Grid System Overview

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Outline

- Gridding requirements
- Descriptions of grids
- Grid sizes
- Qualitative grid comparisons
- Credits

Gridding Guidelines

Initial spacing normal to all viscous walls (RE = 4.3M based on C_{REF}=39.6”):

- Coarse: y^+ ~ 1.0 Dy = 0.00020 in
- Medium: y^+ ~ 2/3 Dy = 0.00013 in
- Fine: y^+ ~ 4/9 Dy = 0.00009 in
- Extra-Fine: y^+ ~ 8/27 Dy = 0.00006 in

Total grid size to grow ~3X between each grid level for grid convergence cases

- For structured meshes, this growth is ~1.5X in each coordinate direction

Growth rate of cell sizes in the viscous layer should be < 1.25

- Include a region with constant cell spacing (growth rate = 1.0) to capture wakes from upstream elements

Farfield located at ~100 C_{REF}’s for all grid levels

For the Medium Baseline Grids:

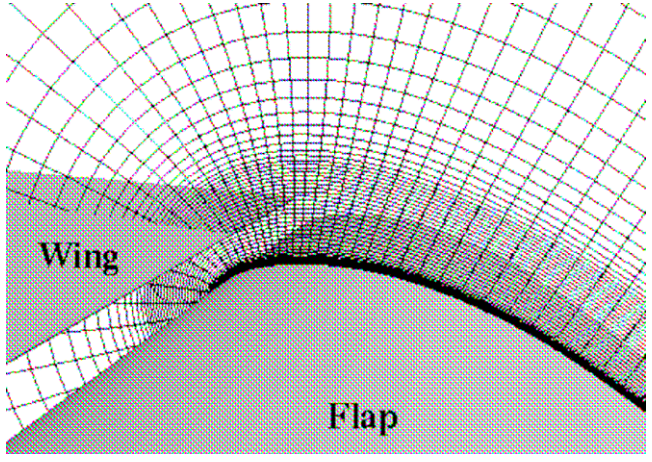
- Chordwise spacing for wing and tail leading edge (LE) and trailing edge (TE) ~0.1% local chord
- Spanwise spacing at root and tip ~0.1% local semispan
- Cell size near fuselage nose and after-body ~2.0% CREF

Wing and Tail Trailing Edge Base:

- Minimum of 4 cells across TE base for the coarse mesh
- Minimum of 6 cells across TE base for the medium mesh
- Minimum of 9 cells across TE base for the fine mesh
- Minimum of 14 cells across TE base for the extra-fine mesh

Be multi-grid friendly

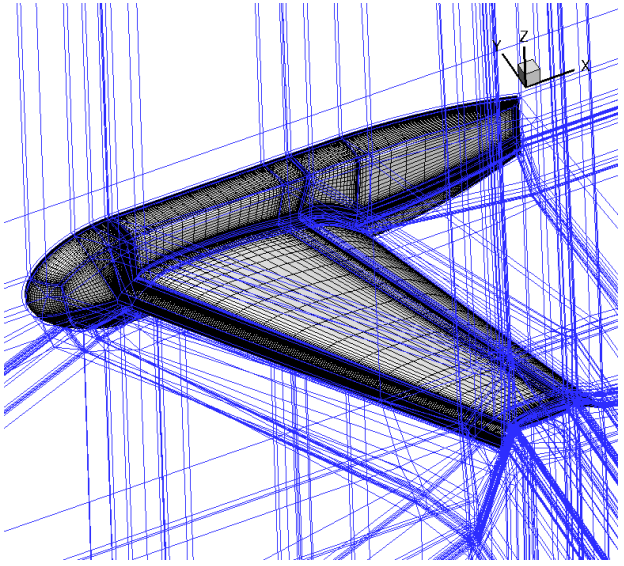
No grid size targets specified



Structured – Point matched

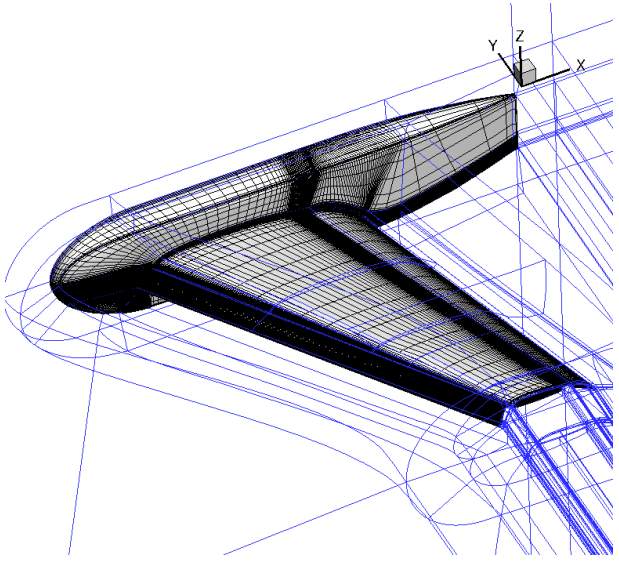
ICEM – Boeing

- Str-OnetoOne-A-v1
- Unstr-Hex-FromOnetoOne-A-v1
  - NASA Langley
  - Codes: CFD++, CFX
- 1235 zones
- Codes: CFL3D, elsA



GridGen - Pointwise

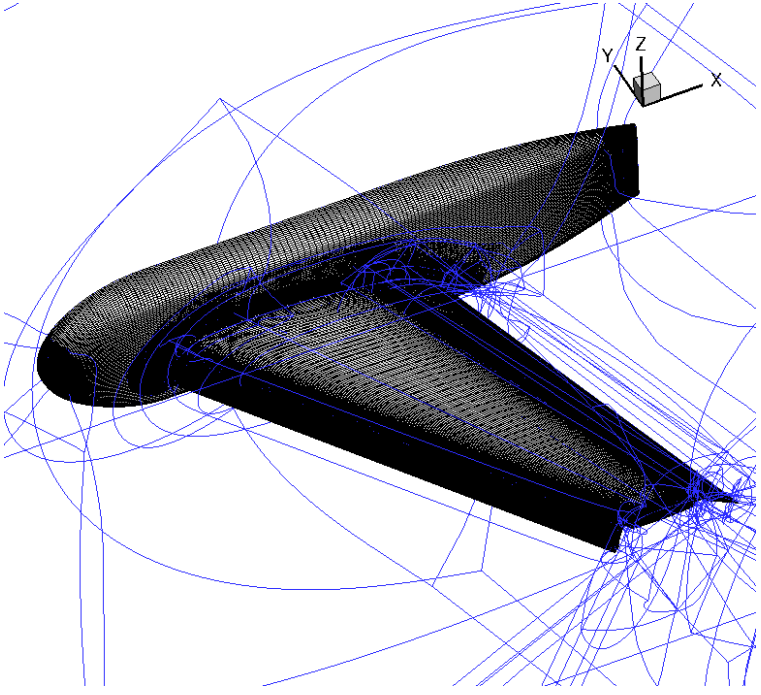
- Str-OnetoOne-B-v1
- 306/309 zones depending on grid size
- Codes: CFL3D



Structured - Overset

Chimera Grid Tools (CGT) + Boeing proprietary tools

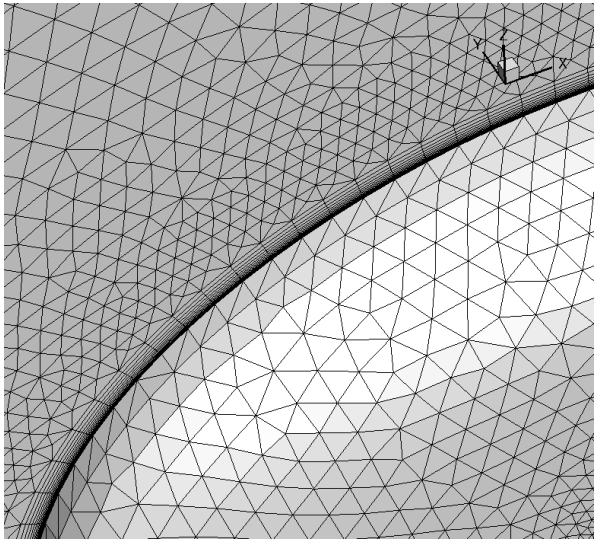
- Str-Overset-A-v3
- 34 zones
- Brackets
- Alternative hole cutting considered by NASA Ames
- Codes: Overflow



Unstructured - Mixed

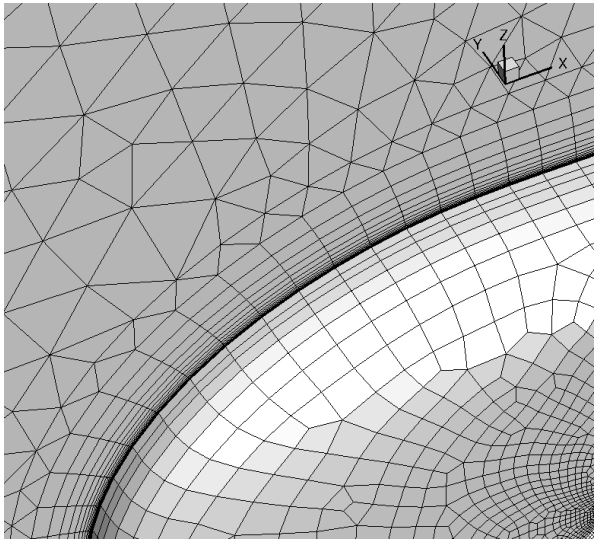
Centaur-DLR

- Unst-Mixed-Nodecentered-A-v1
- BL: Primarily prisms
- Farfield: Tets
- Incomplete set
- Codes: Tau



Solar-DLR

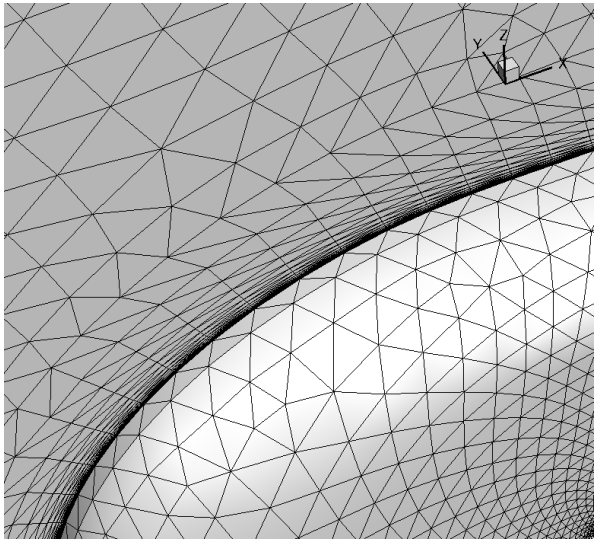
- Unst-Mixed-Nodecentered-B-v1
- BL: Primarily hexas, some prisms
- Farfield: Tets
- Brackets
- Codes: Edge, Tau



Unstructured - Tetrahedral

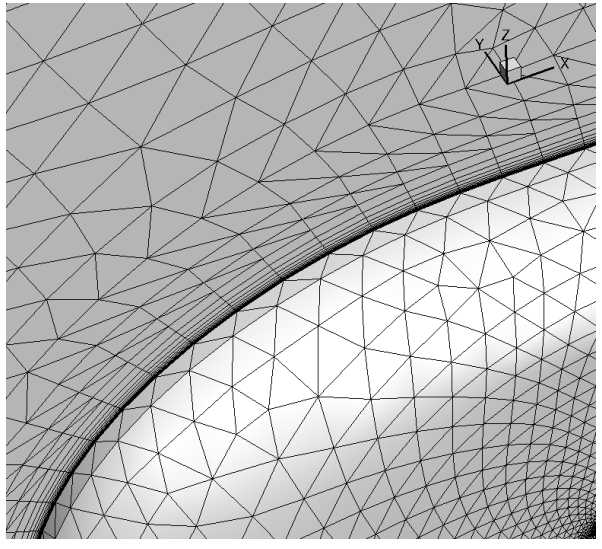
VGrid

- Node Centered – Univ. of Wy
  - Unst-Tet-Nodecentered-A-v1
  - Codes: CFD++, FUN3D
- Cell centered – NASA Langley
  - Unst-Tet-Cellcentered-A-v1
  - Codes: USM3D

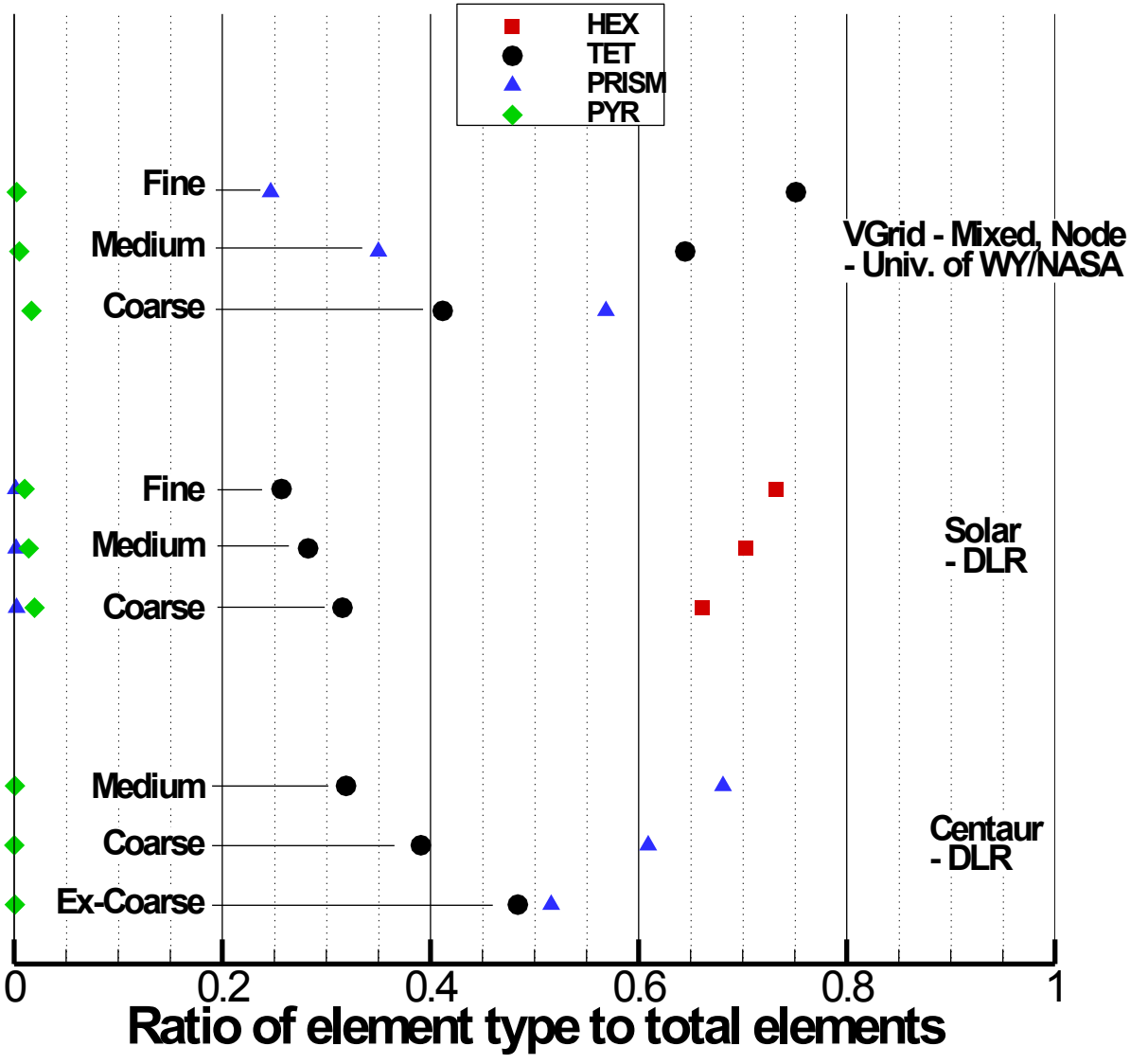


VGrid with mixed/merged viscous cells

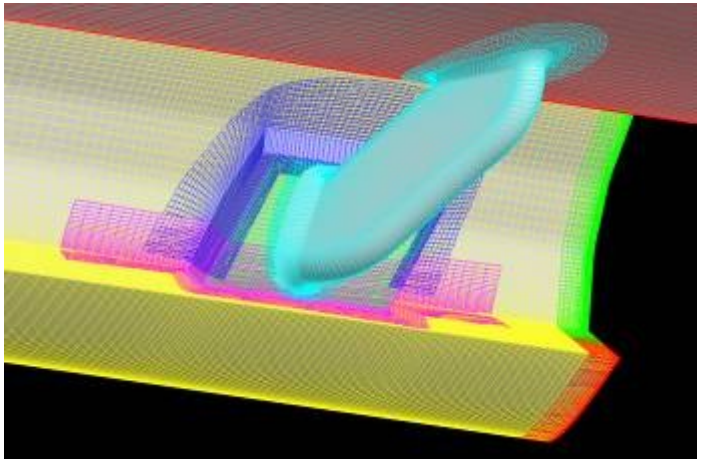
- Mixed/Merged viscous cells
  - Unst-Mixed-FromTet-Nodecentered-A-v1
  - BL: Prisms merged from tets
  - Farfield: Tets
  - Codes: FUN3D, NSU3D

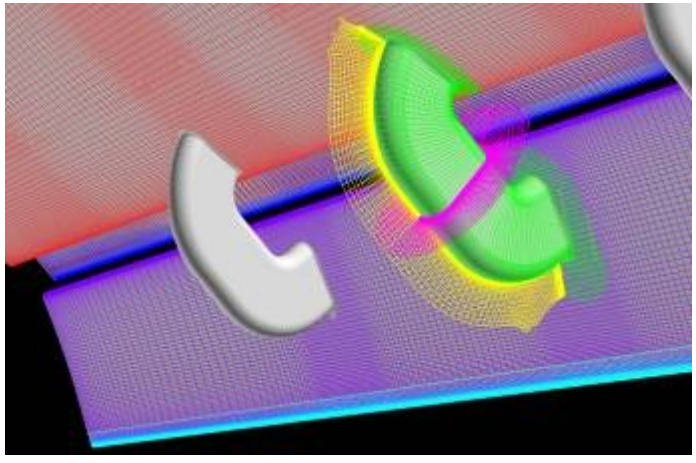


Element types for mixed grids

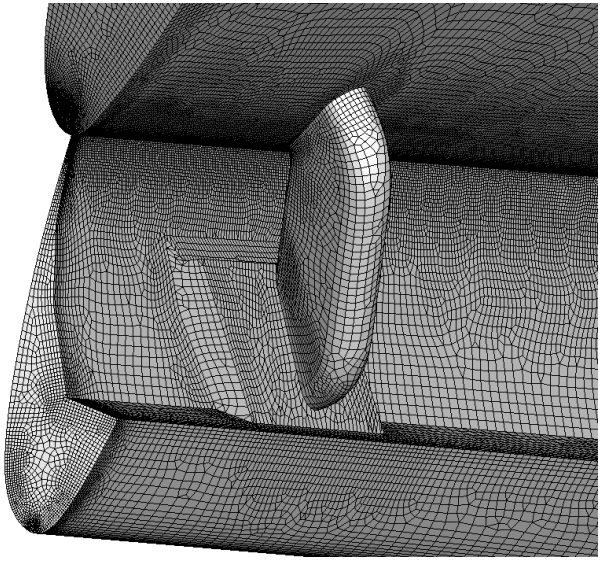


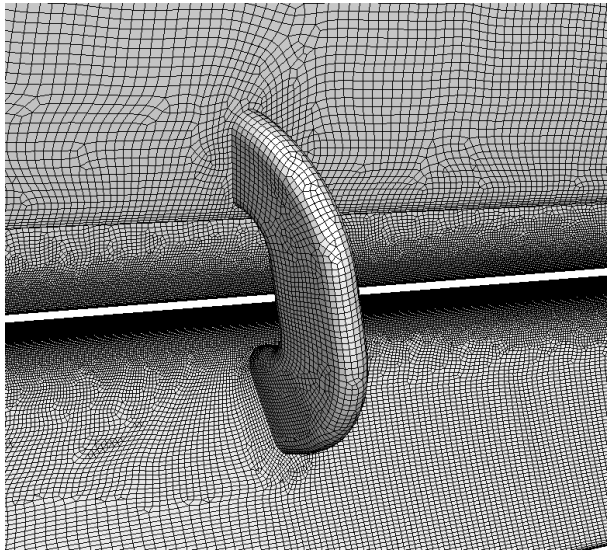
Brackets





CGT - Boeing



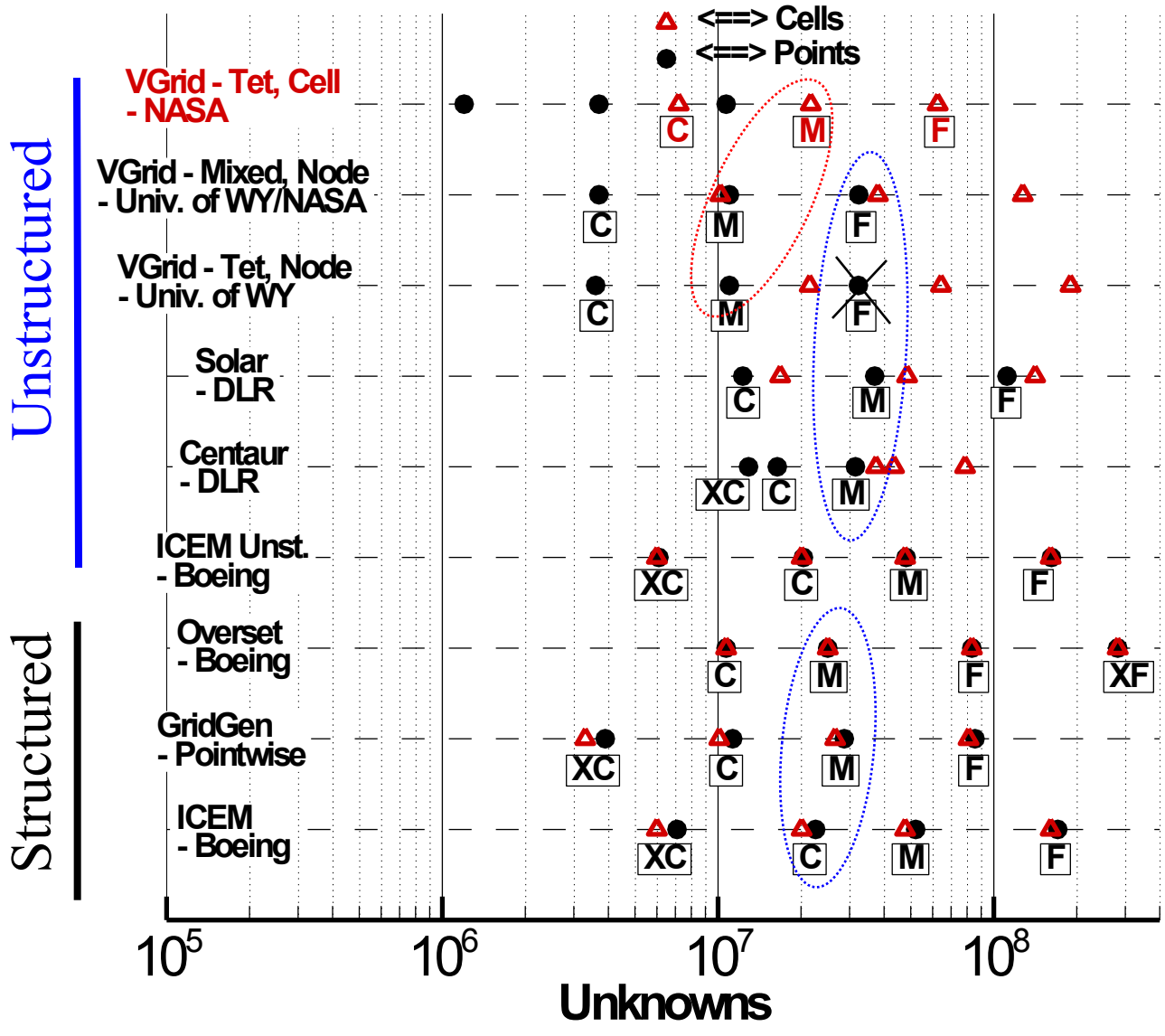


Solar - DLR

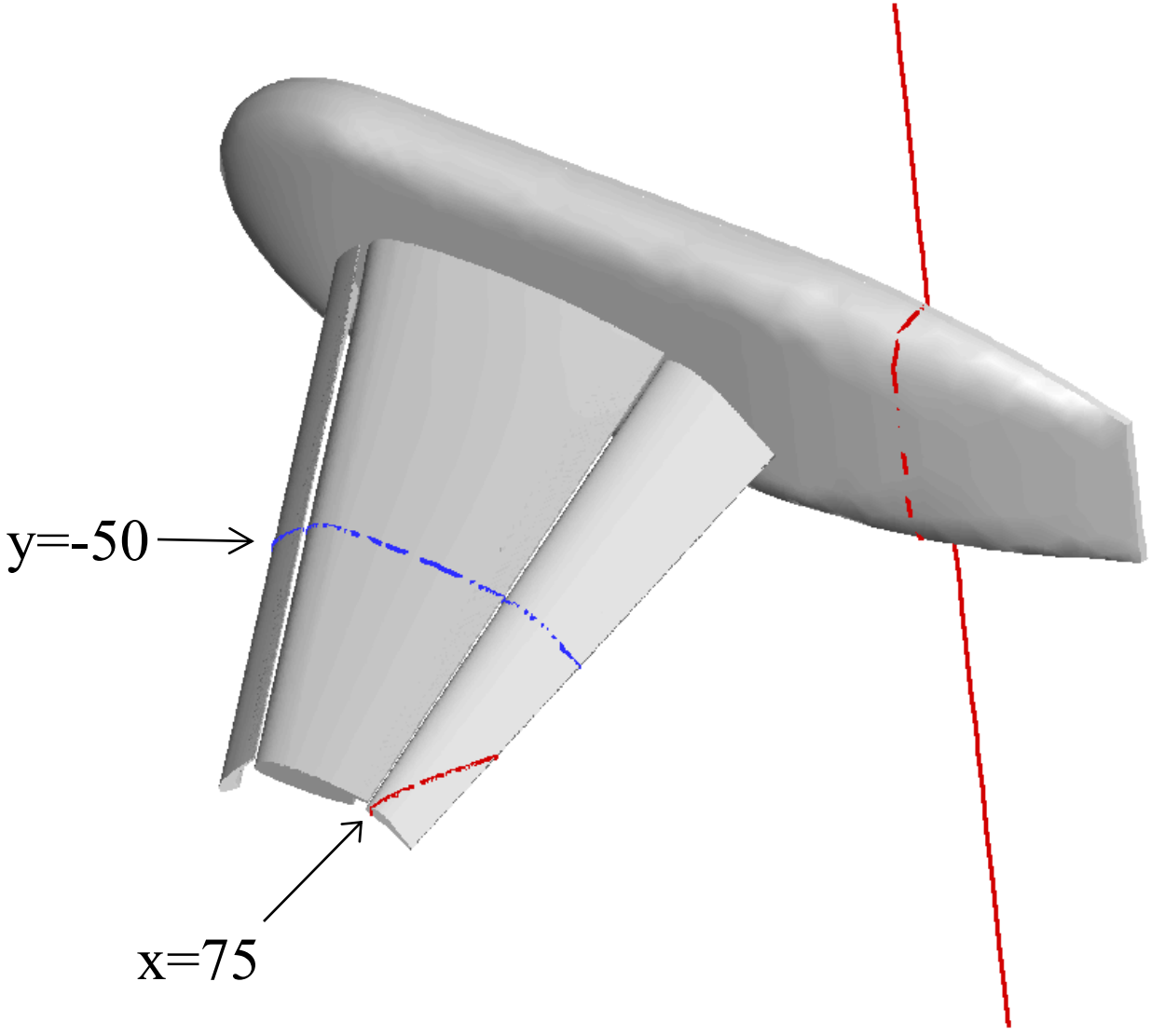
Grid sizes

	Extra Coarse	Coarse	Medium	Fine	Extra Fine
ICEM - Boeing	7,090,371 pts 5,957,632 cells	22,606,727 pts 20,107,008 cells	52,061,907 pts 47,661,056 cells	170,661,635 pts 160,856,064 cells	
GridGen - Pointwise	3,868,435 pts 3,324,920 cells	11,264,061 pts 10,125,268 cells	28,489,092 pts 26,599,360 cells	85,489,092 pts 81,002,144 cells	
CGT-Boeing		10,653,004 pts	24,965,818 pts	83,302,438 pts	281,560,012 pts
ICEM Unst. – Boeing/Langley	6,068,737 pts 5,957,632 cells	20,356,741 pts 20,107,008 cells	48,104,801 pts 47,661,056 cells	161,853,985 pts 160,856,064 cells	
VGrid Tet. - Univ. of Wy		3,652,657 pts 21,492,137 cells	10,957,783 pts 64,441,259 cells	32,297,530 pts 189,895,740 cells	
VGrid Mixed – U of Wy & Langley		3,727,008 pts 10,169,092 cells	11,047,965 pts 38,017,477 cells	32,445,391 pts 127,443,165 cells	
Centaur Mixed – DLR	12,923,391 pts 37,418,633 cells	16,374,761 pts 43,548,725 cells	31,498,984 pts 78,725,517 cells		
Solar Mixed - DLR		12,306,950 pts 16,785,122 cells	36,967,871 pts 48,500,228 cells	110,745,950 pts 141,308,342 cells	
Vgrid Tet, Cell - Langley		1,235,730 pts 7,237,190 cells	3,708,951 pts 21,743,354 cells	10,677,390 pts 62,664,381 cells	

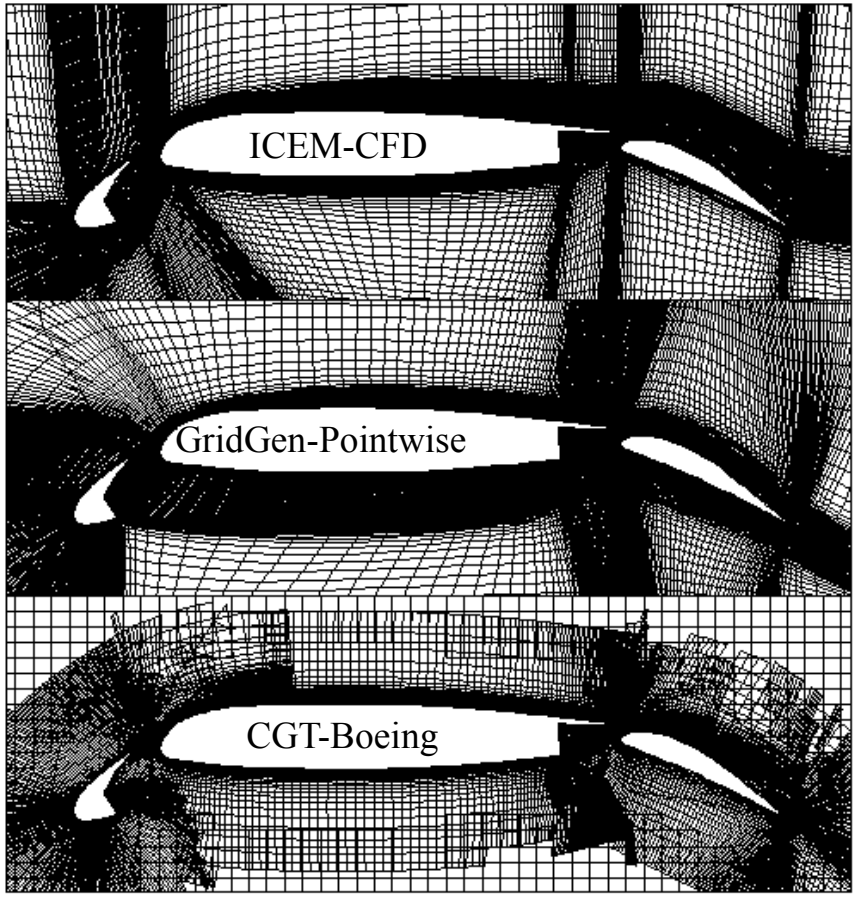
Grid sizes

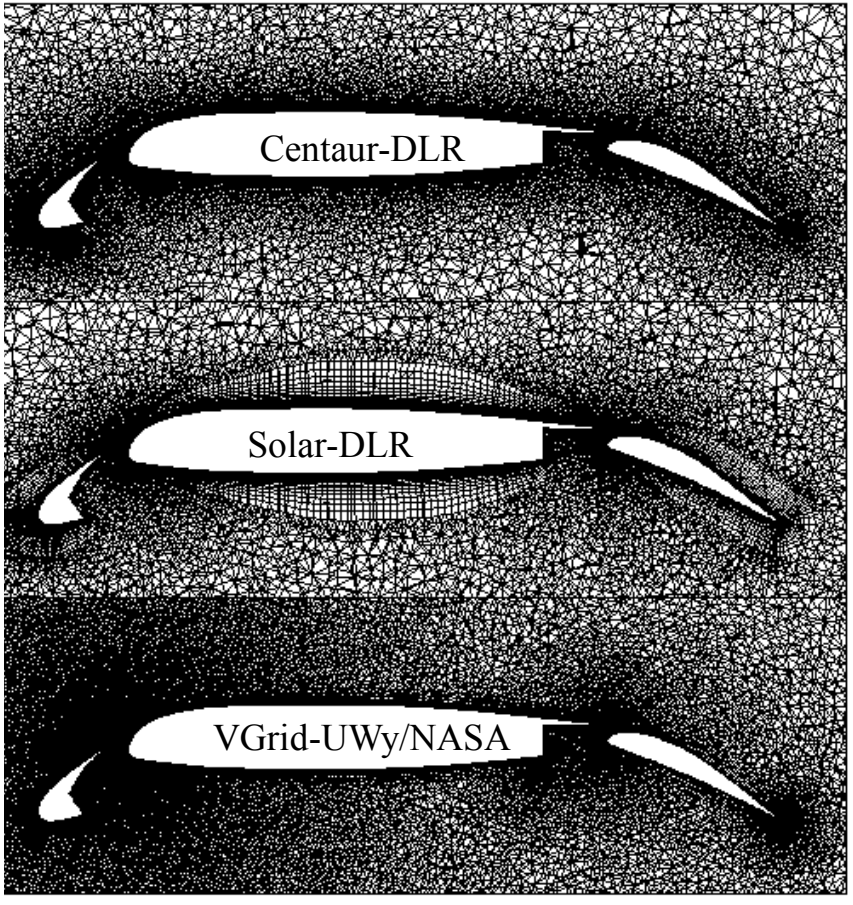

<==> Cells
<==> Points
Unstructured
Structured
VGrid - Tet, Cell - NASA
VGrid - Mixed, Node - Univ. of WY/NASA
VGrid - Tet, Node - Univ. of WY
Solar - DLR
Centaur - DLR
ICEM Unst. - Boeing
Overset - Boeing
GridGen - Pointwise
ICEM - Boeing
XC
C
M
F
XF
10^5
10^6
10^7
10^8
Unknowns

Slice locations

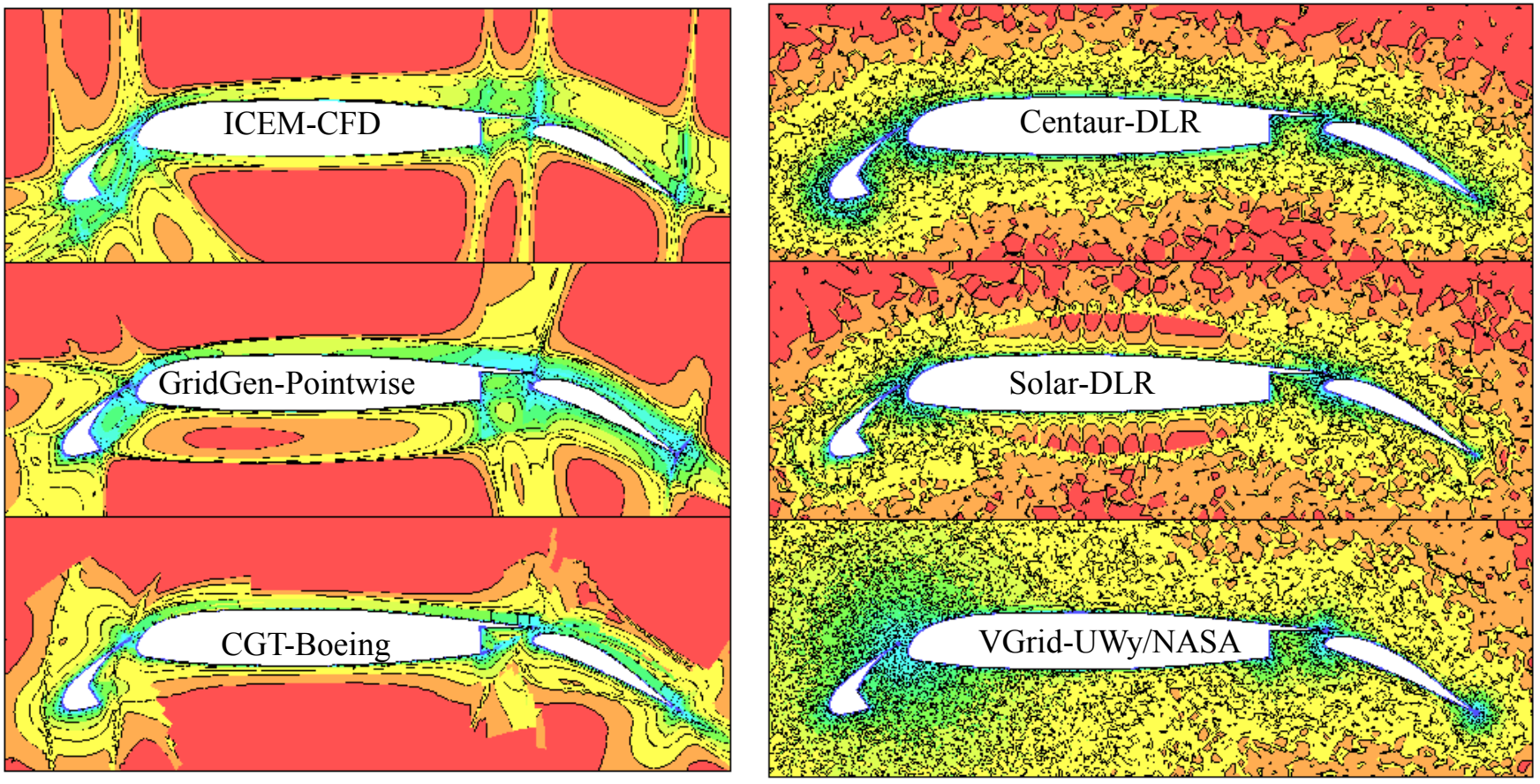


y=-50 slice

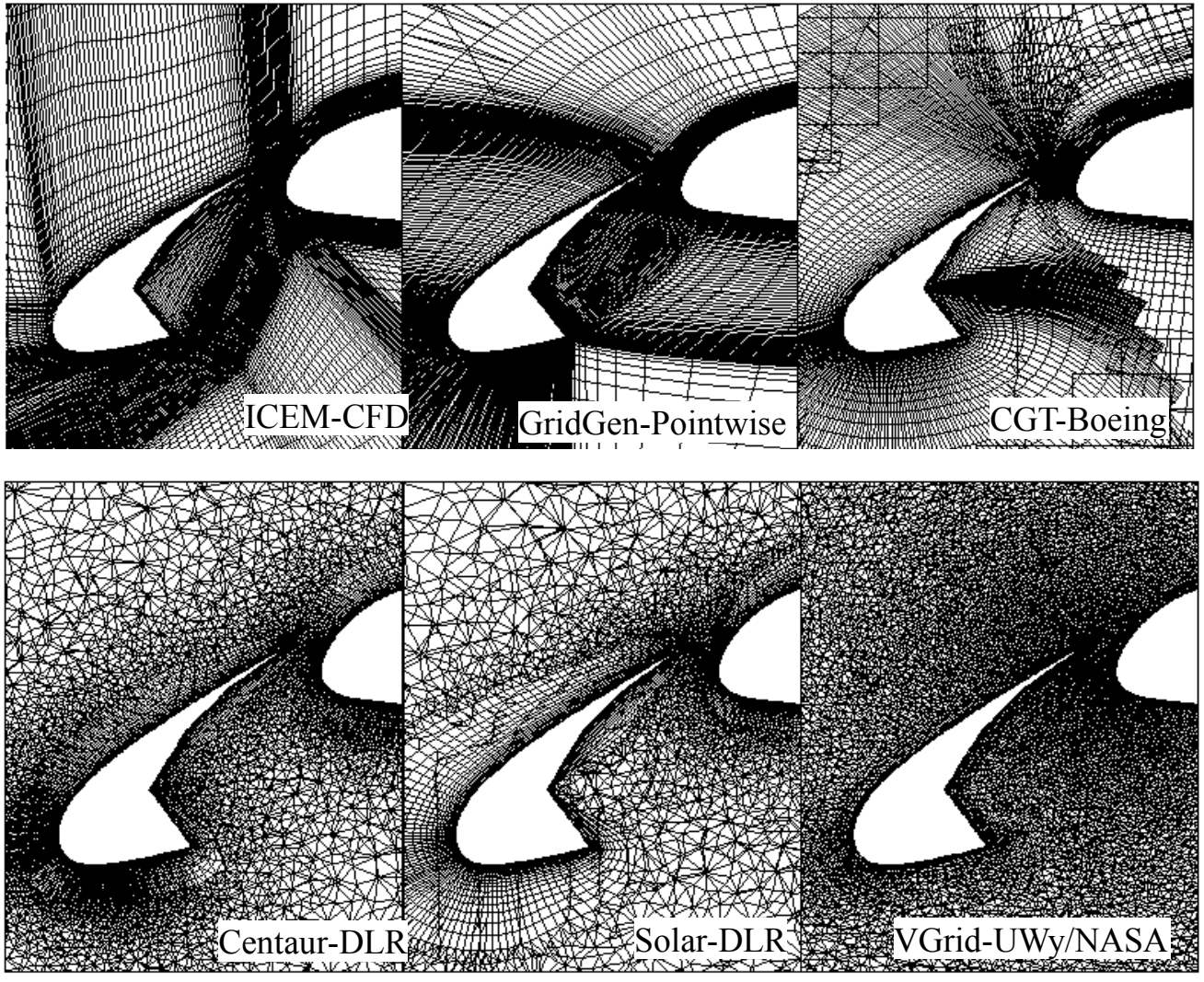

ICEM-CFD
GridGen-Pointwise
CGT-Boeing


Centaur-DLR
Solar-DLR
VGrid-UWy/NASA

y=-50 slice


ICEM-CFD
GridGen-Pointwise
CGT-Boeing
Centaur-DLR
Solar-DLR
VGrid-UWy/NASA
Cell area: 0.0001 0.0002 0.0004 0.0008 0.0016 0.0032 0.0064 0.0128 0.0256 0.0512 0.1024

Slat, y=-50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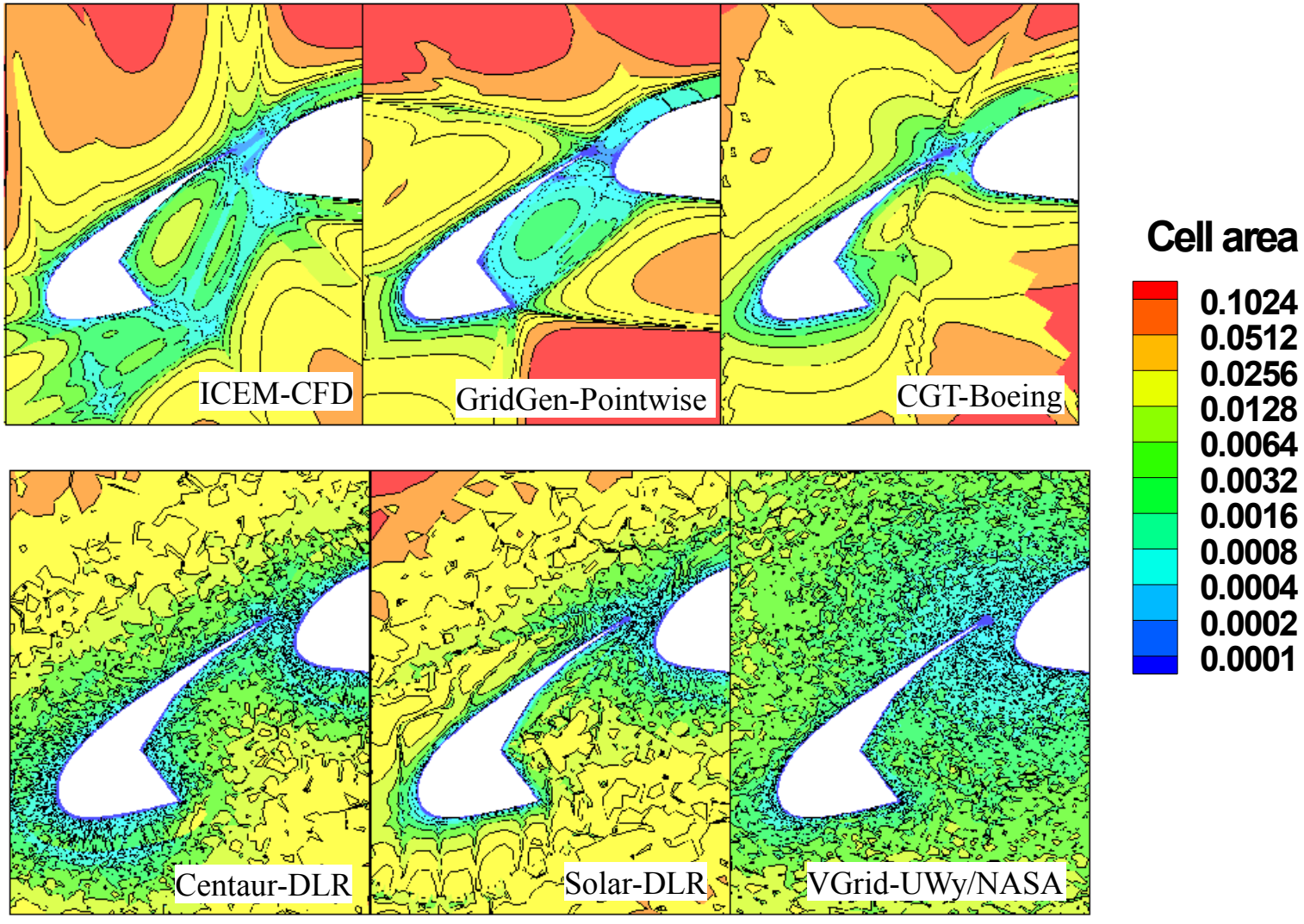
Slat, y=-50


ICEM-CFD
GridGen-Pointwise
CGT-Boeing
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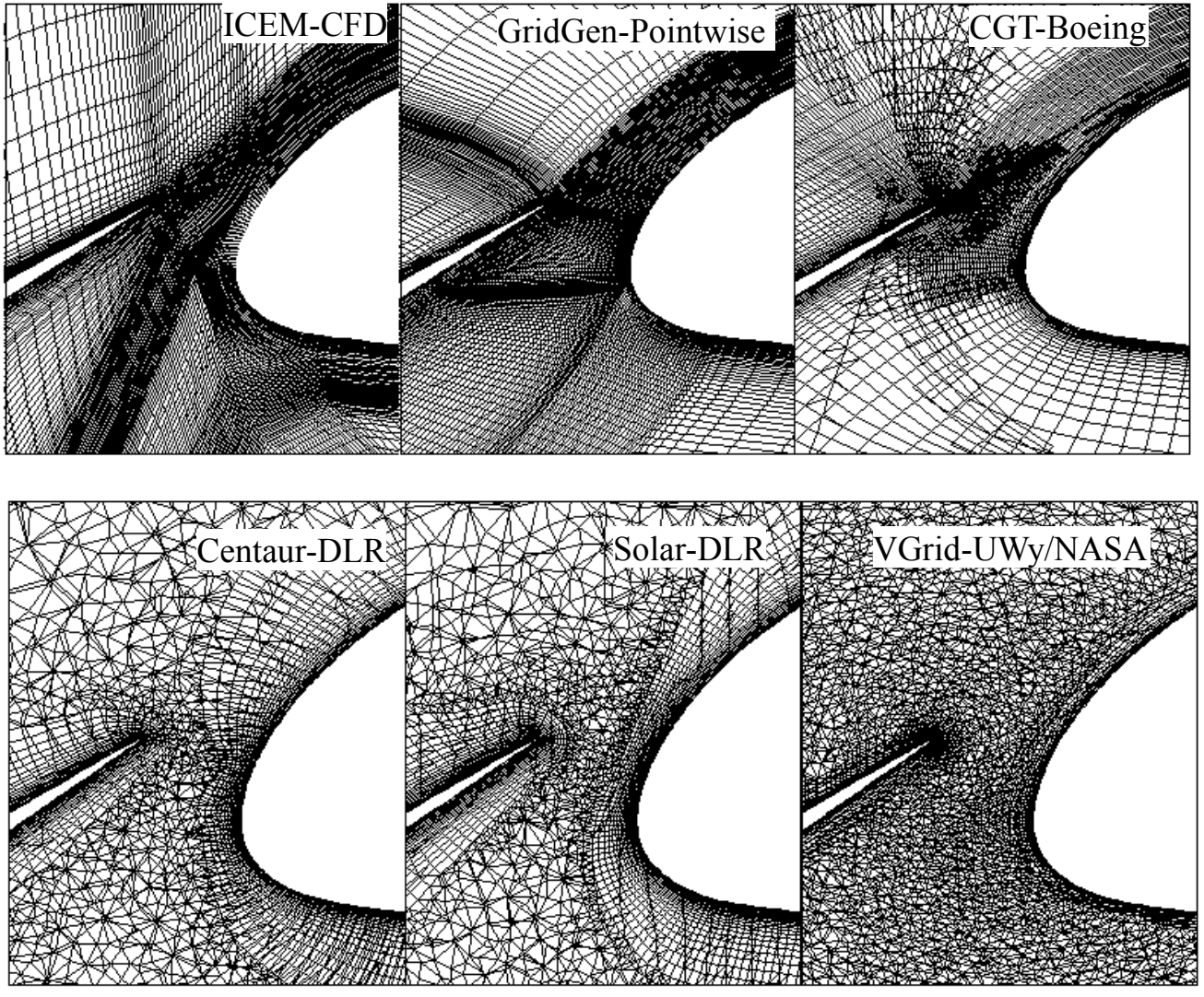
Cell area
0.1024
0.0512
0.0256
0.0128
0.0064
0.0032
0.0016
0.0008
0.0004
0.0002
0.0001

Slat TE, y=-50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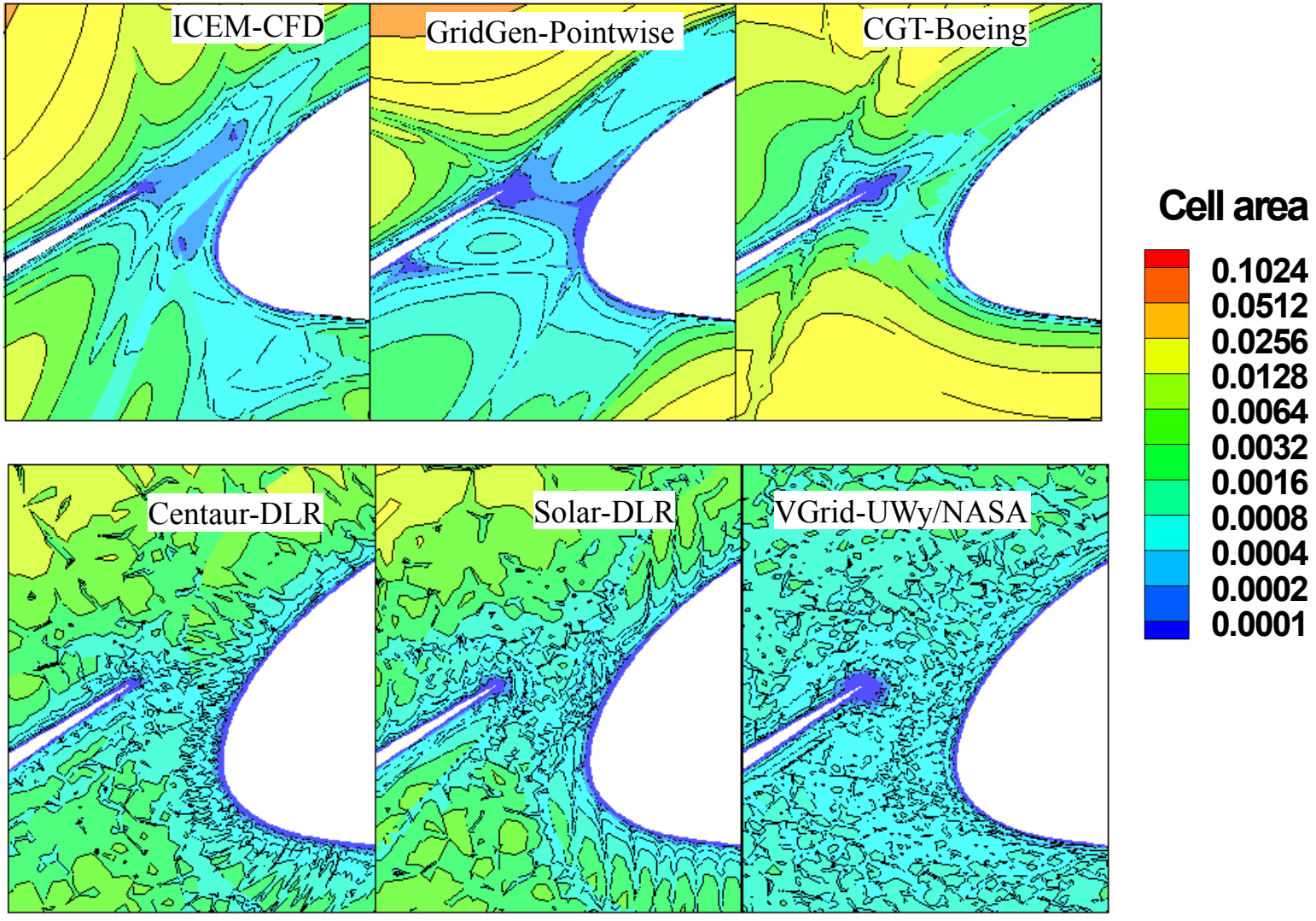
Slat TE, y=-50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GridGen-Pointwise
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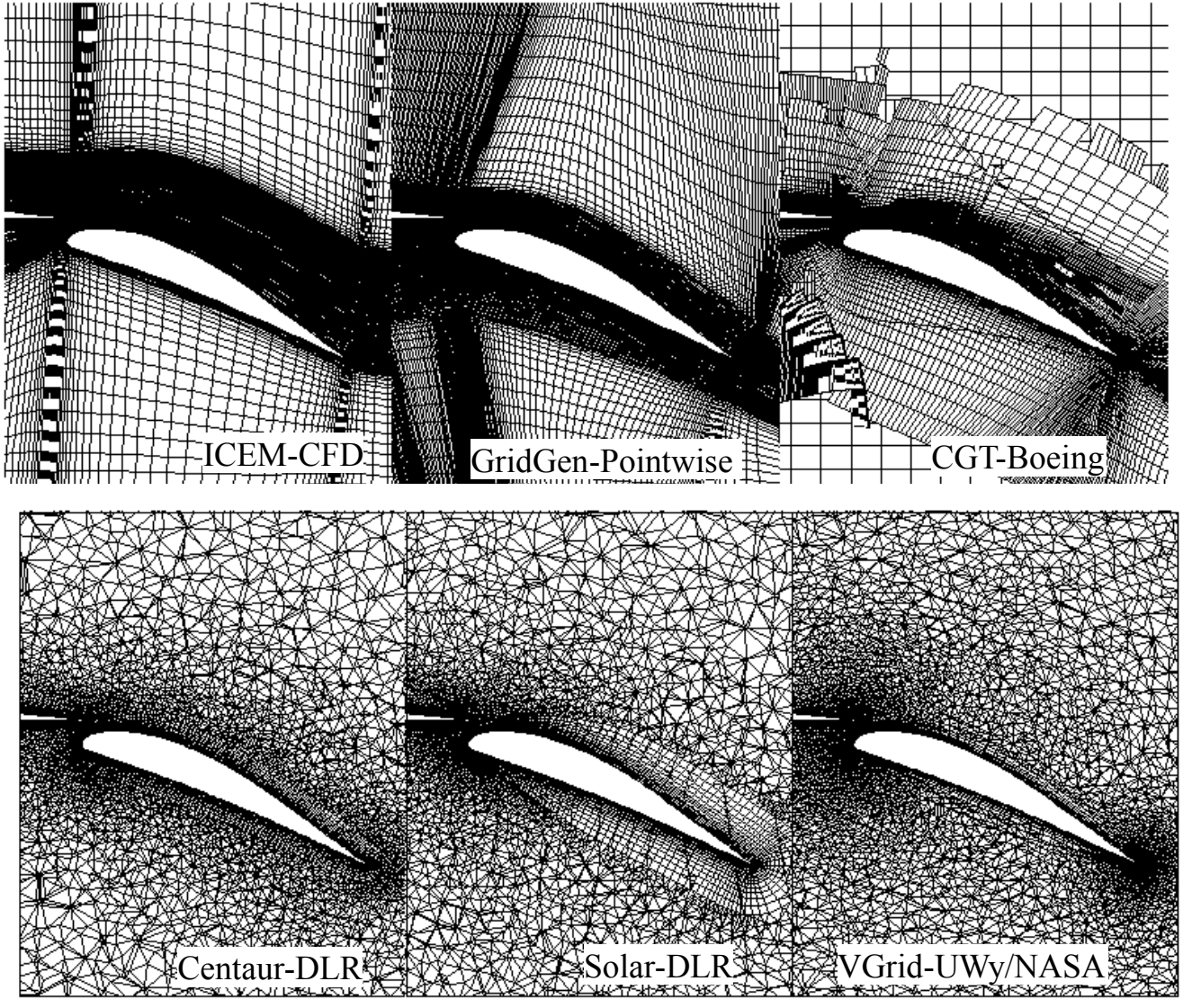
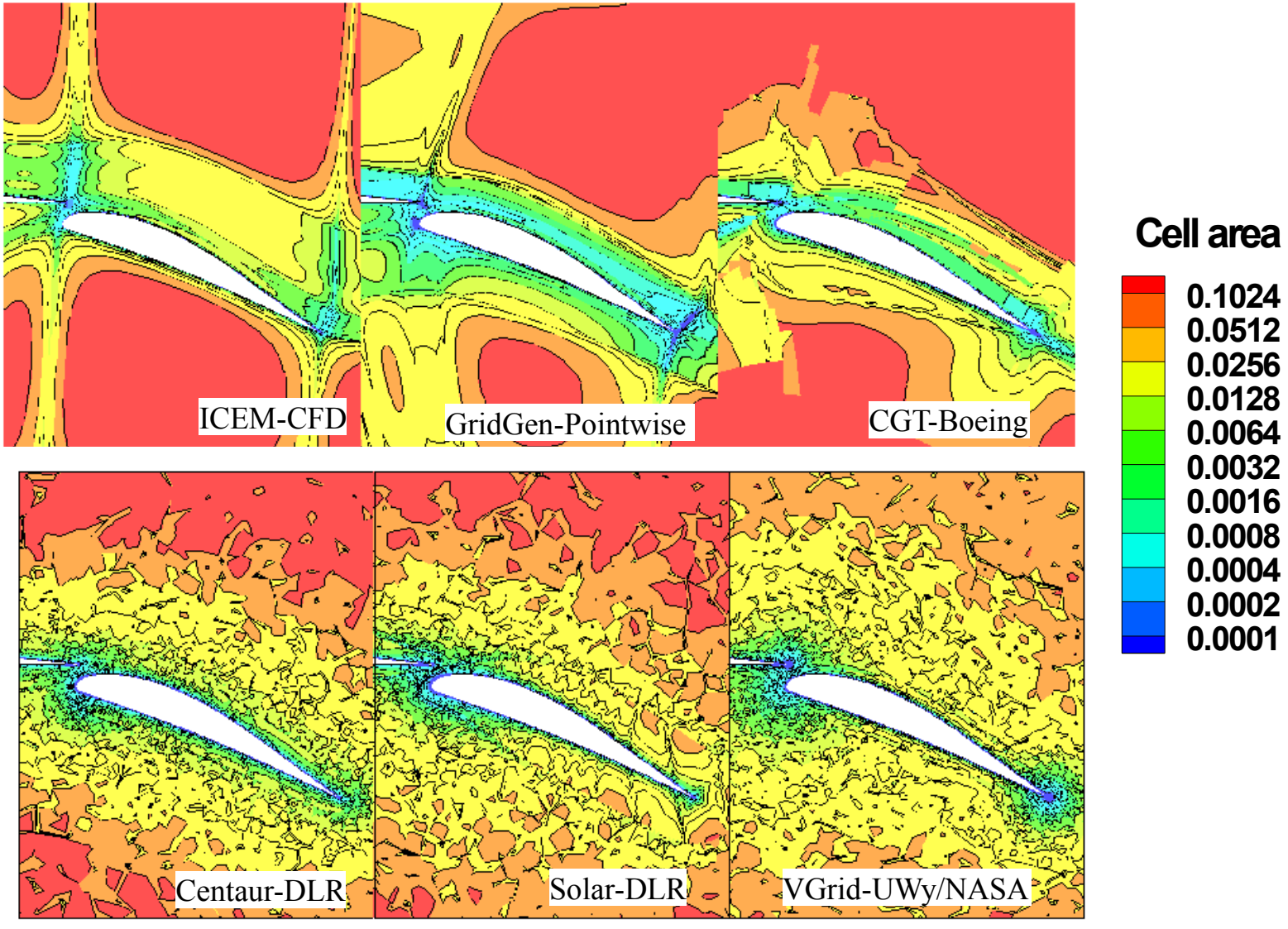
Cell area
0.1024
0.0512
0.0256
0.0128
0.0064
0.0032
0.0016
0.0008
0.0004
0.0002
0.0001

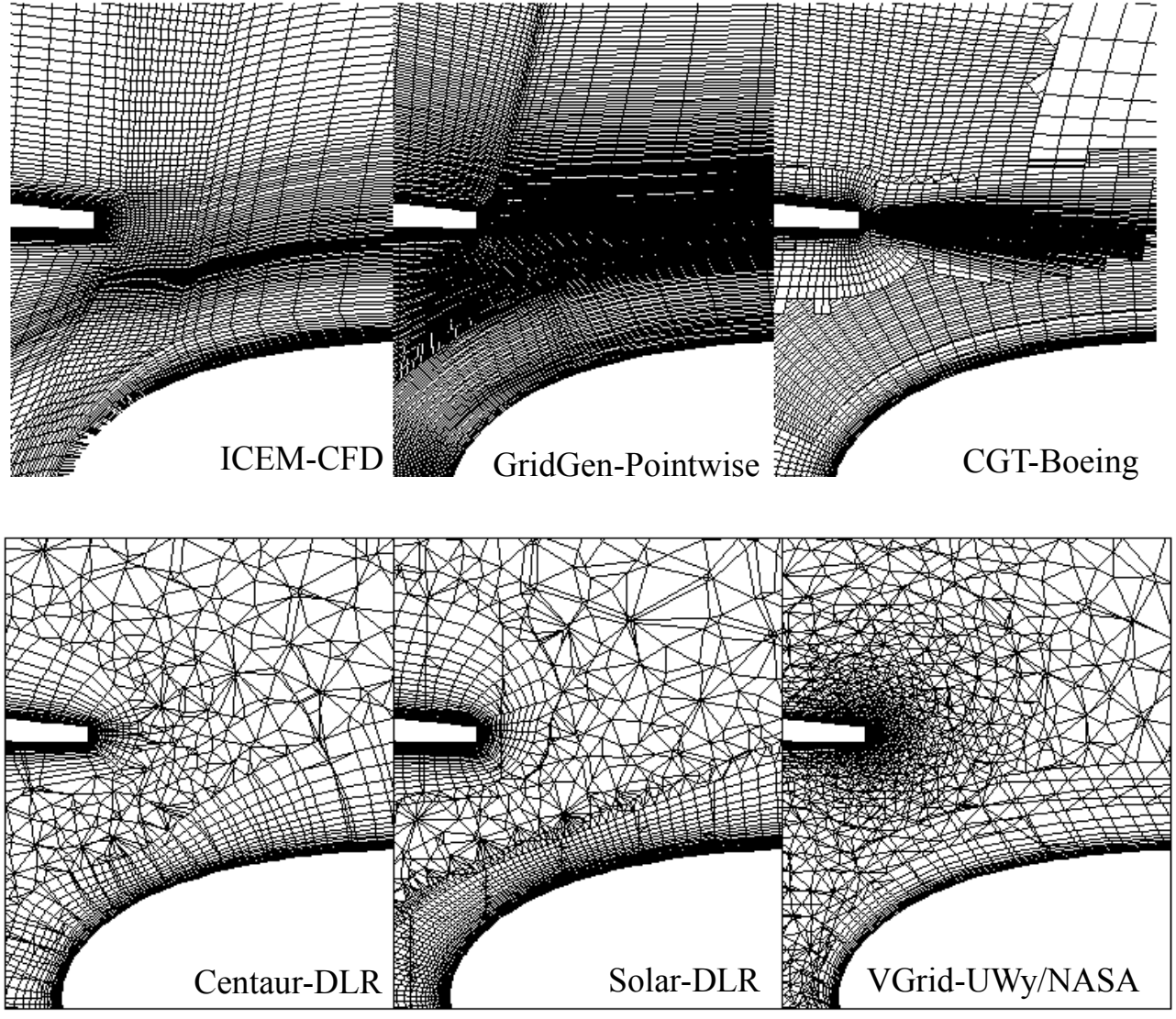
Flap, y=-50


ICEM-CFD
GridGen-Pointwise
CGT-Boeing
Centaur-DLR
Solar-DLR
VGrid-UWy/NASA

Flap, y=-50


ICEM-CFD
GridGen-Pointwise
CGT-Boeing
Centaur-DLR
Solar-DLR
VGrid-UWy/NASA
Cell area
0.1024
0.0512
0.0256
0.0128
0.0064
0.0032
0.0016
0.0008
0.0004
0.0002
0.0001

Main TE, y=-50


ICEM-CFD
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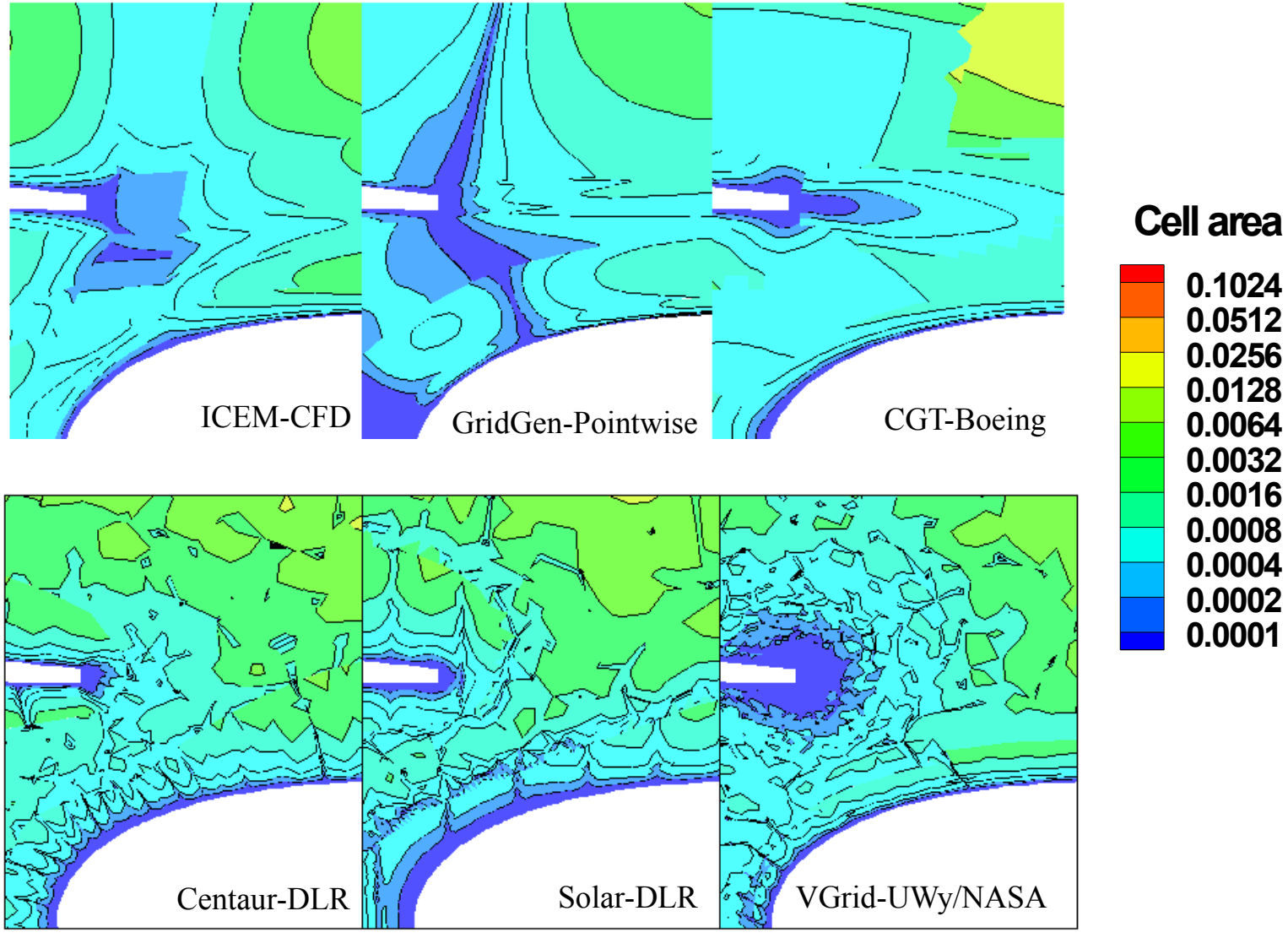
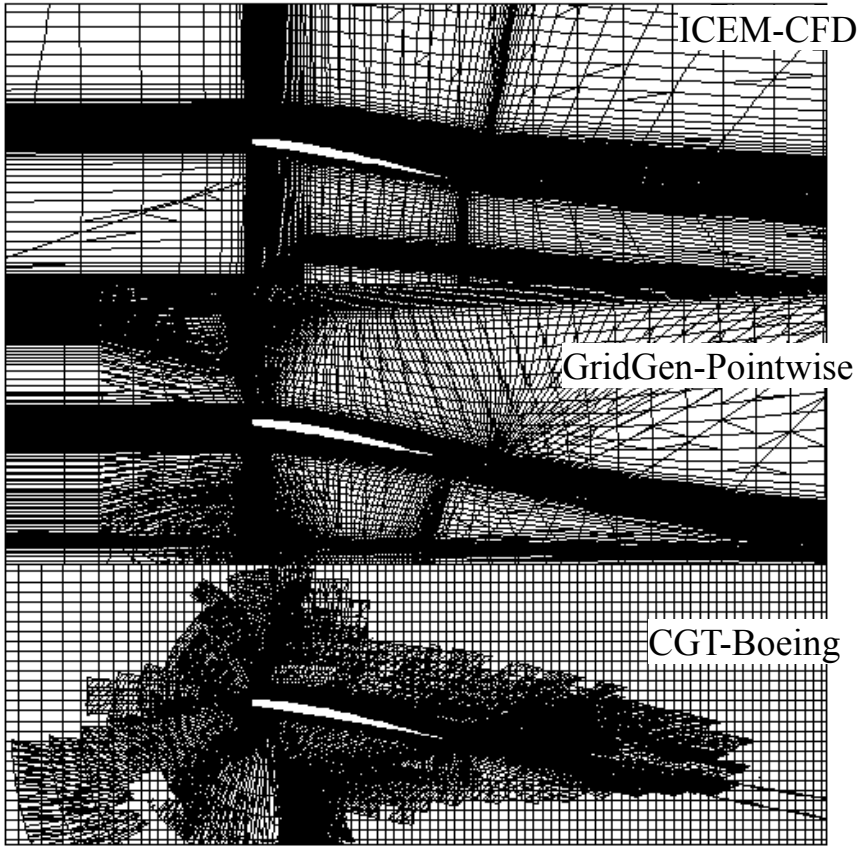
Main TE, y=-50


ICEM-CFD
GridGen-Pointwise
CGT-Boeing
Centaur-DLR
Solar-DLR
VGrid-UWy/NASA
Cell area
0.1024
0.0512
0.0256
0.0128
0.0064
0.0032
0.0016
0.0008
0.0004
0.0002
0.0001

x=75 slice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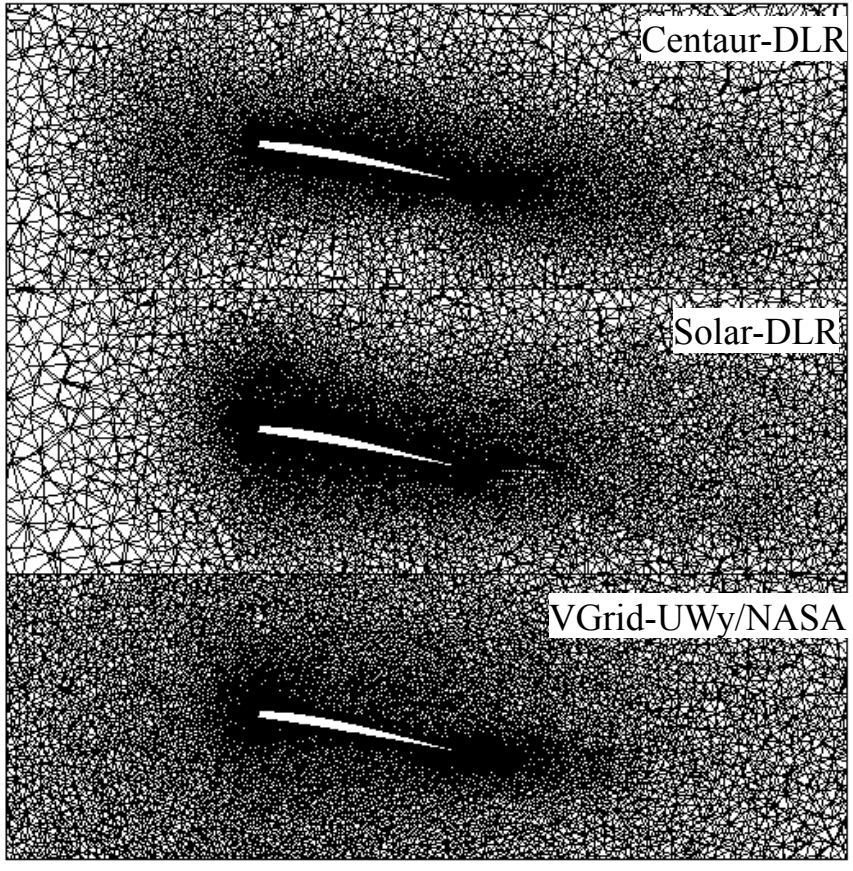
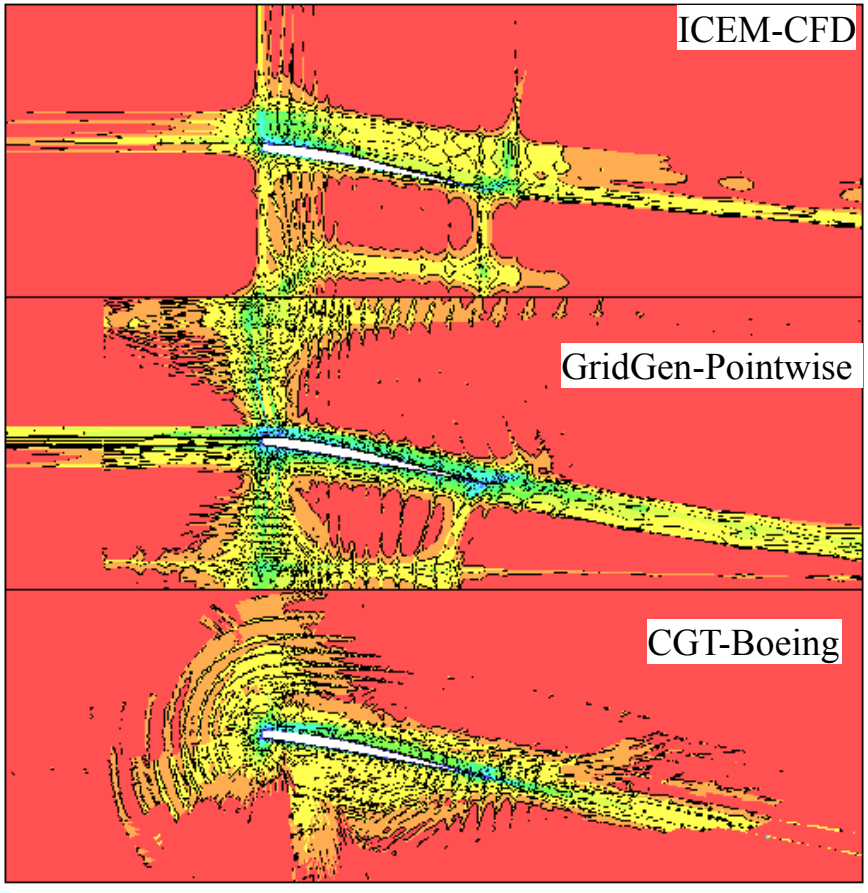
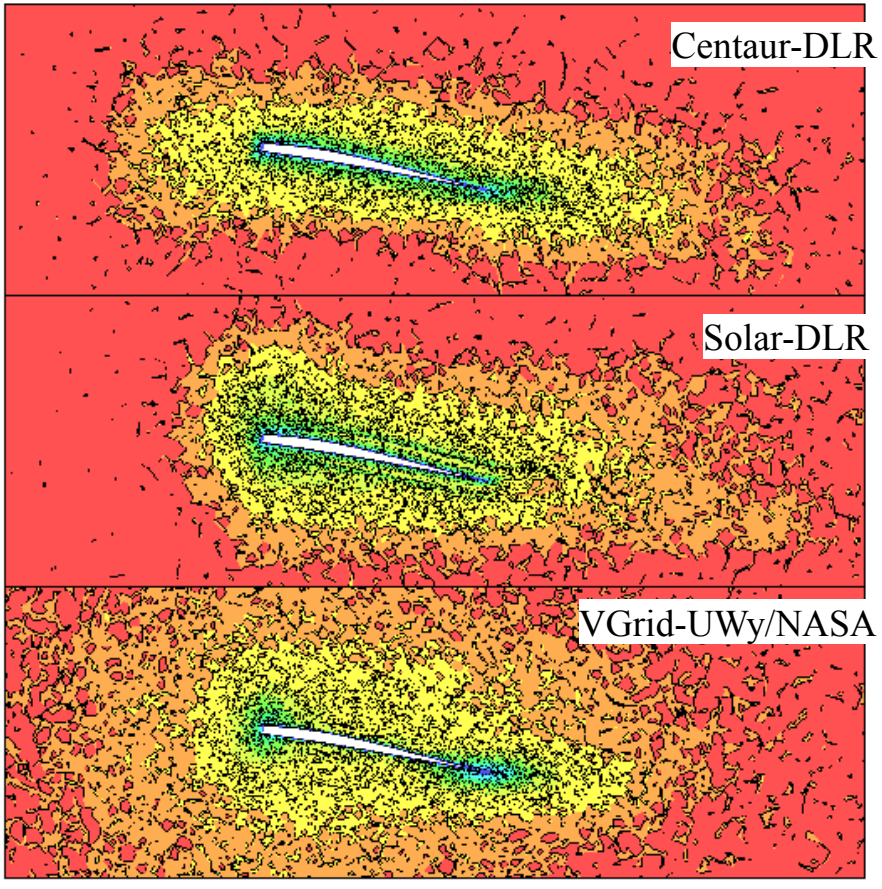

Centaur-DLR
Solar-DLR
VGrid-UWy/NASA

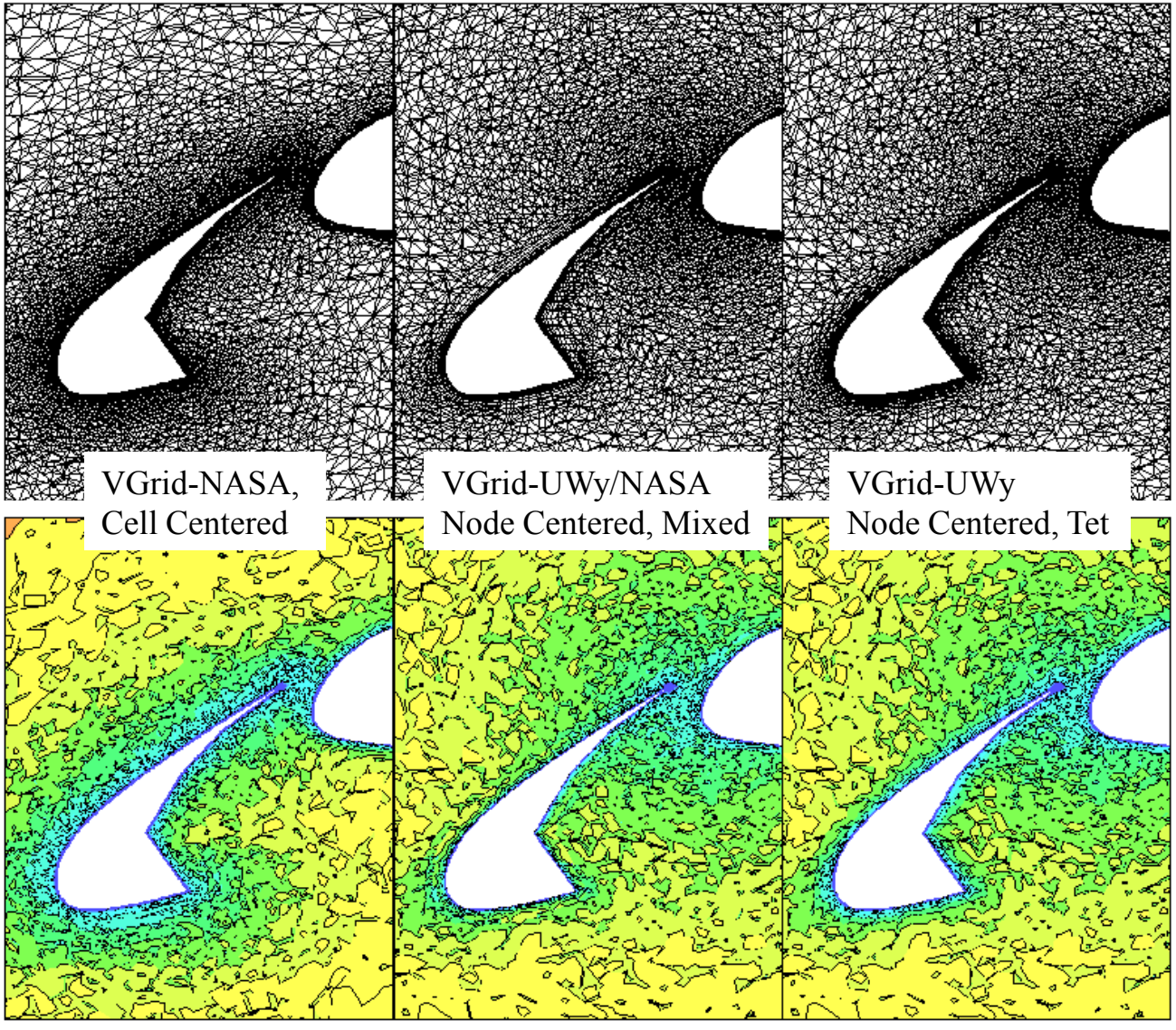
x=75 slice



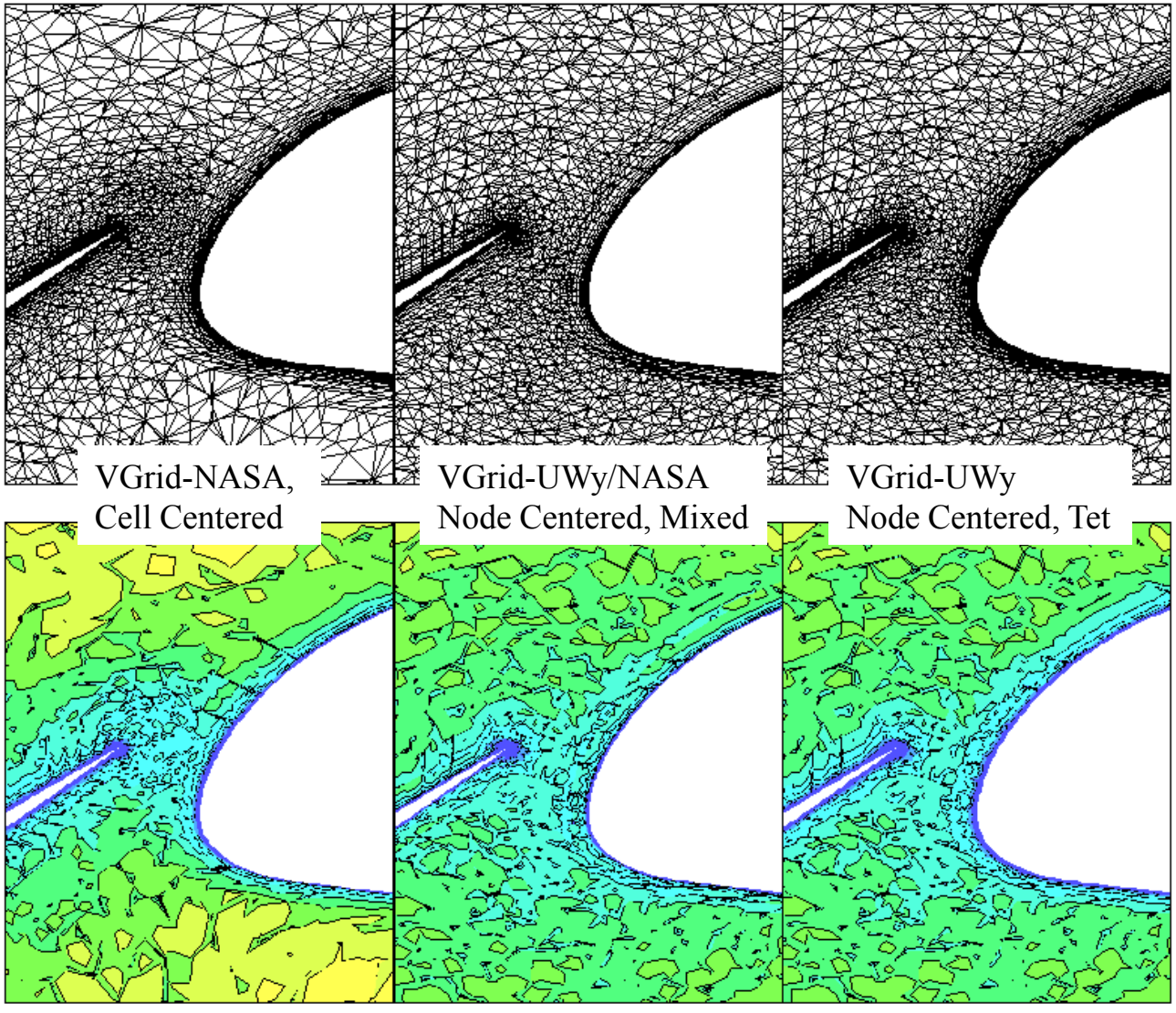


Cell area: 0.0001 0.0002 0.0004 0.0008 0.0016 0.0032 0.0064 0.0128 0.0256 0.0512 0.1024

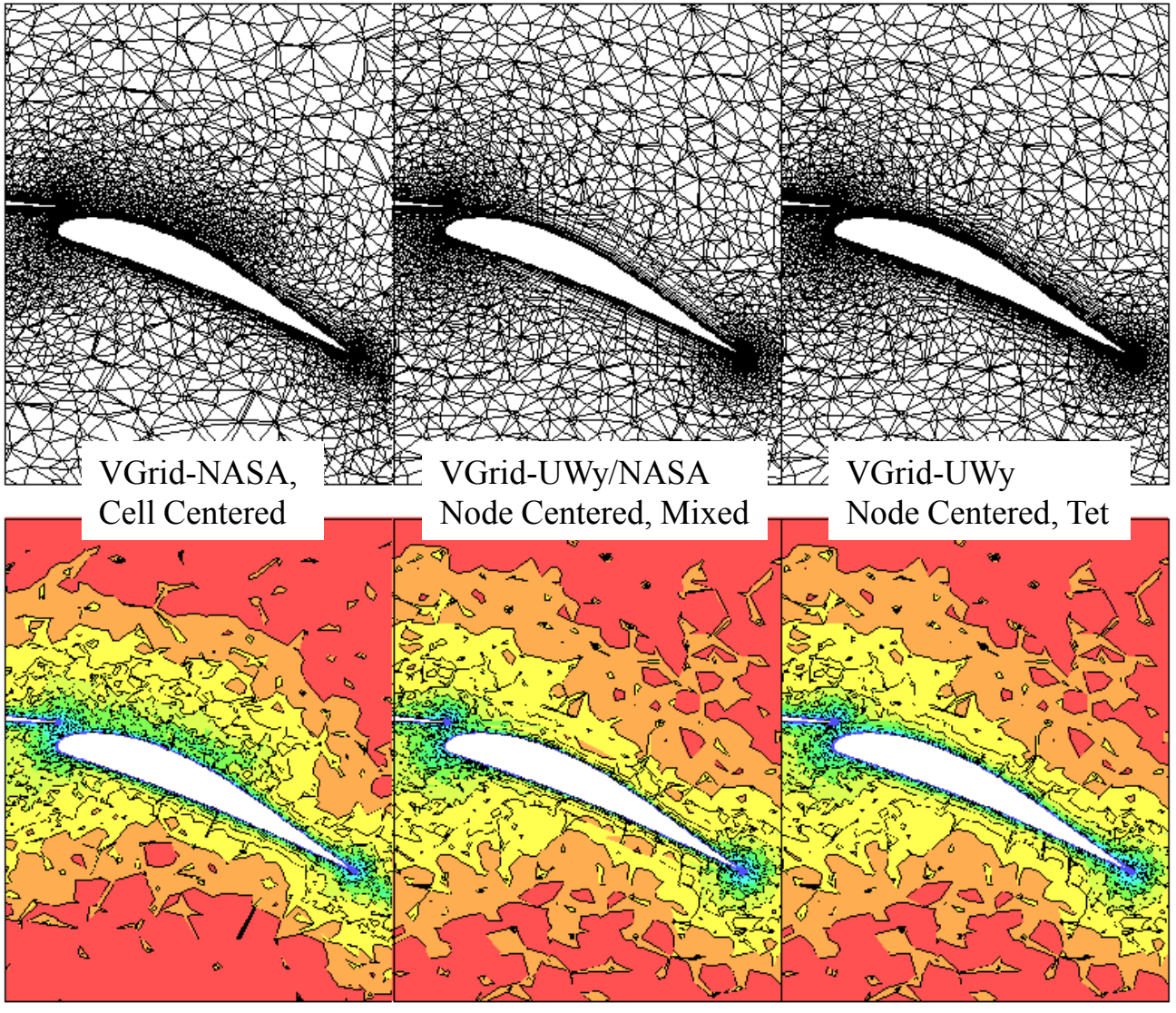
VGrid grids, y=-50



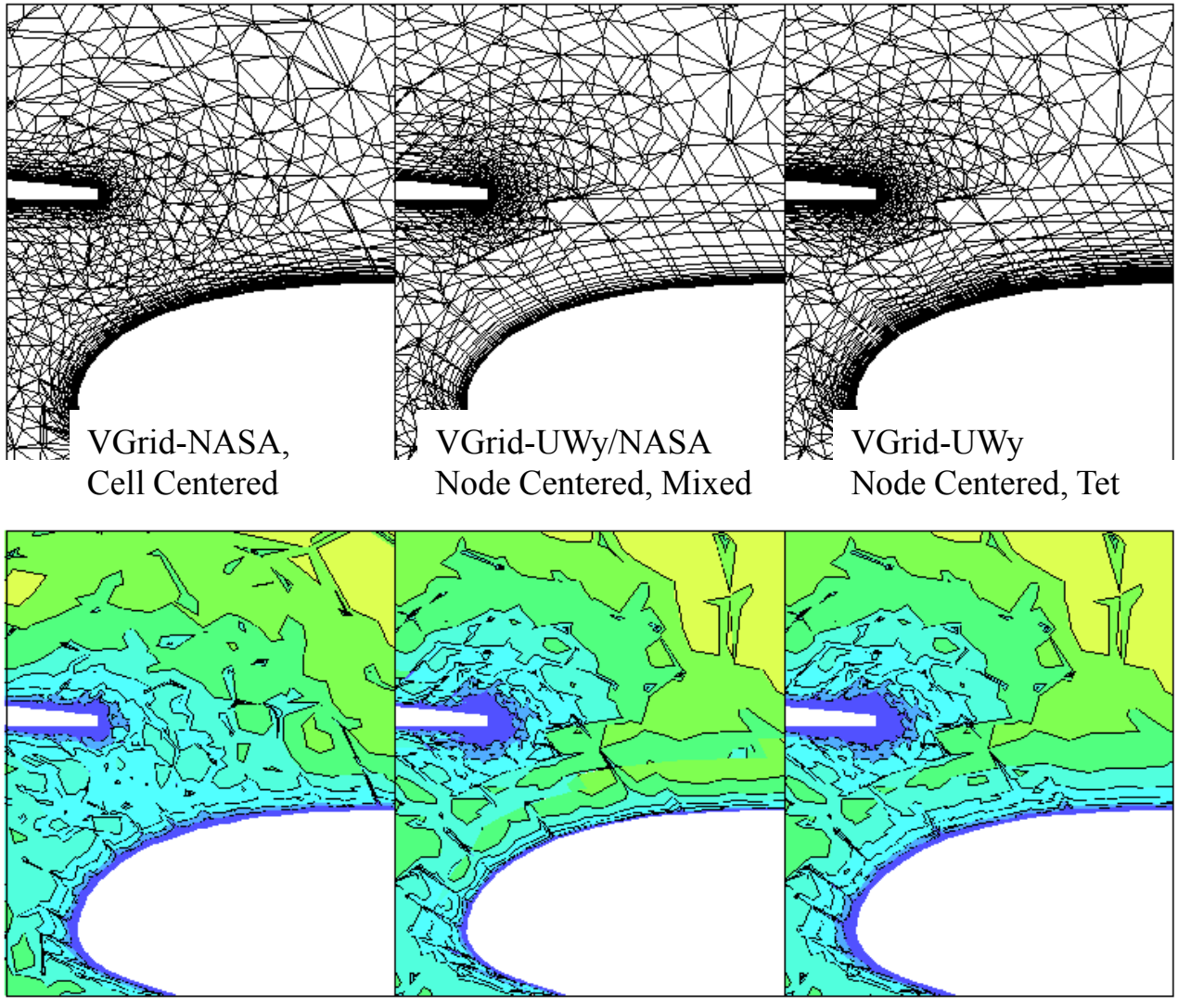
VGrid grids, y=-50



VGrid grids, y=-50



VGrid grids, y=-50



Final thoughts….

"Until the 1960's, our analytical capability was insufficient to make quantitative calculations. Now, since the tools are here, it is time to put the whole story together, as best we know it. That is not to say that nearly all problems have been solved, but to a certain extent the remaining problems amount to just irritating details."

A.M.O. Smith, "High-Lift Aerodynamics," Journal of Aircraft, Vol. 12, No. 6, June 1975

Thanks

… to those who worked on some of the irritating details.

ICEM – Boeing
- Leonel Serrano

GridGen – Pointwise
- Nick Wyman

CGT – Boeing
- Tony Sclafani, Jeff Slotnick, Leonel Serrano, John Vassberg, Neal Harrison

Centaur – DLR
- Stefan Melber-Wilkending, Ralf Rudnik

Solar – DLR
- Simone Crippa

VGrid – Node centered
- Mike Long, Scientific Solutions/Univ. of Wyoming

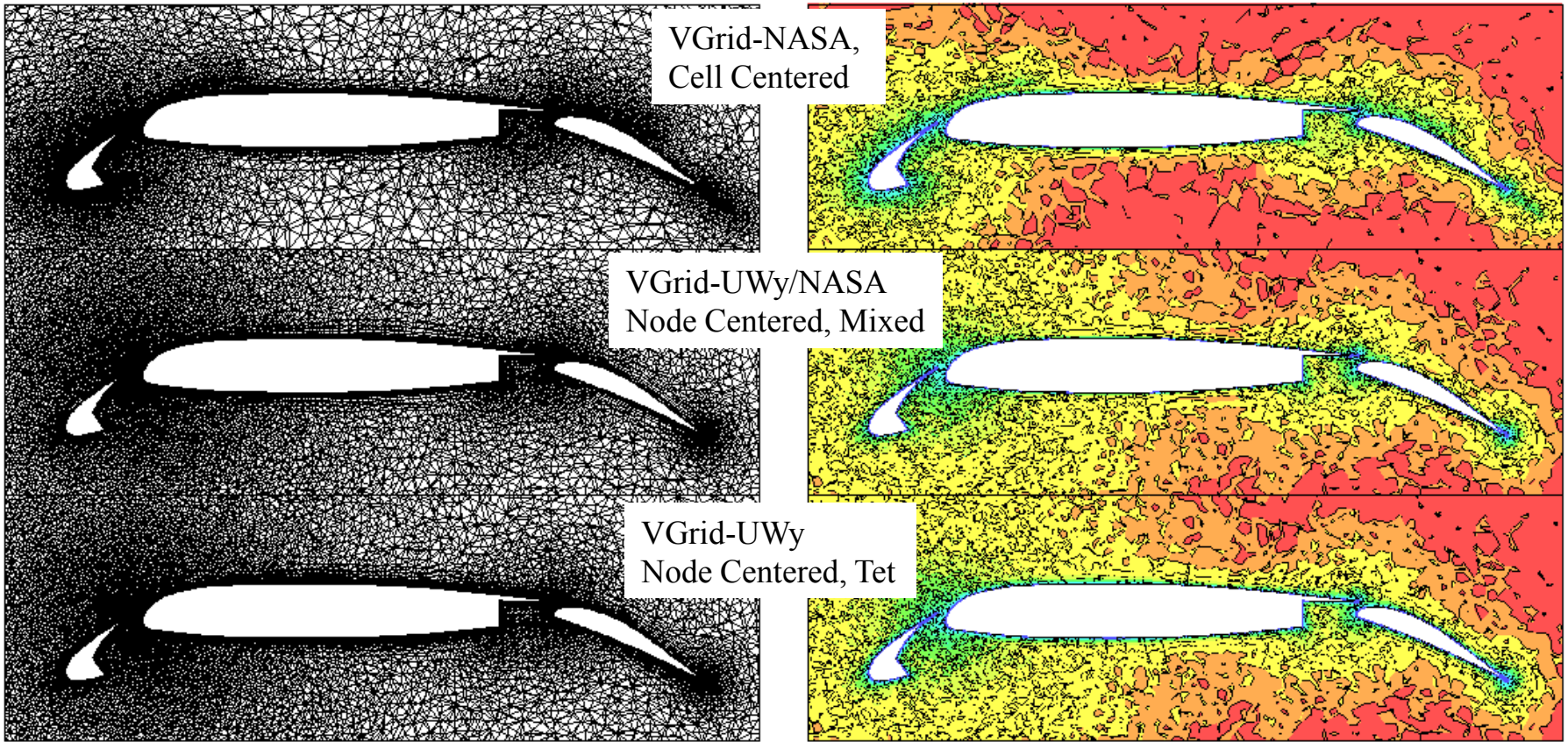
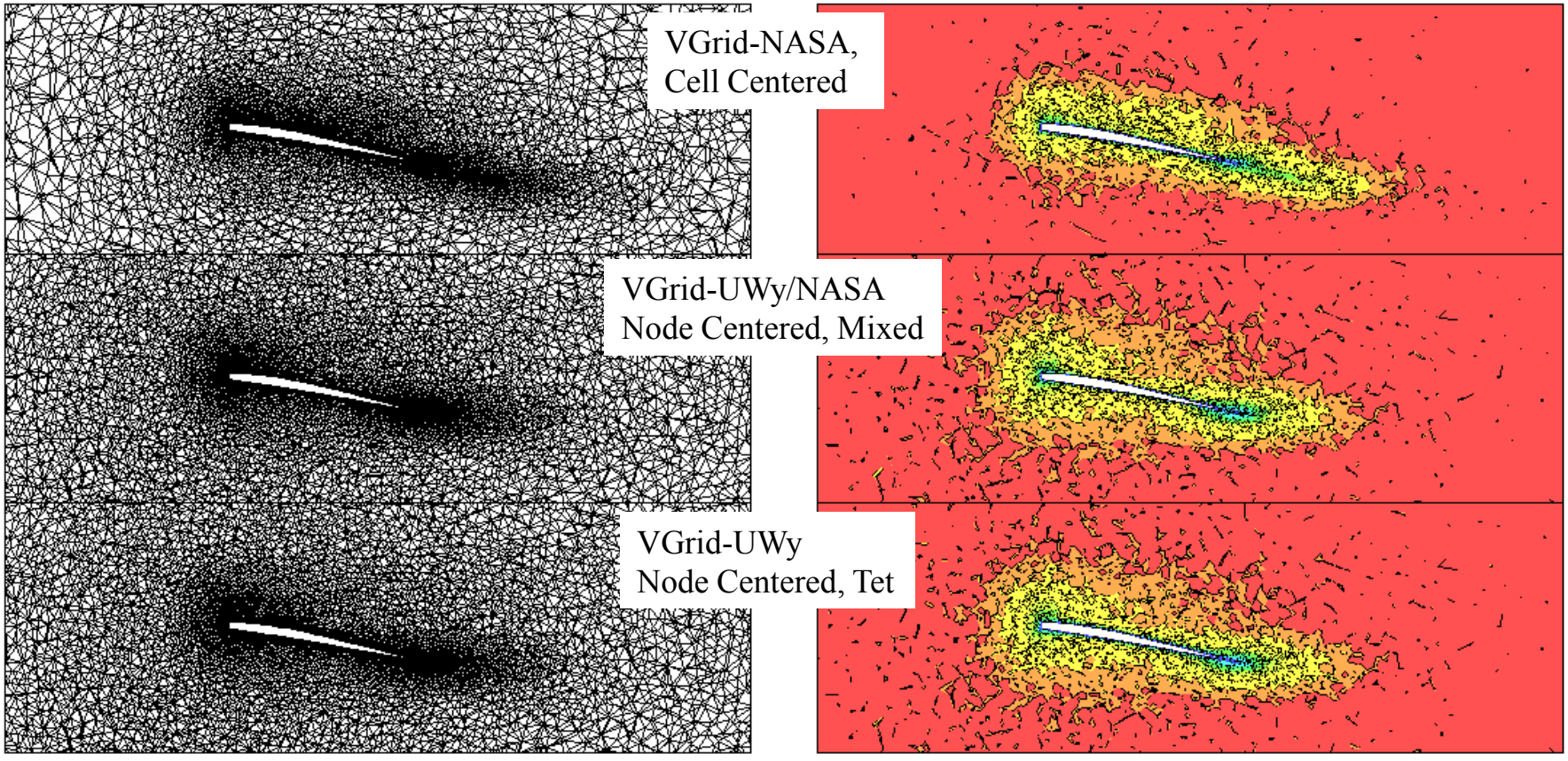
VGrid – Cell centered
- Ed Parlette, ViGYAN/NASA Langley

Geometry
- Scott Verden, Geolab/NASA Langley; Bill Jones, NASA Langley

Conversions/maintenance/ftp
- Chris Rumsey, NASA Langley

- Backups

VGrid grids, y=-50



VGrid grids, y=-50