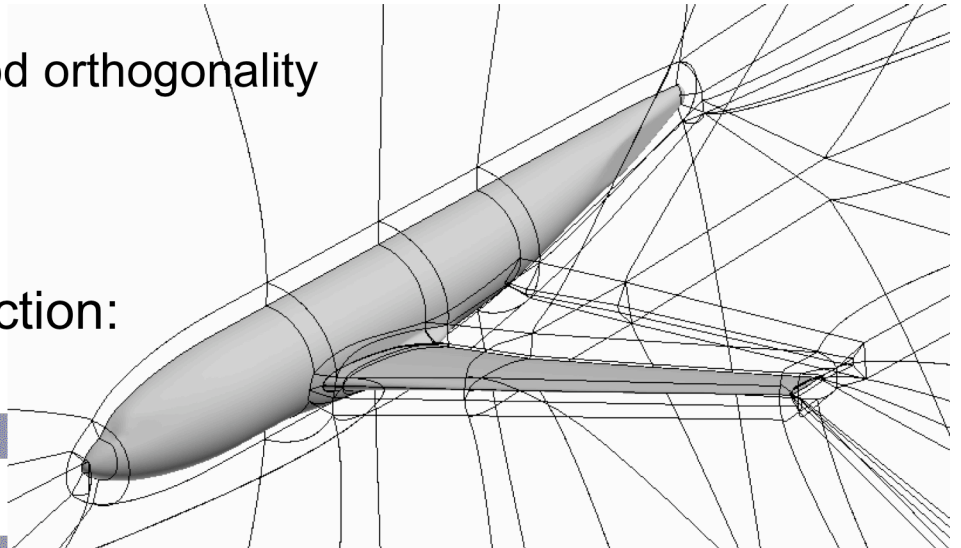
O-O grid topology to guarantee good orthogonality within the boundary layer

Outward:

C-O grid topology

At the corner of the wing-body junction:

Two kinds of grid topology

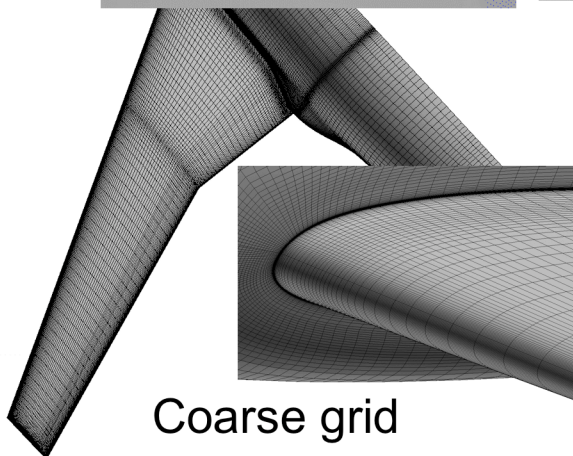


Block wire frame for DLR-F6 FX2B

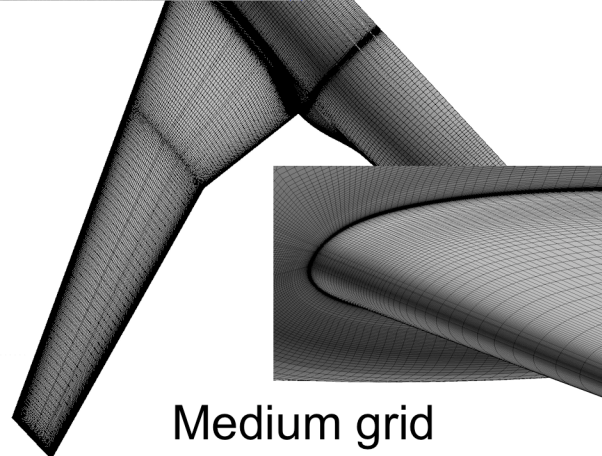
Wing-Body Junction

Simple

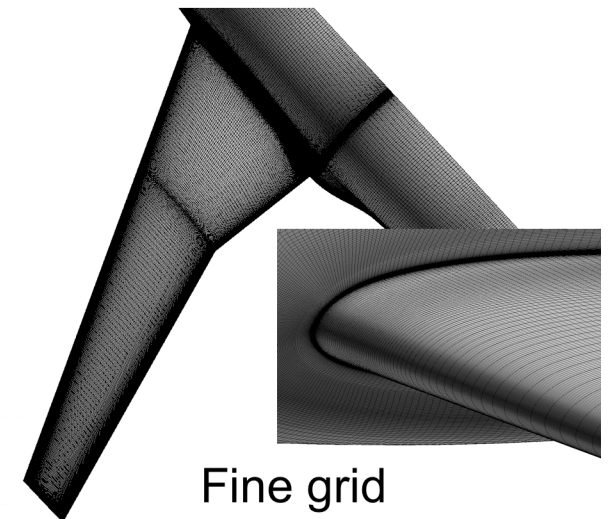
Extrude



Coarse grid



Medium grid



Fine grid

Mixed element unstructured grids

- Generated using TAS-Mesh

Surface grid (Triangles)

Direct advancing front method

Regular triangles that are not so stretched

Volume grid (Tetrahedra, Prisms, Pyramids)

Option of the generation method

(a) Delauney (tetra) → insertion of prismatic layer (prism)

(b) Advancing front (tetra) → insertion of prism layer (prism)

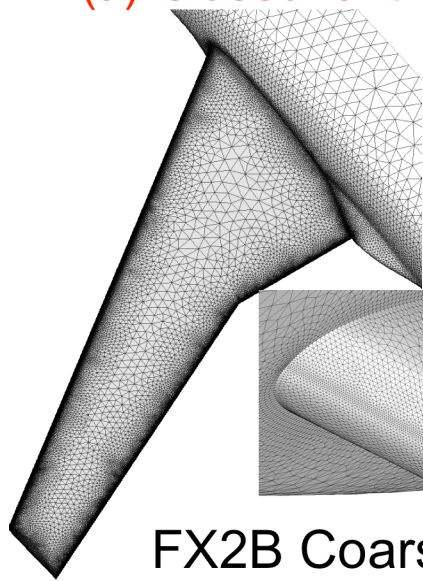
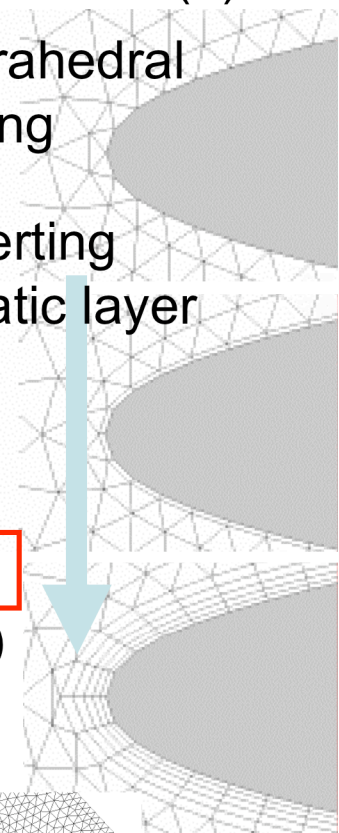
(c) Advancing layer (prism) → Advancing front (tetra)

(a) is used for the computations

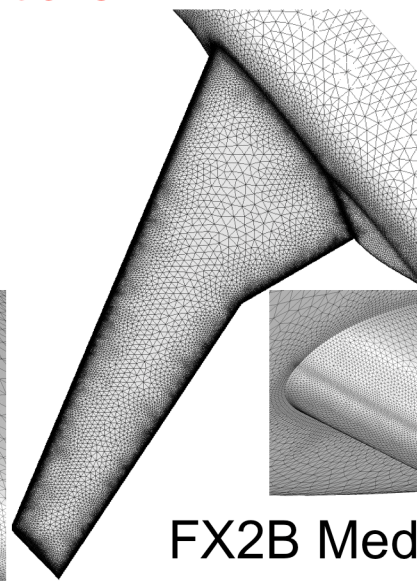
Procedure of (a)

1. Tetrahedral meshing

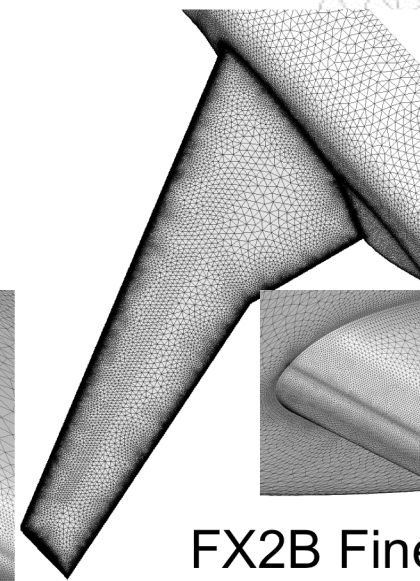
2. Inserting prismatic layer



FX2B Coarse



FX2B Medium



FX2B Fine

Grid information

Structured grid (Simple)

Config.	Density	Nodes	Surf.Nodes	BL1stCellSize	GrowthRate	TE Cells
DLR-F6	Coarse	3.1M	47K	0.0006[mm]	1.29	8
	Medium	9.8M	100K	0.0004[mm]	1.17	12
	Fine	29.8M	209K	0.00027[mm]	1.12	16
DLR-F6 FX2B	Coarse	3.3M	49K	0.0006[mm]	1.29	8
	Meidum	10.0M	103K	0.0004[mm]	1.17	12
	Fine	29.8M	209K	0.00027[mm]	1.12	16

Unstructured grid

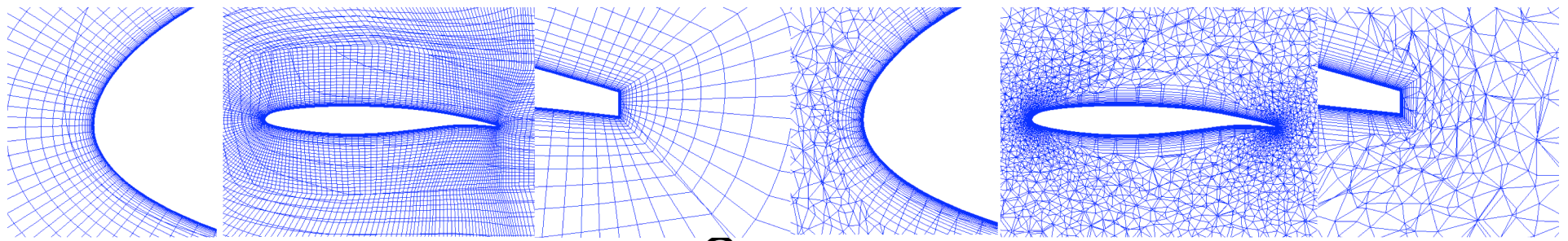
Config.	Density	Nodes	Surf.Nodes	BL1stCellSize	GrowthRate	TE Cells
DLR-F6	Coarse	5.4M	134K	0.0006[mm]	1.2	4
	Medium	9.4M	219K	0.0004[mm]	1.2	5
	Fine	17.5M	368K	0.00027[mm]	1.2	6
DLR-F6 FX2B	Coarse	5.4M	136K	0.0006[mm]	1.2	4
	Meidum	9.5M	223K	0.0004[mm]	1.2	5
	Fine	17.2M	378K	0.00027[mm]	1.2	6

Different from the grid guideline

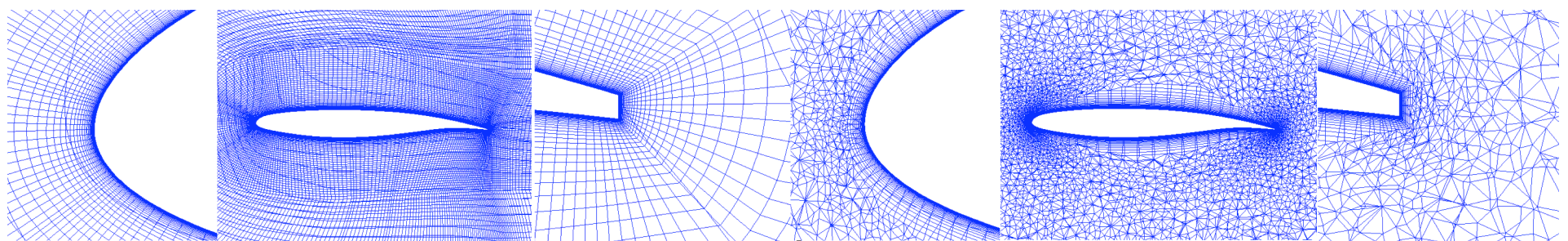
Comparison of cross-sectional view at kink location

Multi-block structured

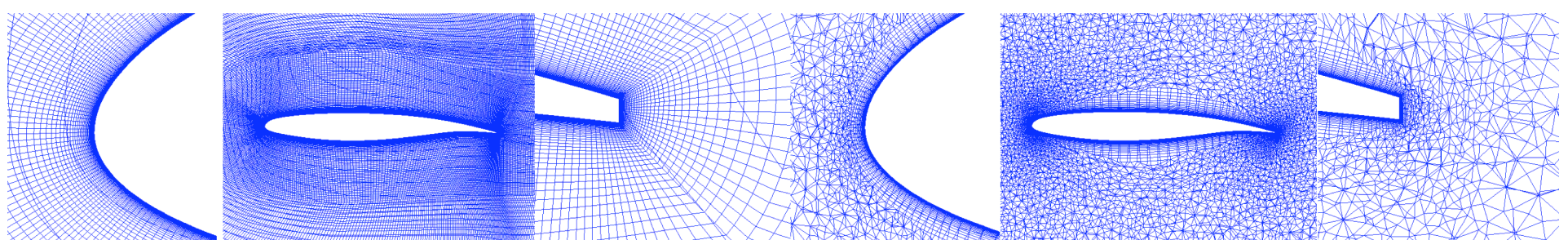
Unstructured



Coarse



Medium



Fine

Grid information (Detail)

Structured grid (Simple)

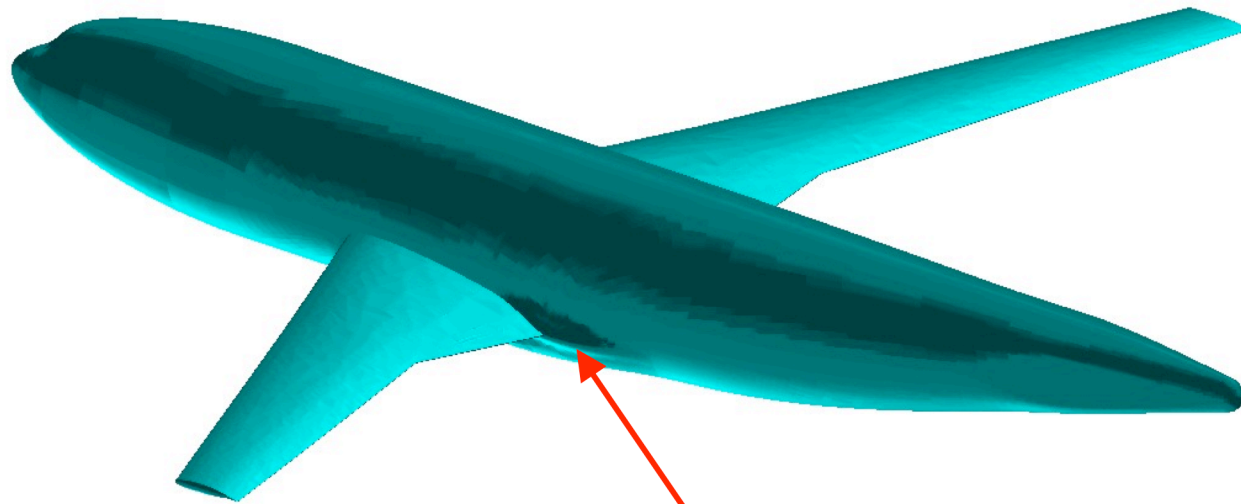
Config.	MeshType	Density	Zone	Nodes	Cells	Surf.Nodes	BL1stCellSize	GrowthRate	TE Cells
DLR-F6	Multi-block structured	Coarse	222	3.1M	2.7M	47K	0.0006[mm]	1.29	8
		Medium	222	9.8M	8.9M	100K	0.0004[mm]	1.17	12
		Fine	222	29.8M	28.0M	209K	0.00027[mm]	1.12	16
DLR-F6 FX2B	Multi-block structured	Coarse	222	3.3M	2.8M	49K	0.0006[mm]	1.29	8
		Medium	222	10.0M	9.1M	103K	0.0004[mm]	1.17	12
		Fine	222	29.8M	28.0M	209K	0.00027[mm]	1.12	16

Unstructured grid

Config.	MeshType	Density	Zone	Nodes	Cells	Surf.Nodes	BL1stCellSize	GrowthRate	TE Cells
DLR-F6	Mixed Unstructured	Coarse	1	5.4M	5.0M tet, 8.9M pri	134K	0.0006[mm]	1.2	4
		Medium	1	9.4M	10.7M tet, 14.9M pri	219K	0.0004[mm]	1.2	5
		Fine	1	17.5M	25.3M tet, 25.9M pri	368K	0.00027[mm]	1.2	6
DLR-F6 FX2B	Mixed Unstructured	Coarse	1	5.4M	5.0M tet, 8.9M pri	136K	0.0006[mm]	1.2	4
		Medium	1	9.5M	10.8M tet, 15.0M pri	223K	0.0004[mm]	1.2	5
		Fine	1	17.2M	23.9M tet, 25.8M pri	378K	0.00027[mm]	1.2	6

GridPro grids for Drag Prediction Workshop 2006

High Fidelity grid on a wing-body geometry with fairing

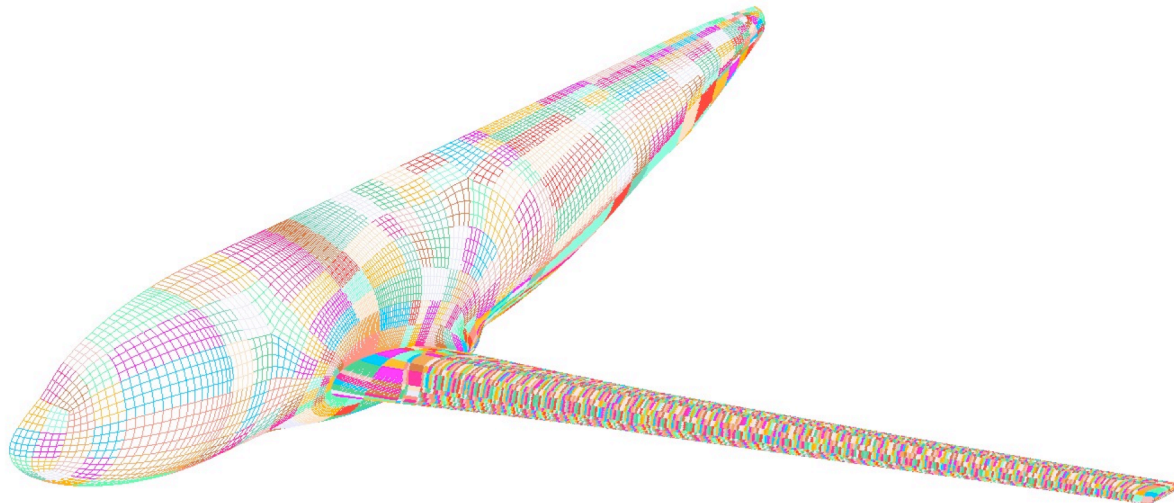


Fairing



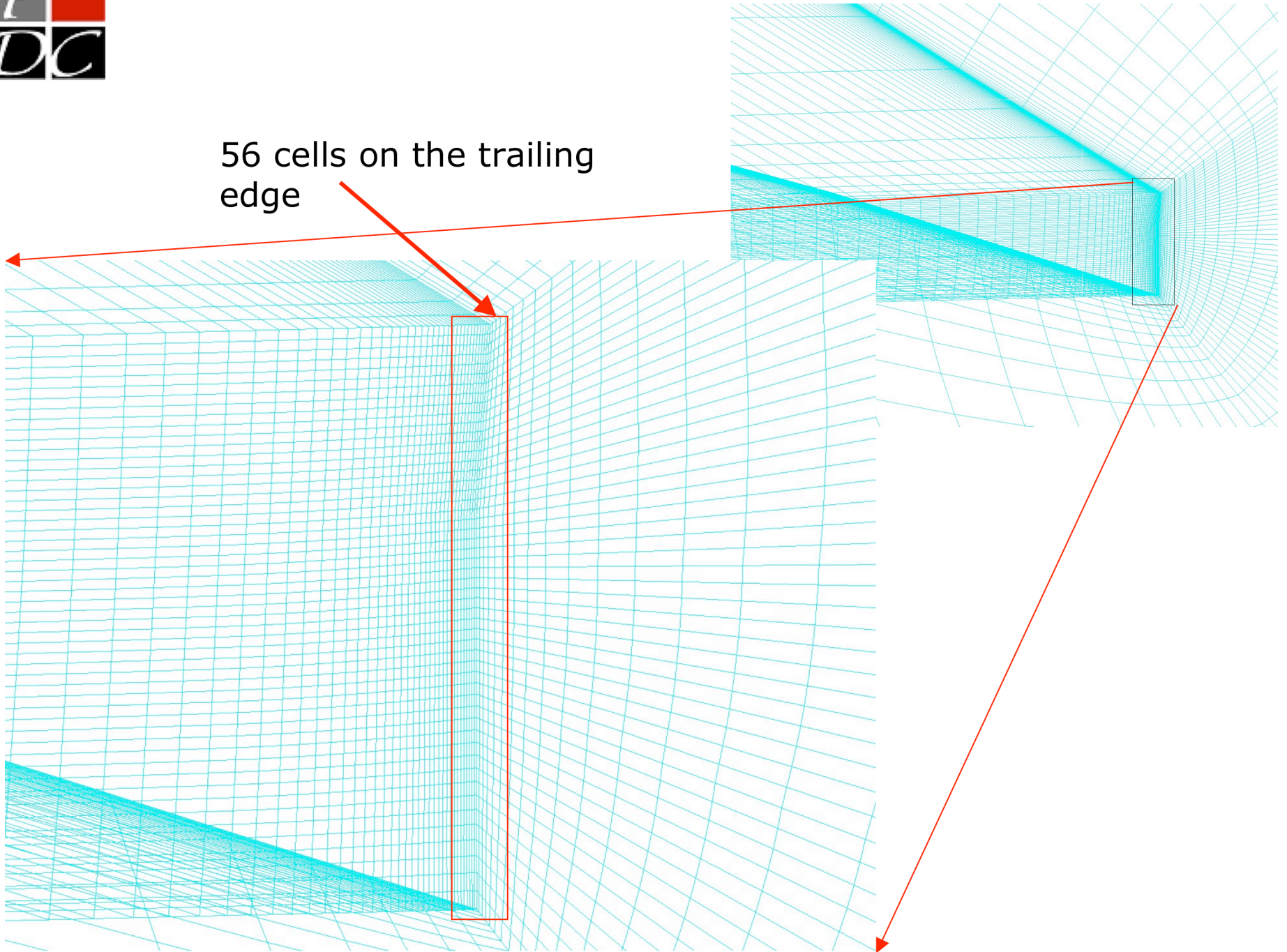
Some Grid Stats

1. ~ 380k Cells on the surface
2. ~ 17 million cells on the whole grid – Most of them near the surface
3. 56 cells on the width of the blunt trailing edge
4. First grid off wall spacing from the surface 1.8×10^{-4}
5. Nested grid.
6. Far Field boundary – about 100 times the length of the fuselage



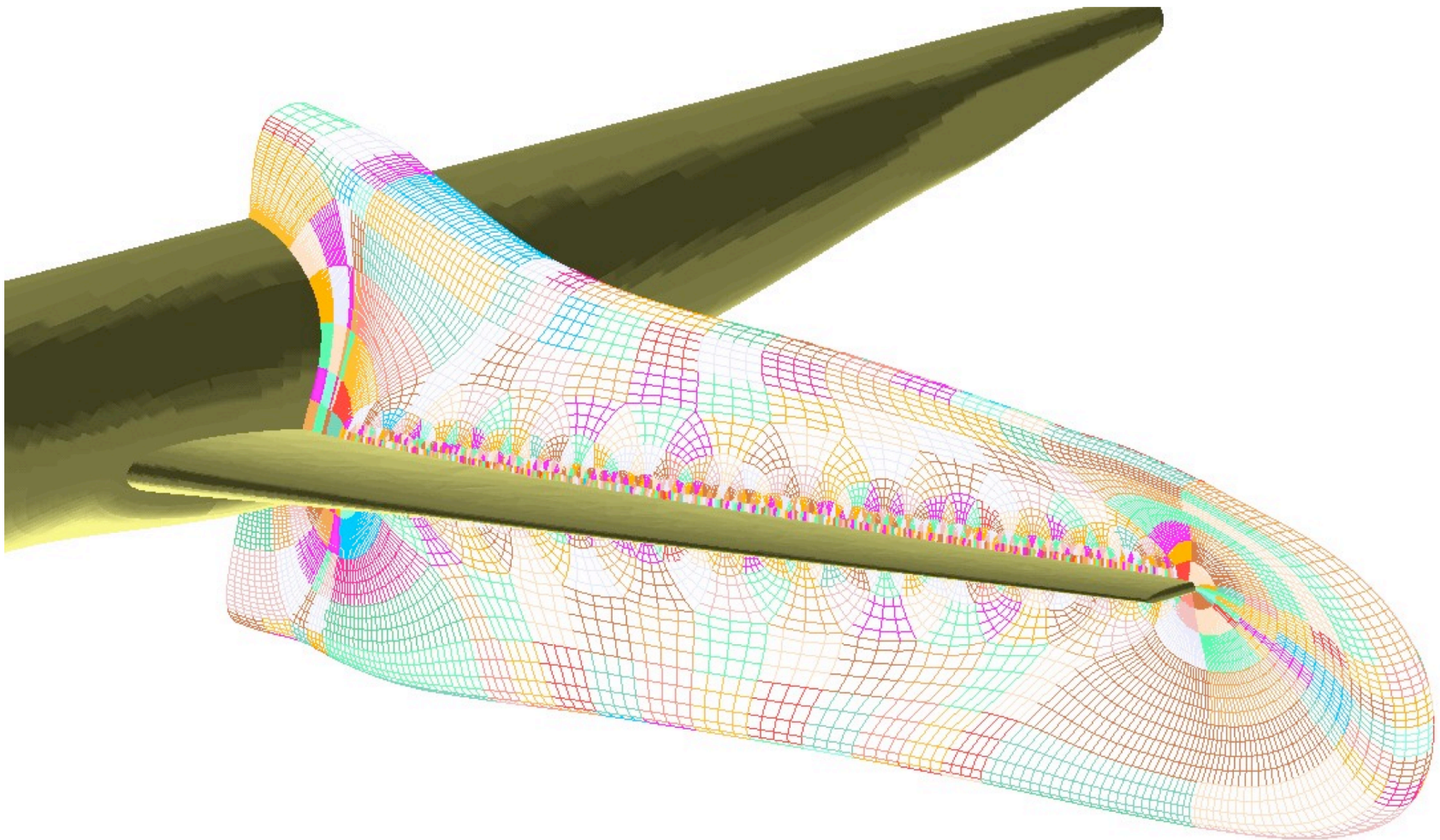


56 cells on the trailing edge



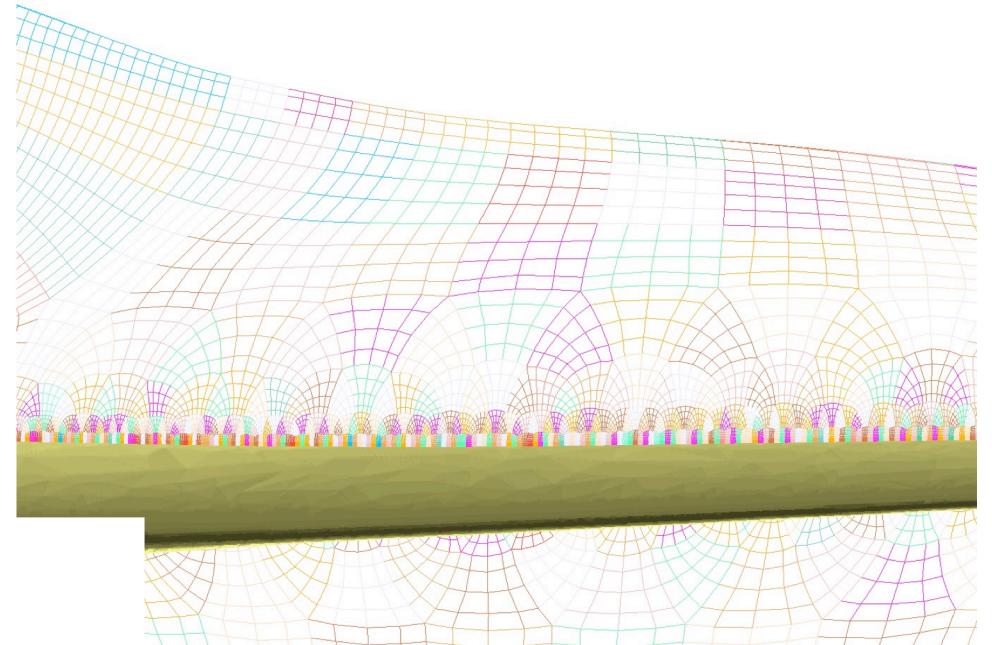
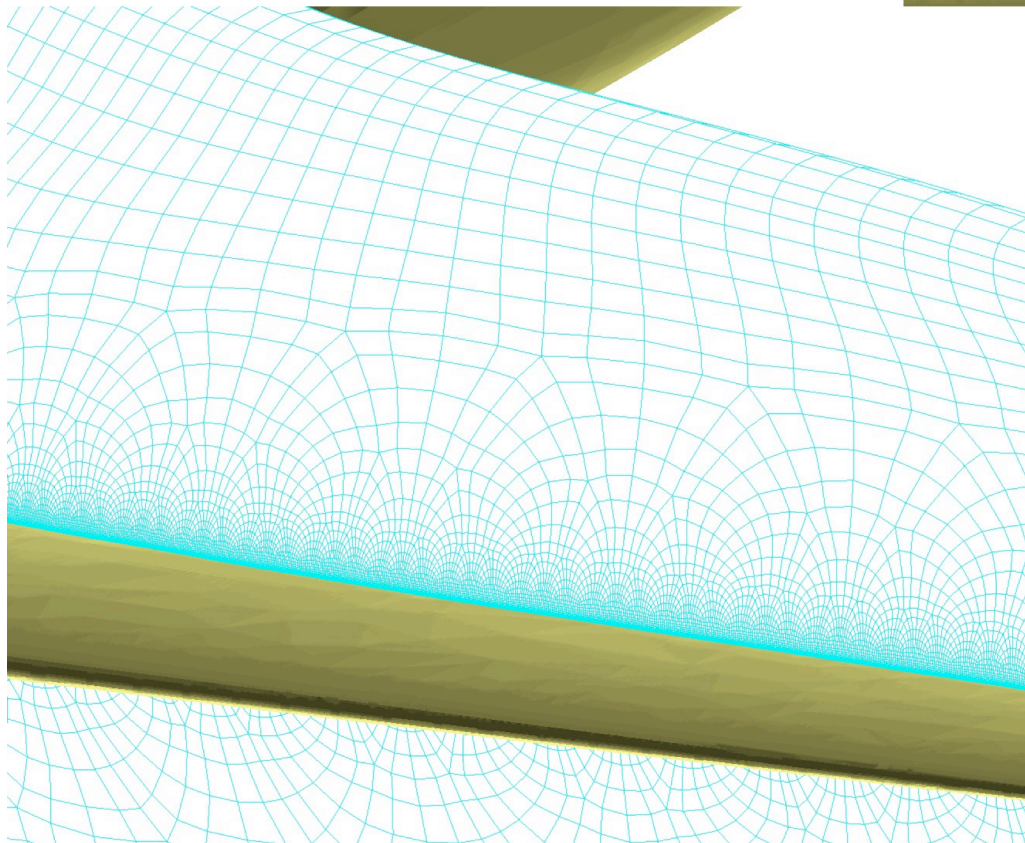


Grid sheet on the wing. (Nested Grid)



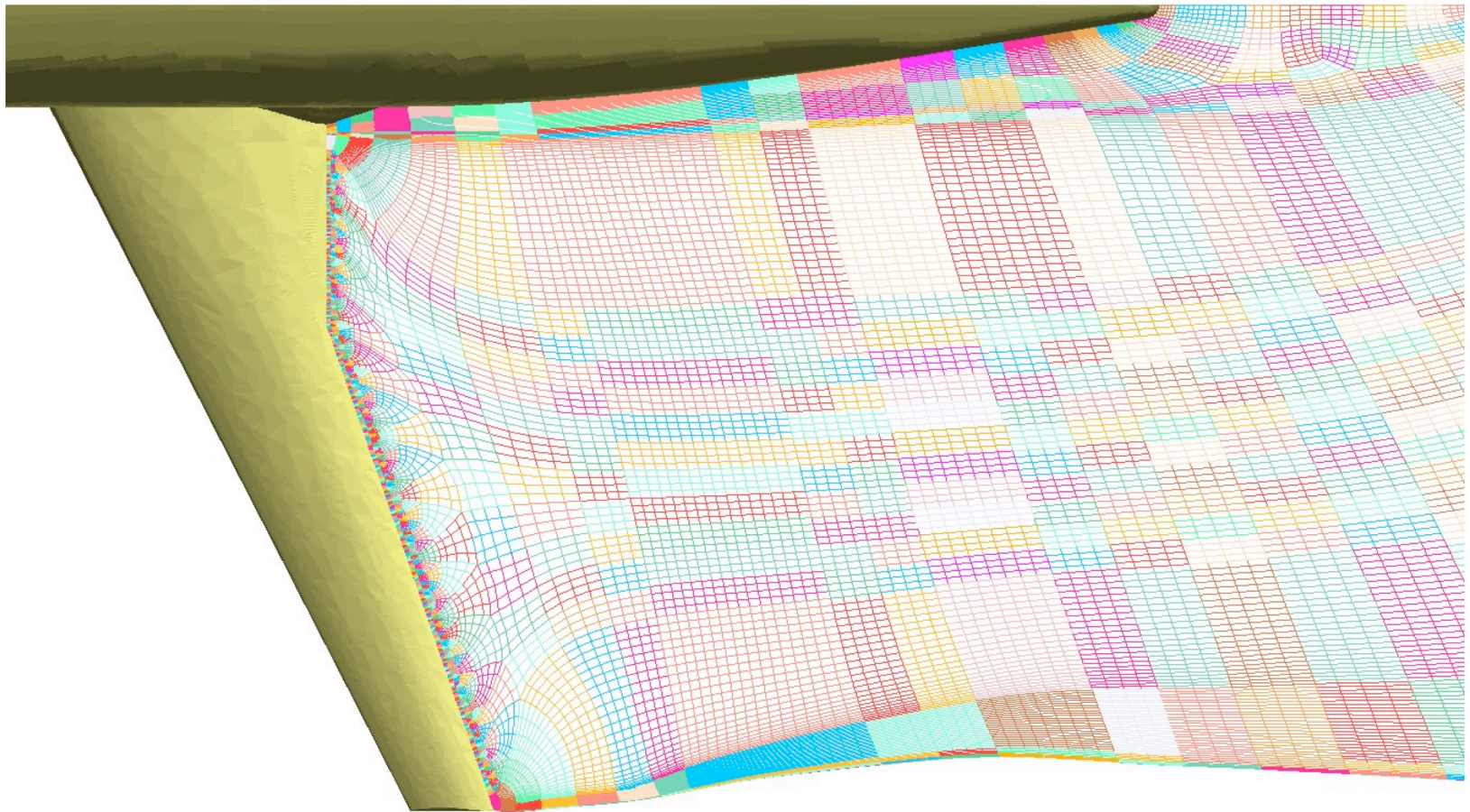


Grid sheet on
the wing.
(Nested Grid)





Grid in the wake region





Grid in the wake region – Near the fairing

