DLR Results DPW-V

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AIAA Applied Aerodynamics Technical Committee

Introduction – Motivation

- Hex-dominant grids have shown potential (DPW-3, DPW-4) but limitations in certain areas
- Revisit unstructured grid topology: How does an “optimal” unstructured grid look like?
- Revisit dissipation influence on off-design conditions

Introduction – Cases/grids

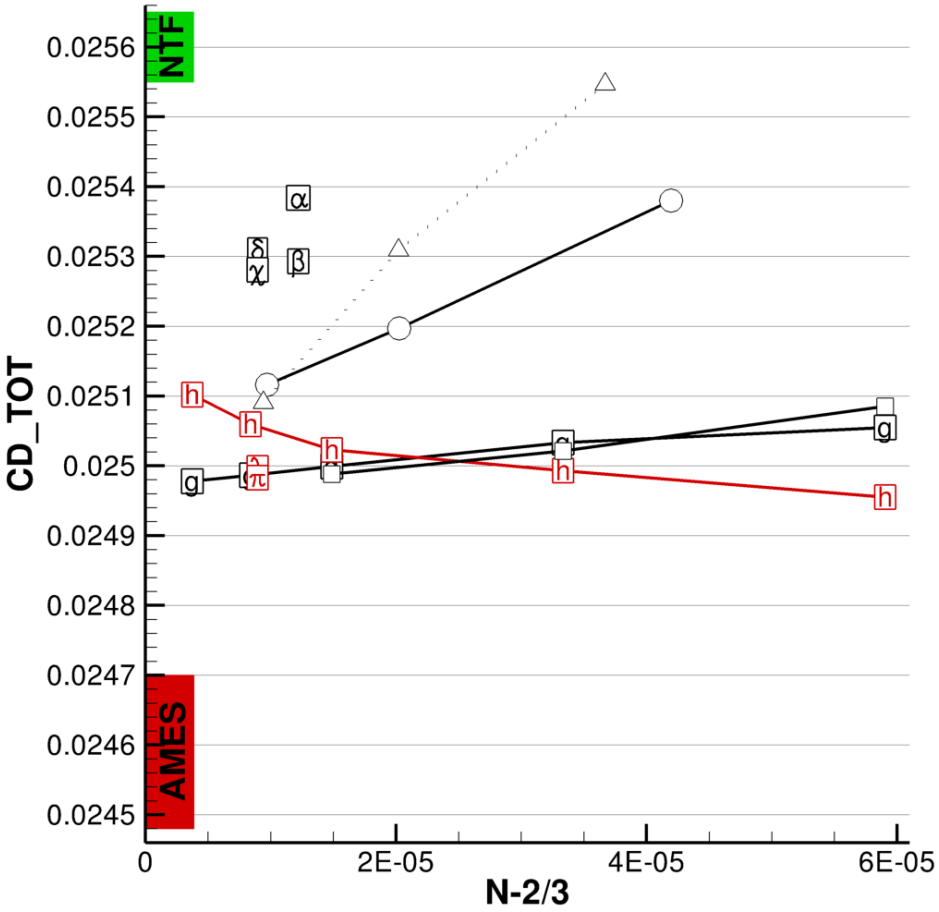
		CommonHex	Solar	SolarChimera	Centaur	CentaurHexaWake
case 1	L2	SA & SST	SA	SA		
	L3	SA & SST	SA	SA	SA	SA & SST
	L4	SA & SST	SA	SA		
	L5	SA & SST				
	L6	SA & SST				
case 2	L3	SA & SST	SA	SA	SA	SA & SST
case 3		SA & SST				

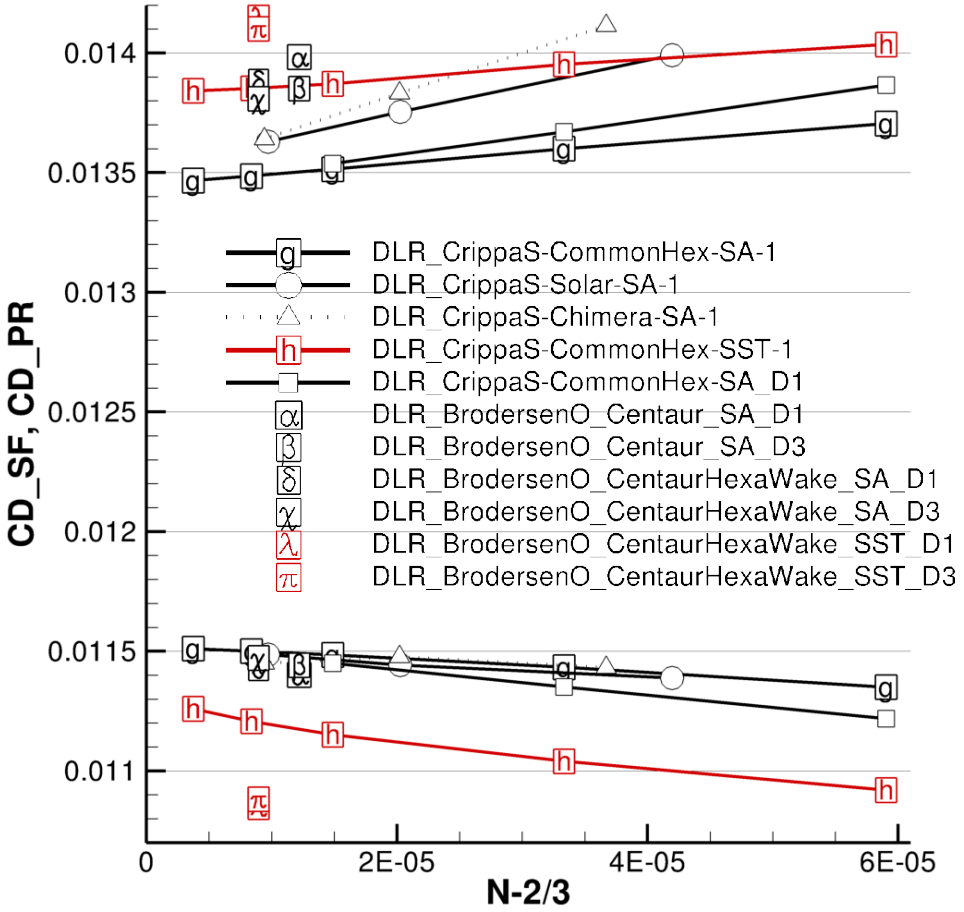
- Focus on SOB junction separation at C_L=0.5 with CommonHex, Solar and Solar/Hexa Chimera grids
- Focus on angle-of-attack sweep with Centaur grids

Introduction – TAU

- Finite-volume
- Node-centered, LU-SGS, 4w-MG, full-NS, central scheme
- 1994 Spalart-Allmaras (SA), 1994 Menter k-ω SST (SST)
- TAU release 2011.2.0 with scalar dissipation
- TAU development snapshot with new formulation of matrix dissipation

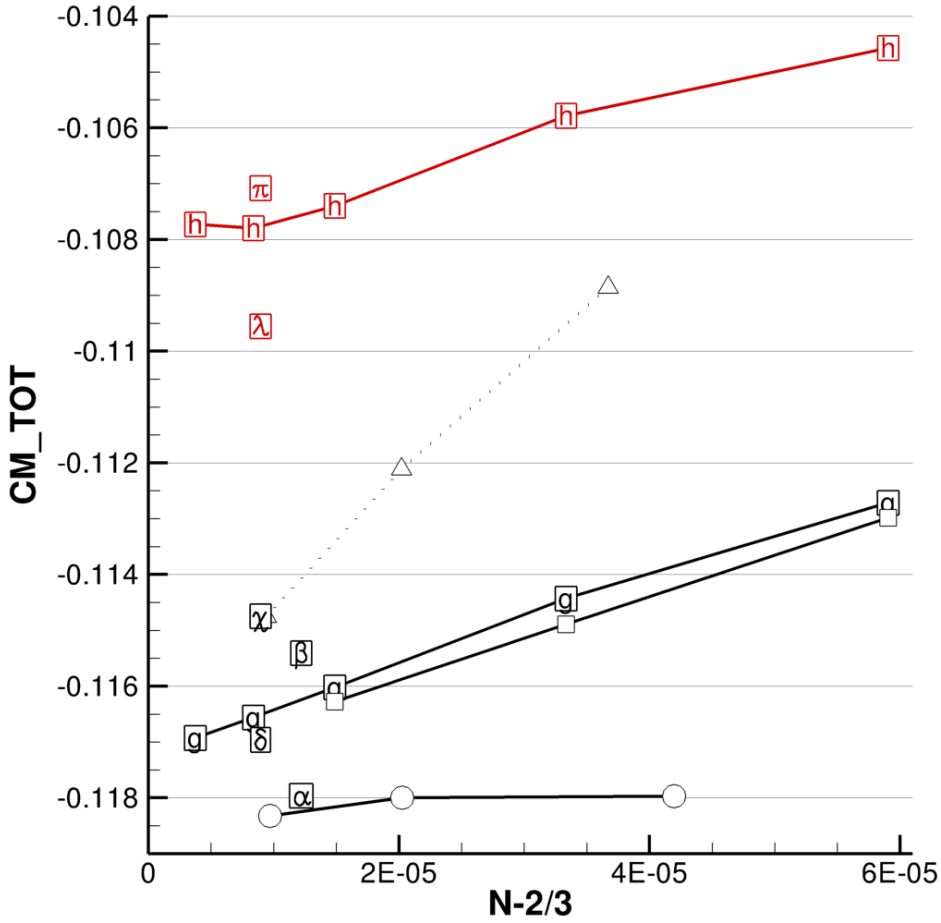
Case 1 – Grid Convergence



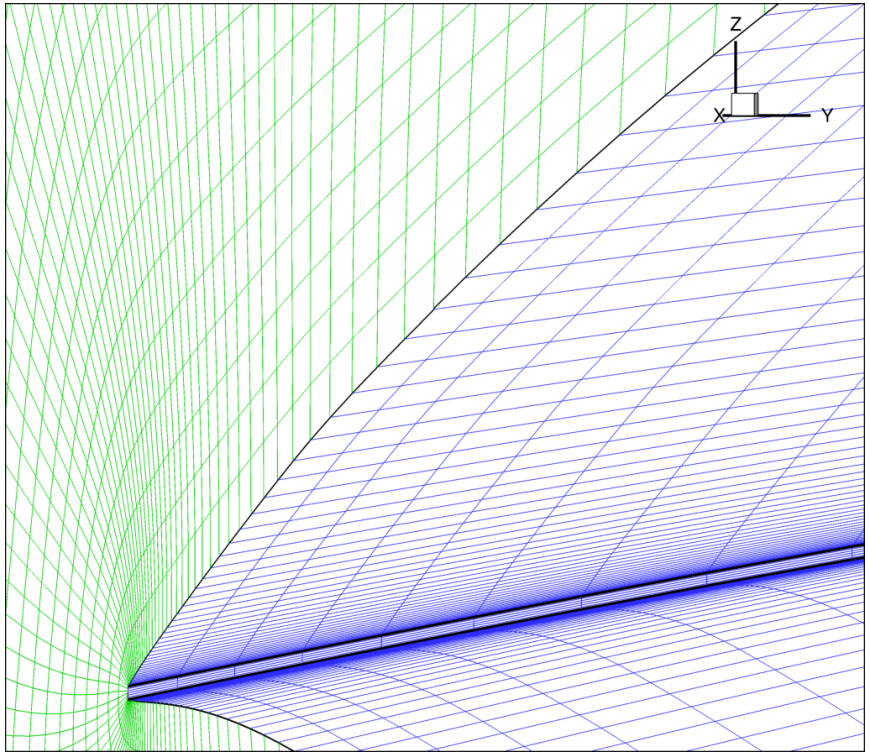


Case 1 – Grid Convergence

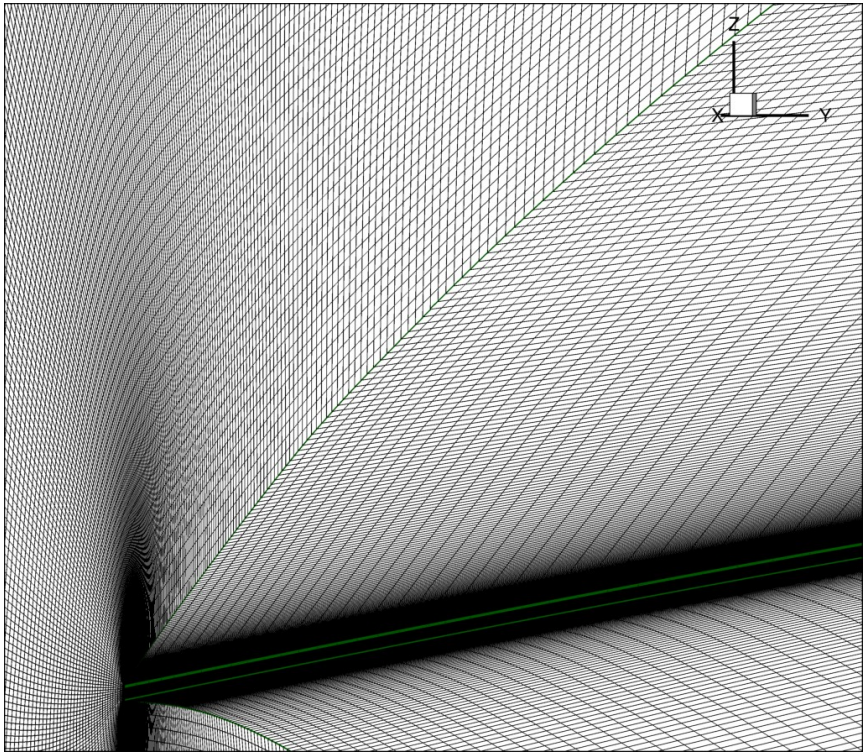
- CommonHex: CDTOT seemingly grid-independent
  - CDPR/CDSF with similar gradient, but different sign
- SST vs SA difference in CDPR/CDSF relatively grid-independent
- CommonHex L2 slightly off from SA linear convergence: SOB



Case 1 – SOB Separation

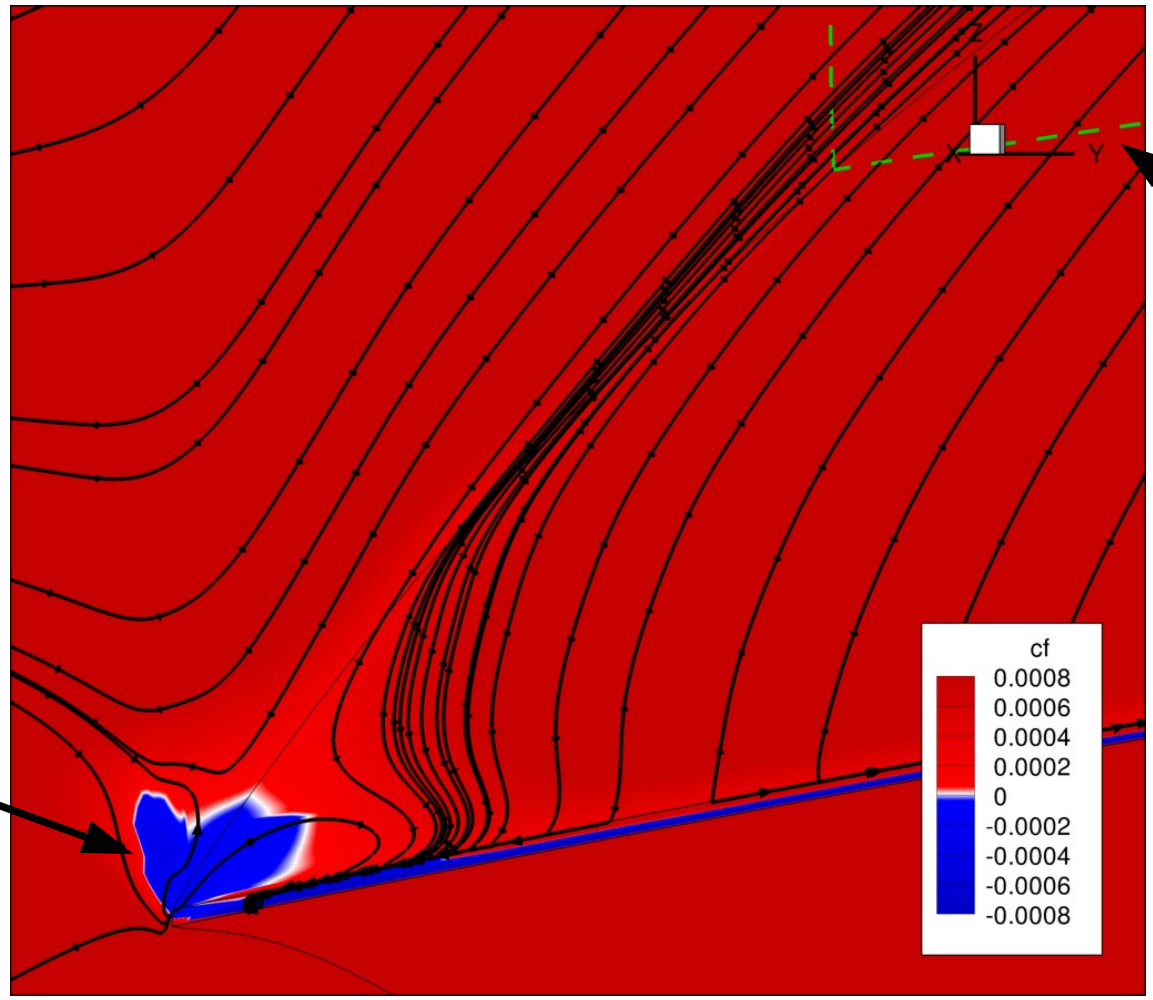


CommonHex – L2



CommonHex – L6

Case 1 – SOB Separation

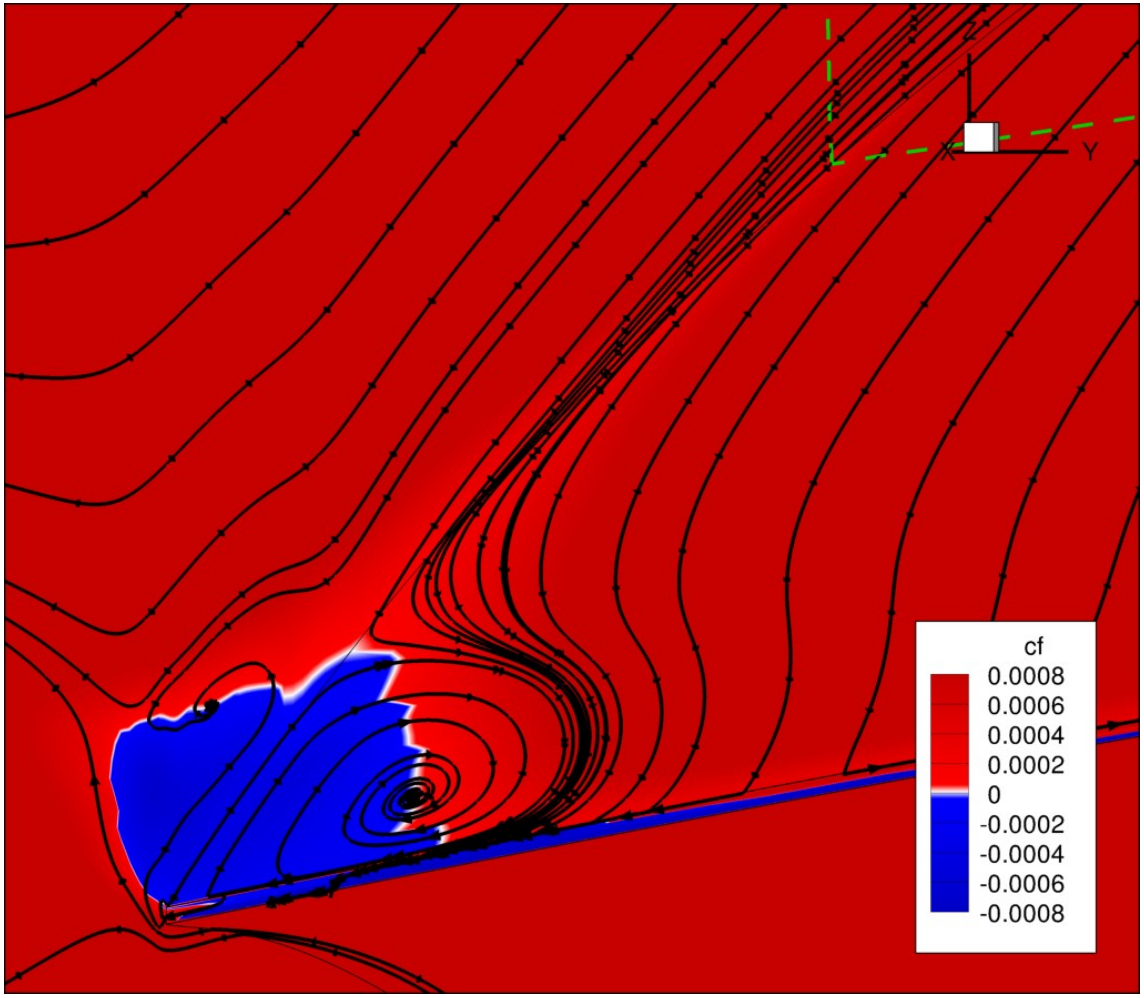


Critical pressure coefficient (Ma=0.85 → $c_{p,crit}$=-0.302)

SOB separation near the wing trailing edge

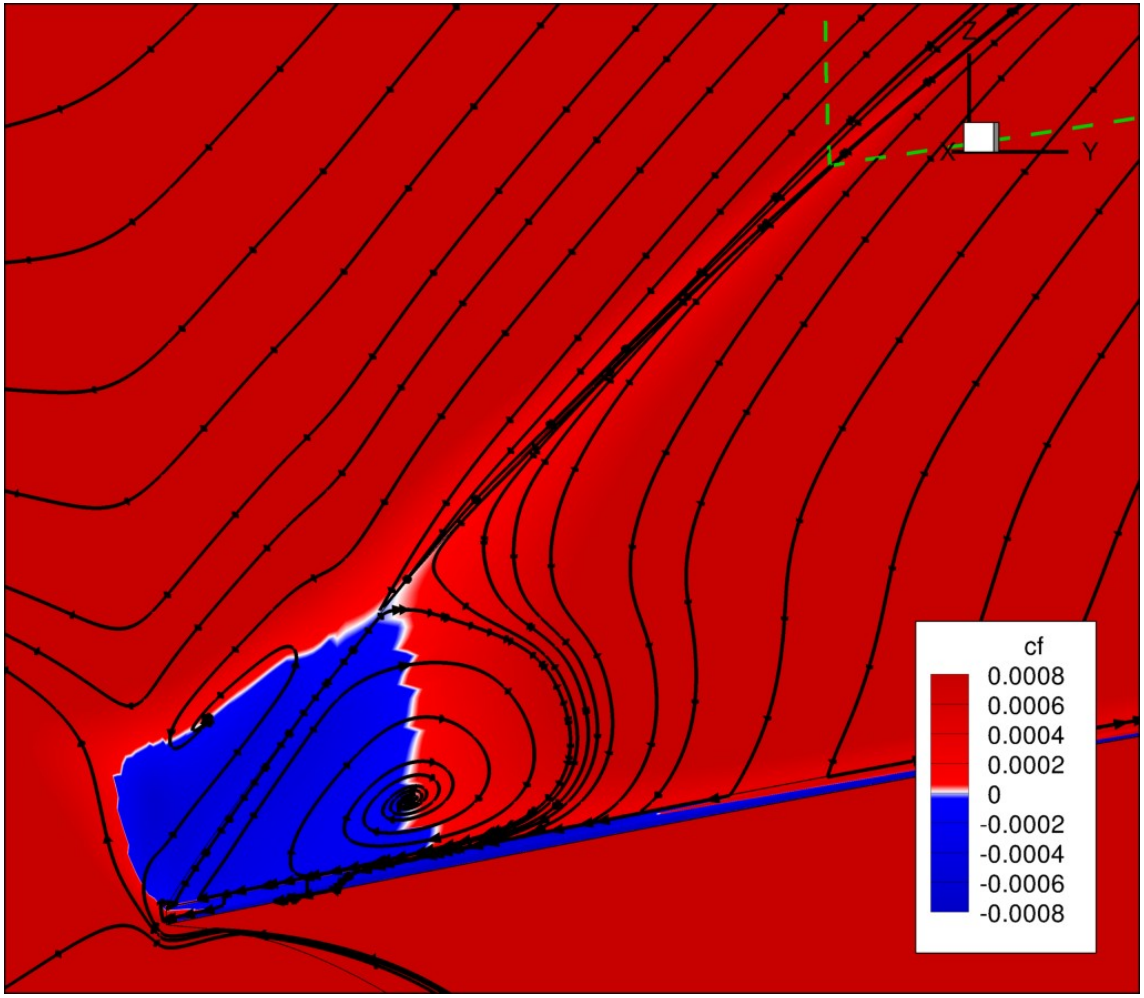
CommonHex – L2

Case 1 – SOB Separation



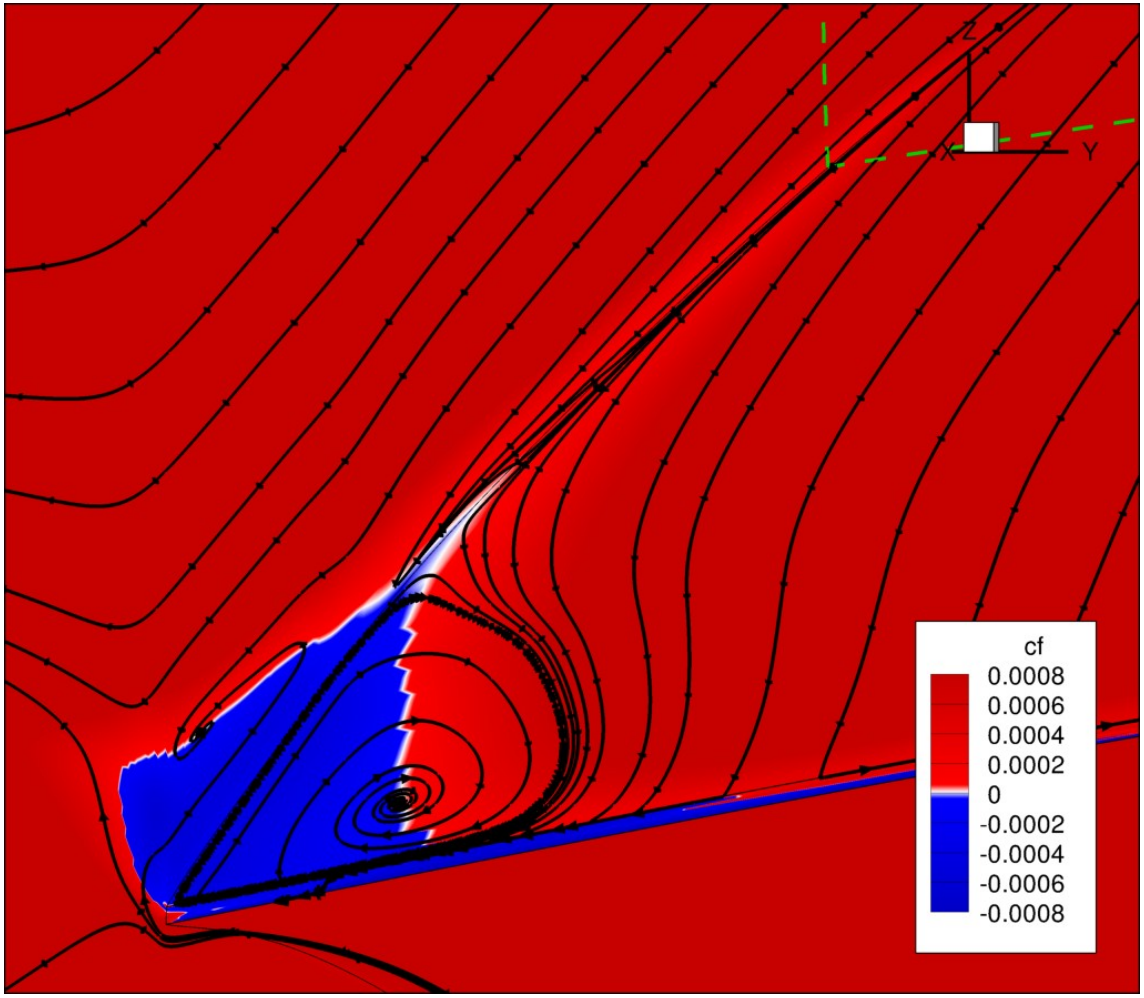
CommonHex – L3

Case 1 – SOB Separation



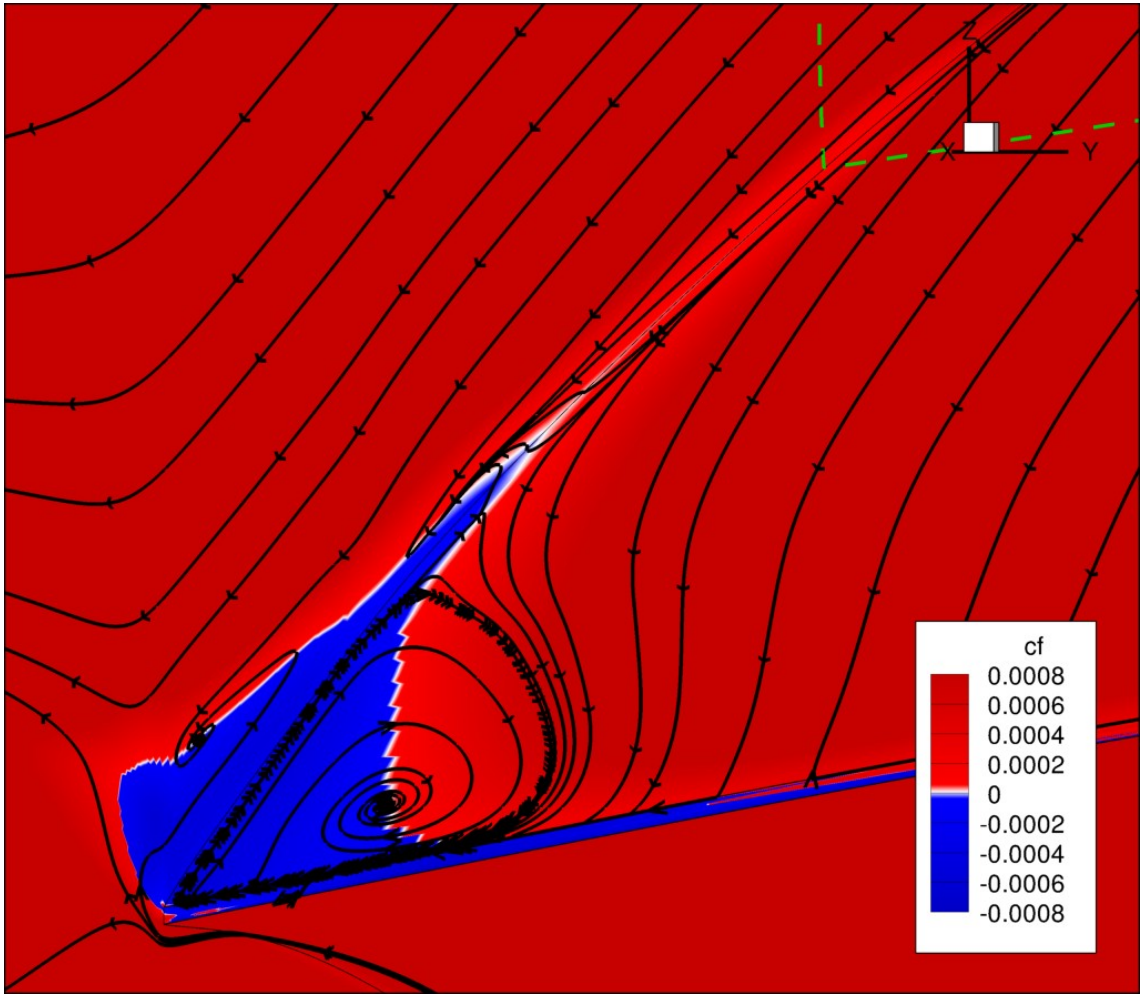
CommonHex – L4

Case 1 – SOB Separation



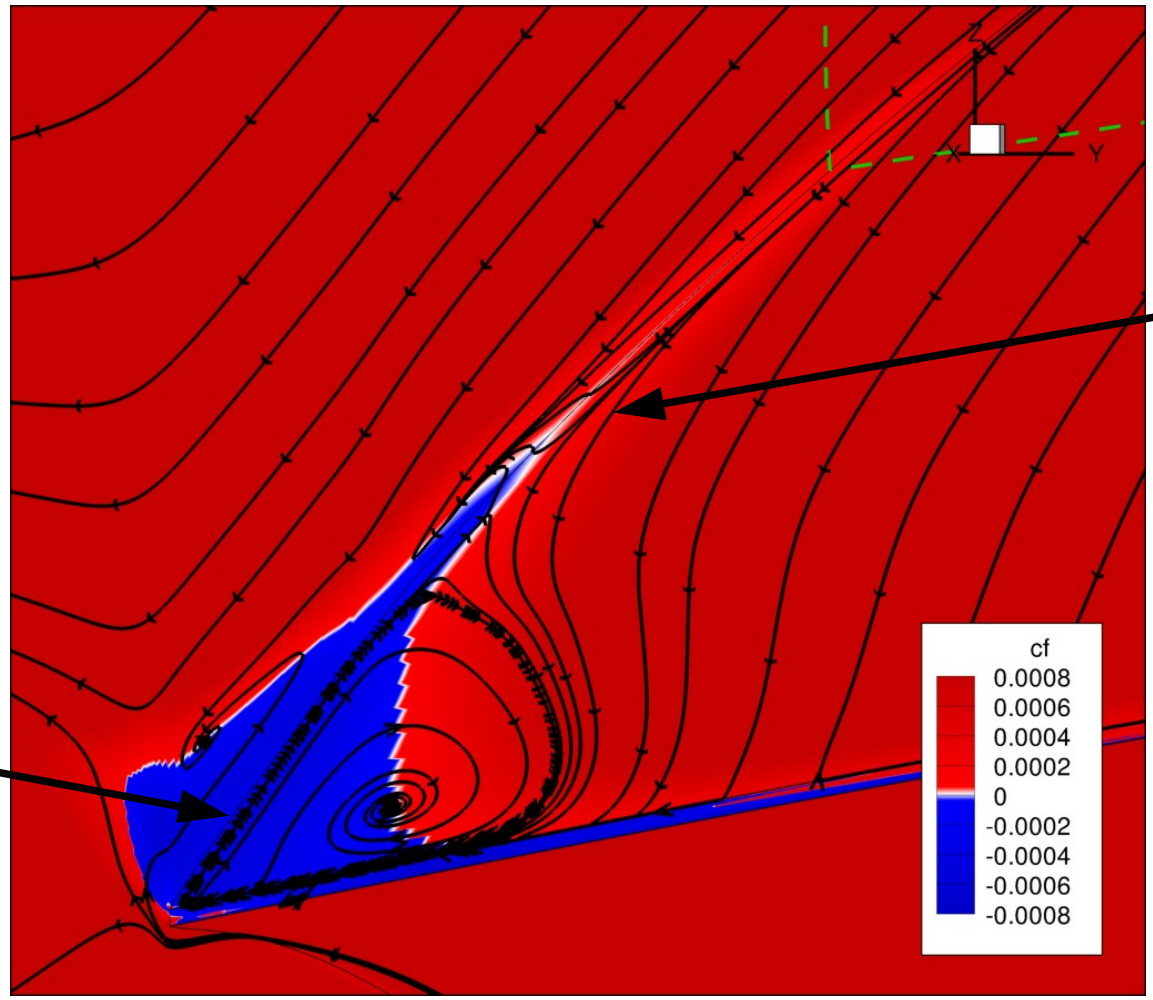
CommonHex – L5

Case 1 – SOB Separation



CommonHex – L6

Case 1 – SOB Separation



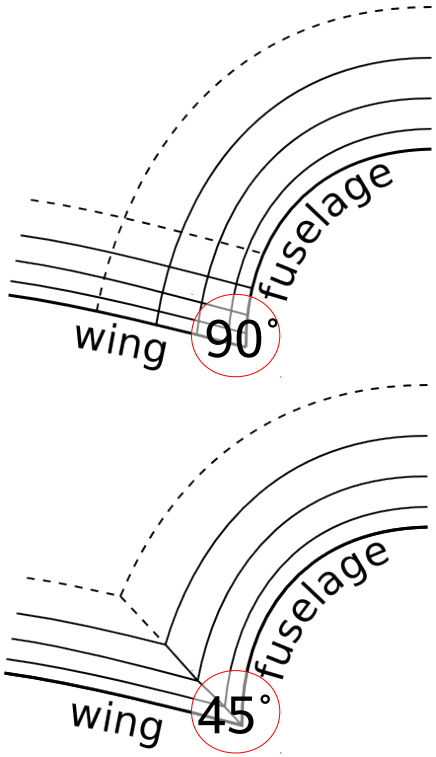
SOB separation initial position moves upstream from L2-L6

SOB separation similar from L3-L6

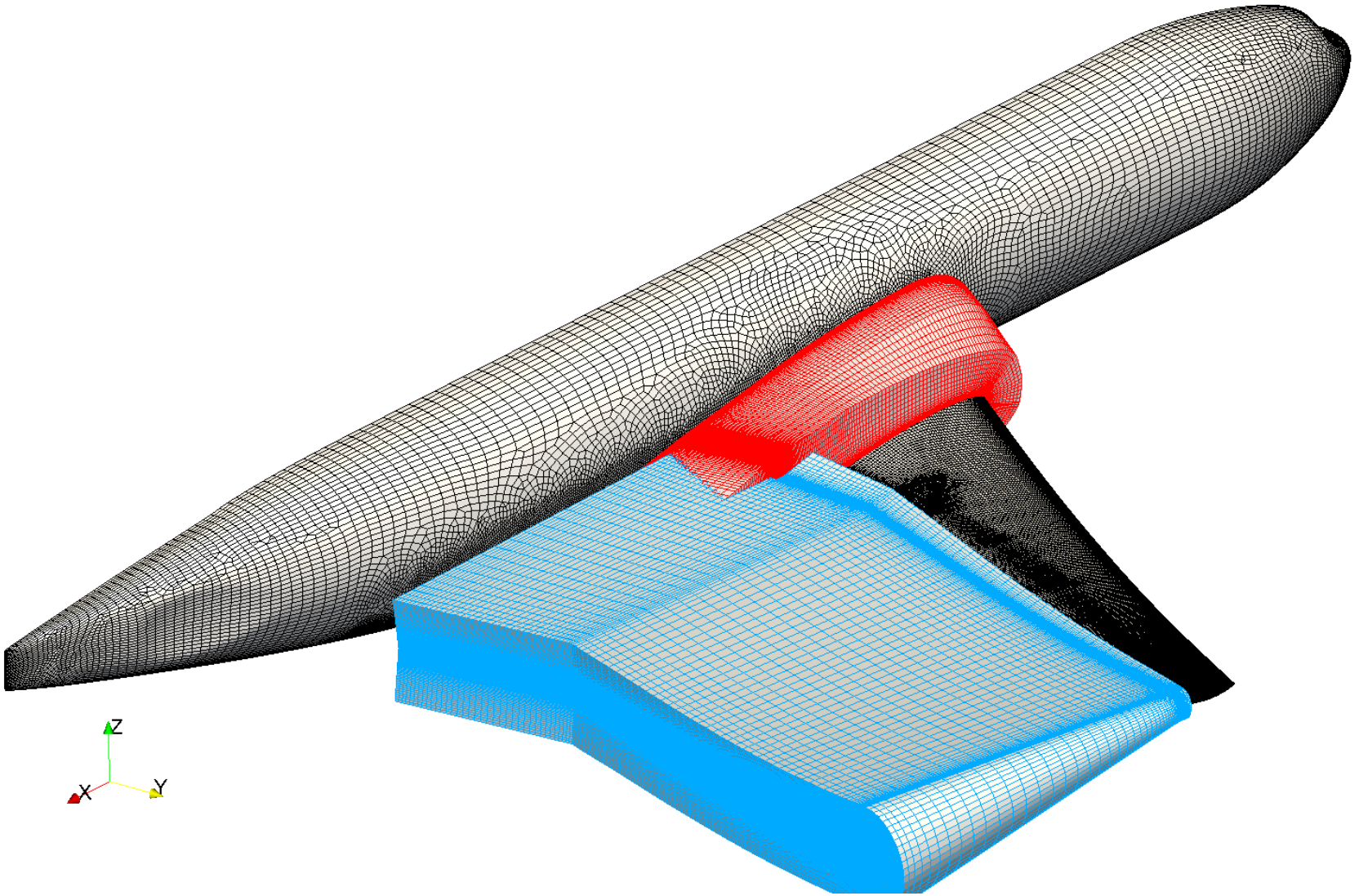
CommonHex – L6

Case 1 – SOB Separation

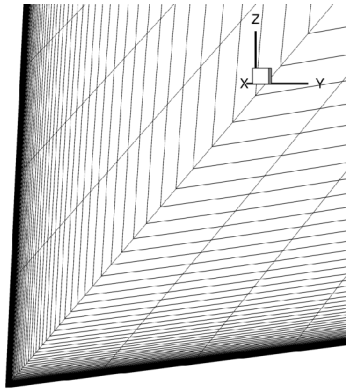
- Extensive post-DPW-4 SOB separation studies
- Comparison of DPW-4 Airbus/ONERA/DLR results on different grids shows that C/H- vs. O-type junction topology (C/90 vs. C/45) has big impact
- Common DPW-5 grids feature a global O-O-type topology
  - Additional comparison of TAU results on reference Solar grid and hexa-block-enhanced Chimera grid

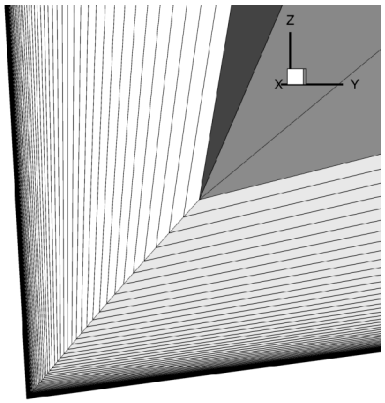


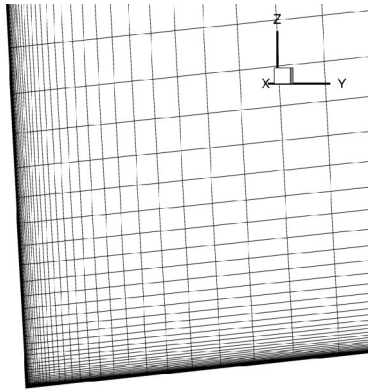
CRM WBT – Discretization Improvements

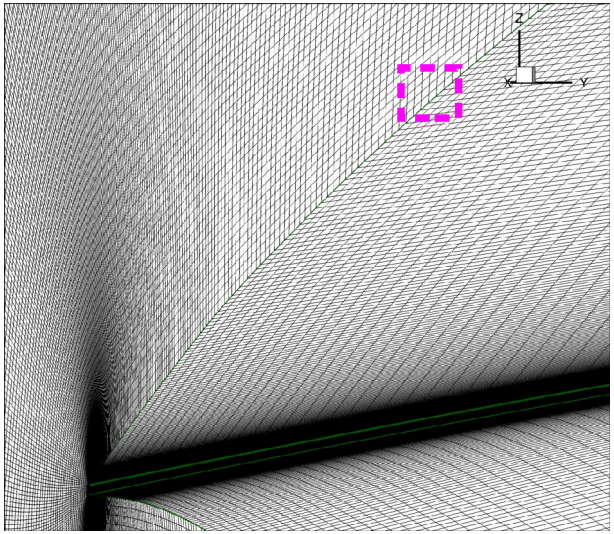


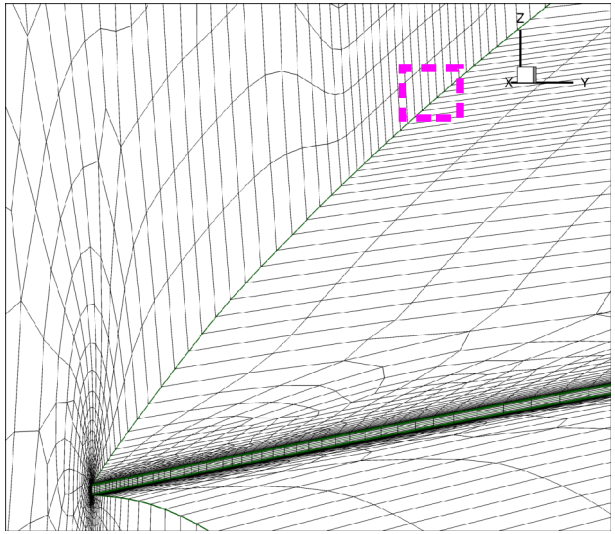
Case 1 – SOB Separation

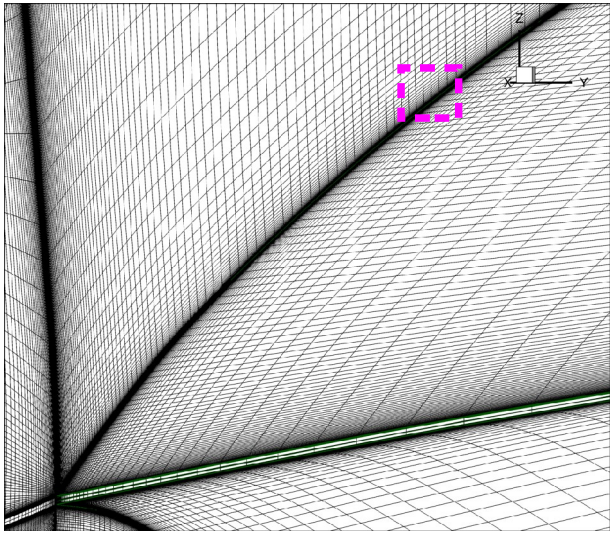












CommonHex - L6

Solar - L3

SolarChimera - L3

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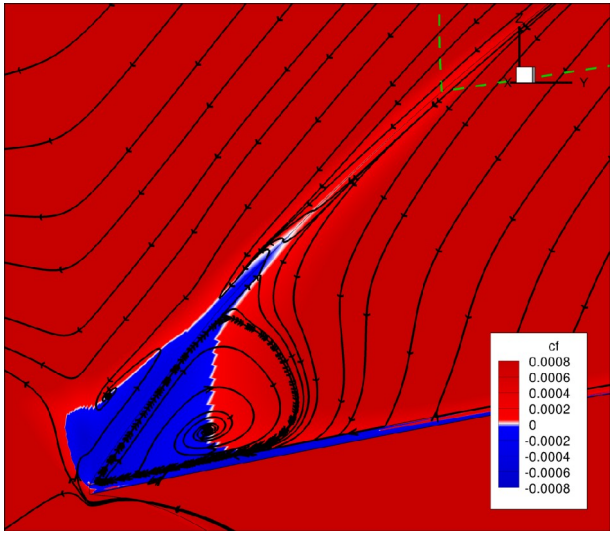
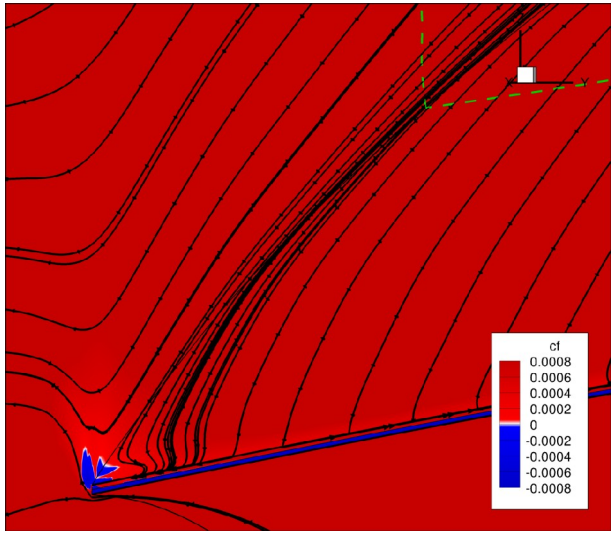
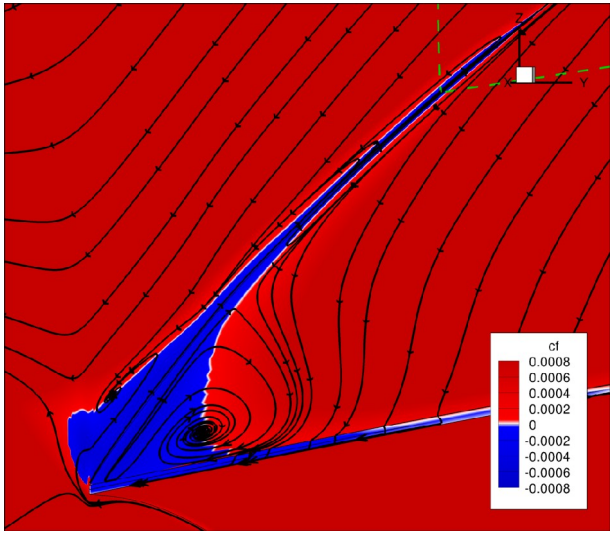
Case 1 – SOB Separation



CommonHex - L6



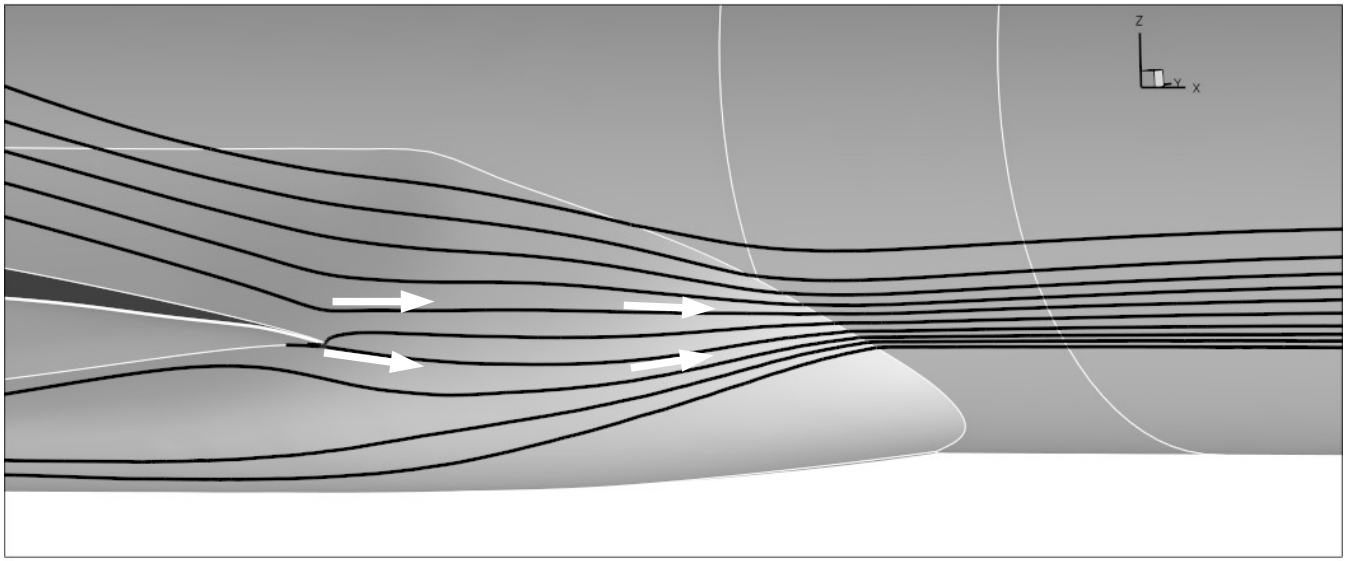
Solar - L3



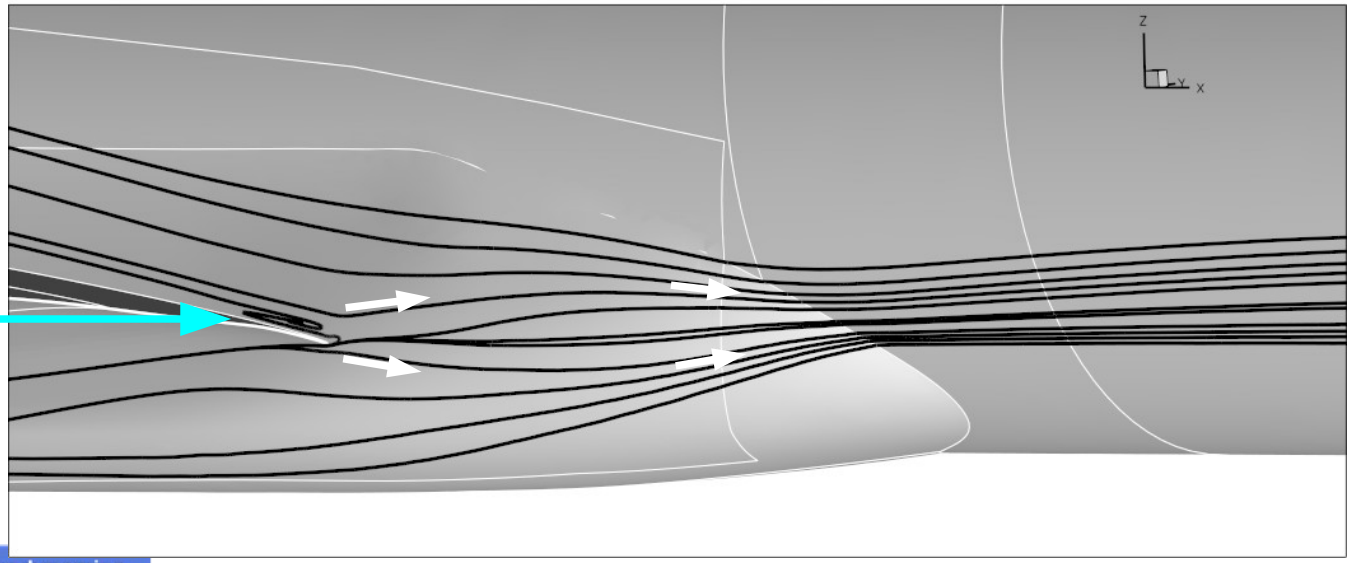
SolarChimera - L3

Case 1 – SOB Separation

CFD result **without** SOB separation

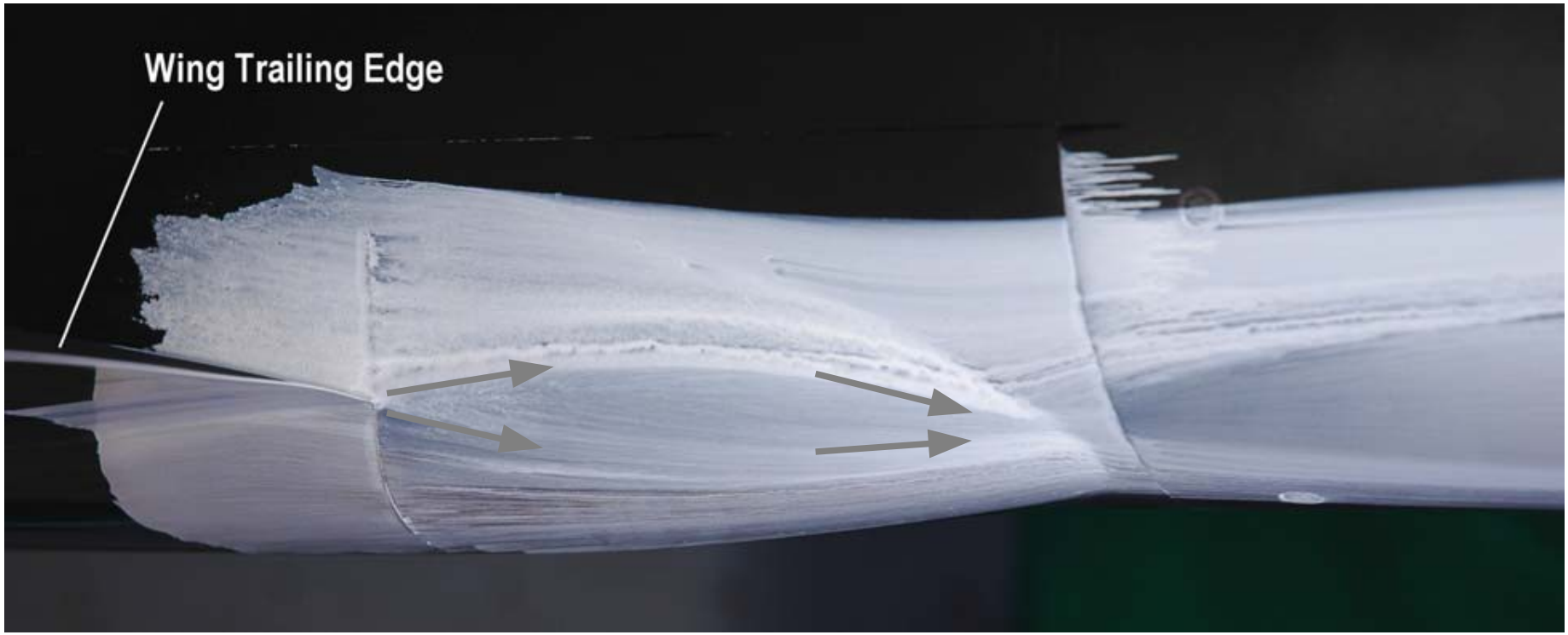


CFD result **with** SOB separation



Case 1 – SOB Separation

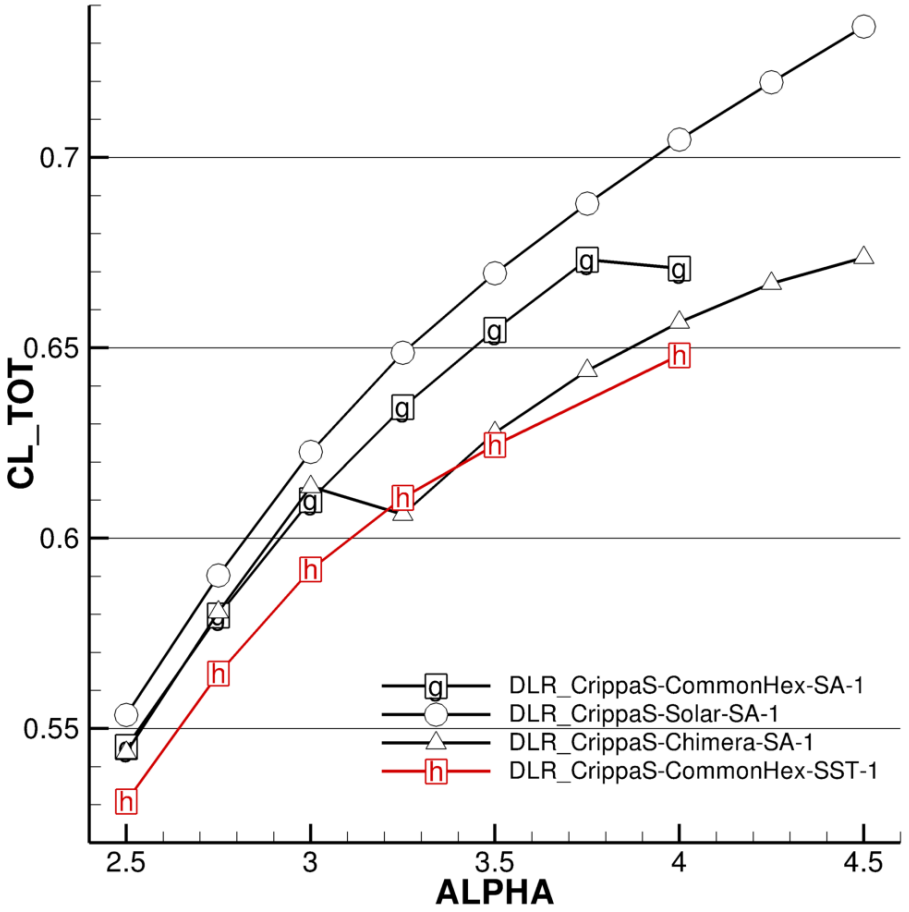
- SOB clues from WT: AIAA 2011-1129, figure 8



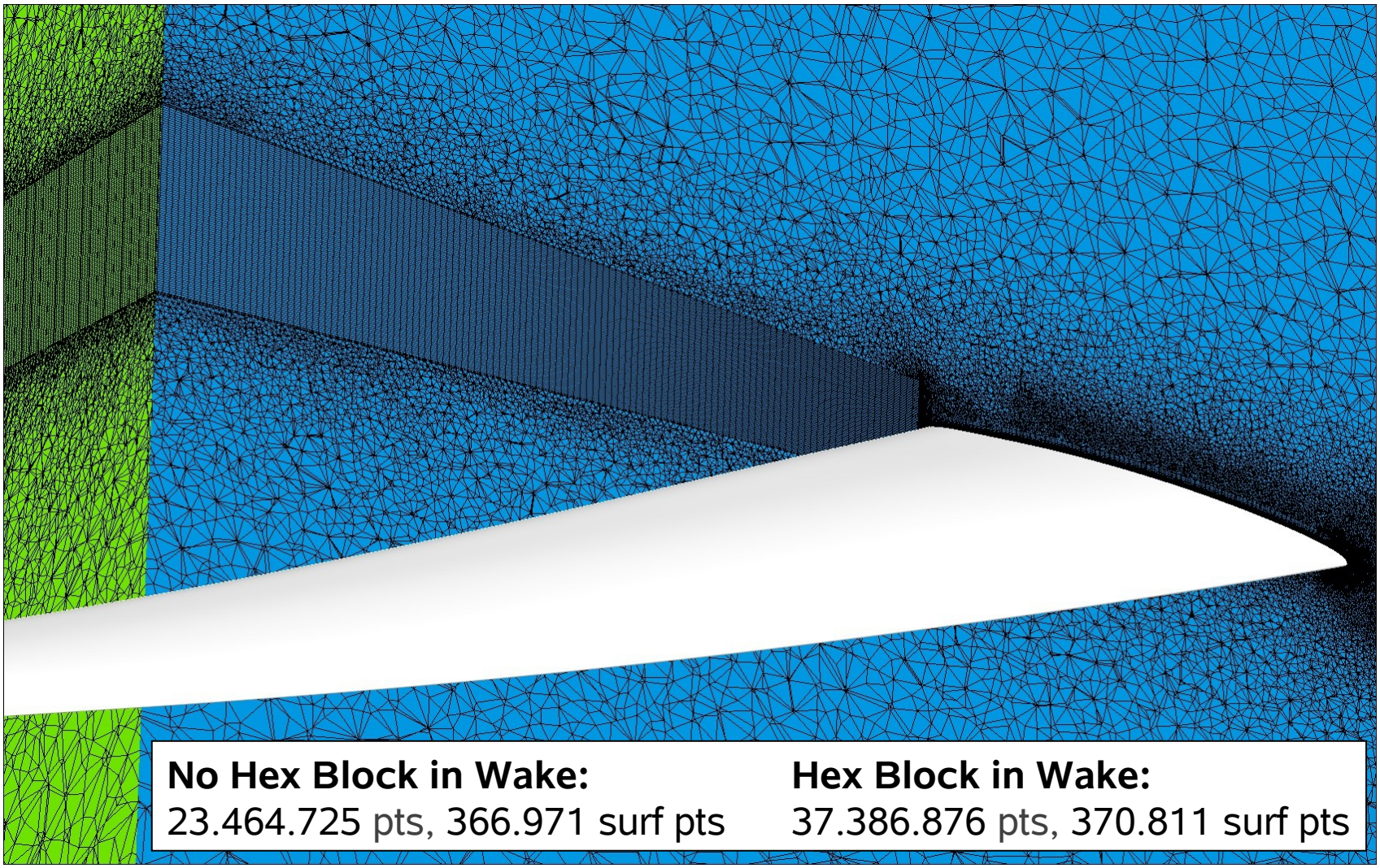
"expansion", then "contraction"

Case 2

- Solar grid: no CL-drop
- SolarChimera earlier CL-drop than CommonHex-L3
- SST/CommonHex no CL-drop



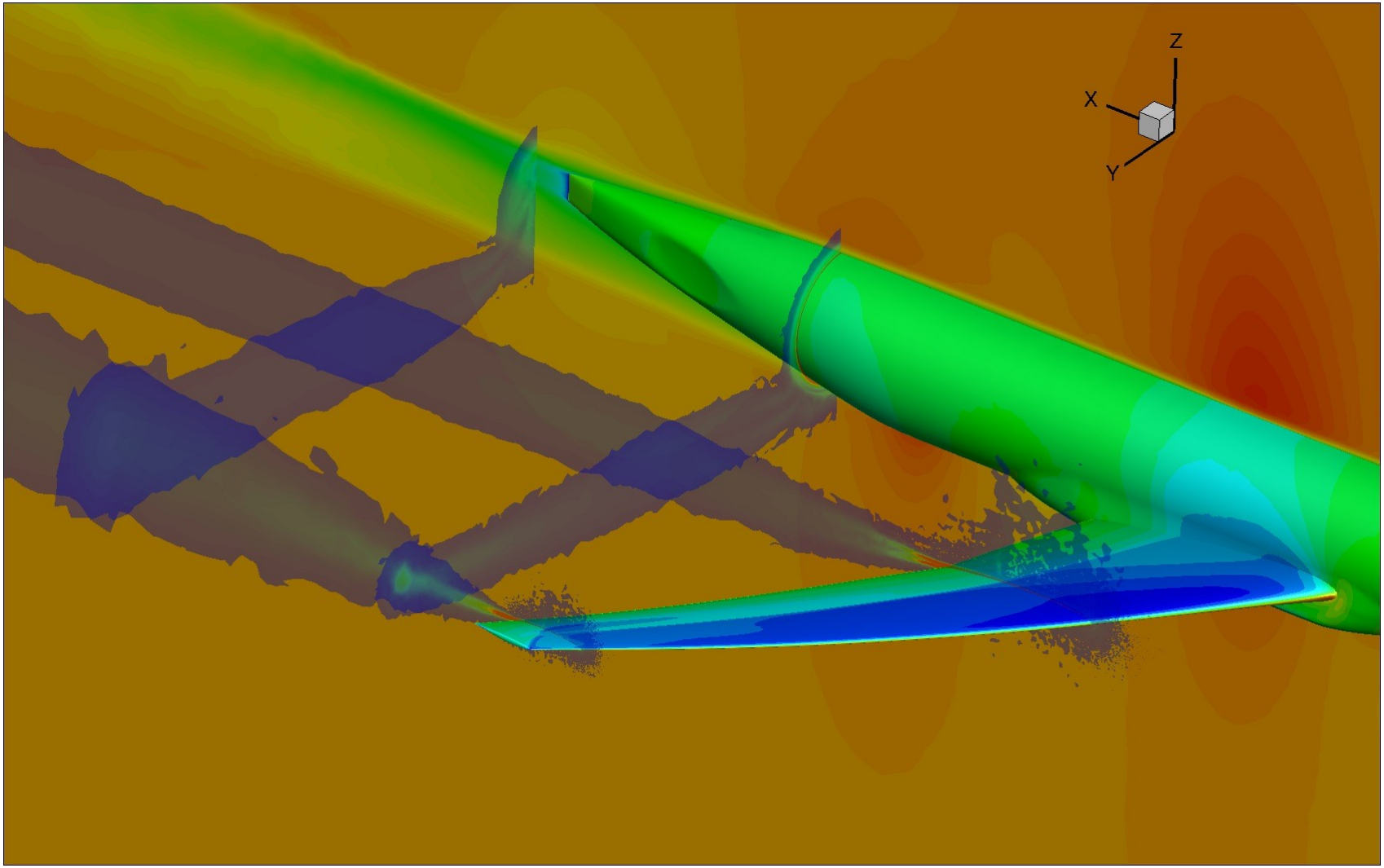
Case 2 - Hybrid Centaur Grids with/without Hex-Wake Block



No Hex Block in Wake:
23.464.725 pts, 366.971 surf pts

Hex Block in Wake:
37.386.876 pts, 370.811 surf pts

Case 2 - Hybrid Centaur Grids with/without Hex-Wake Block



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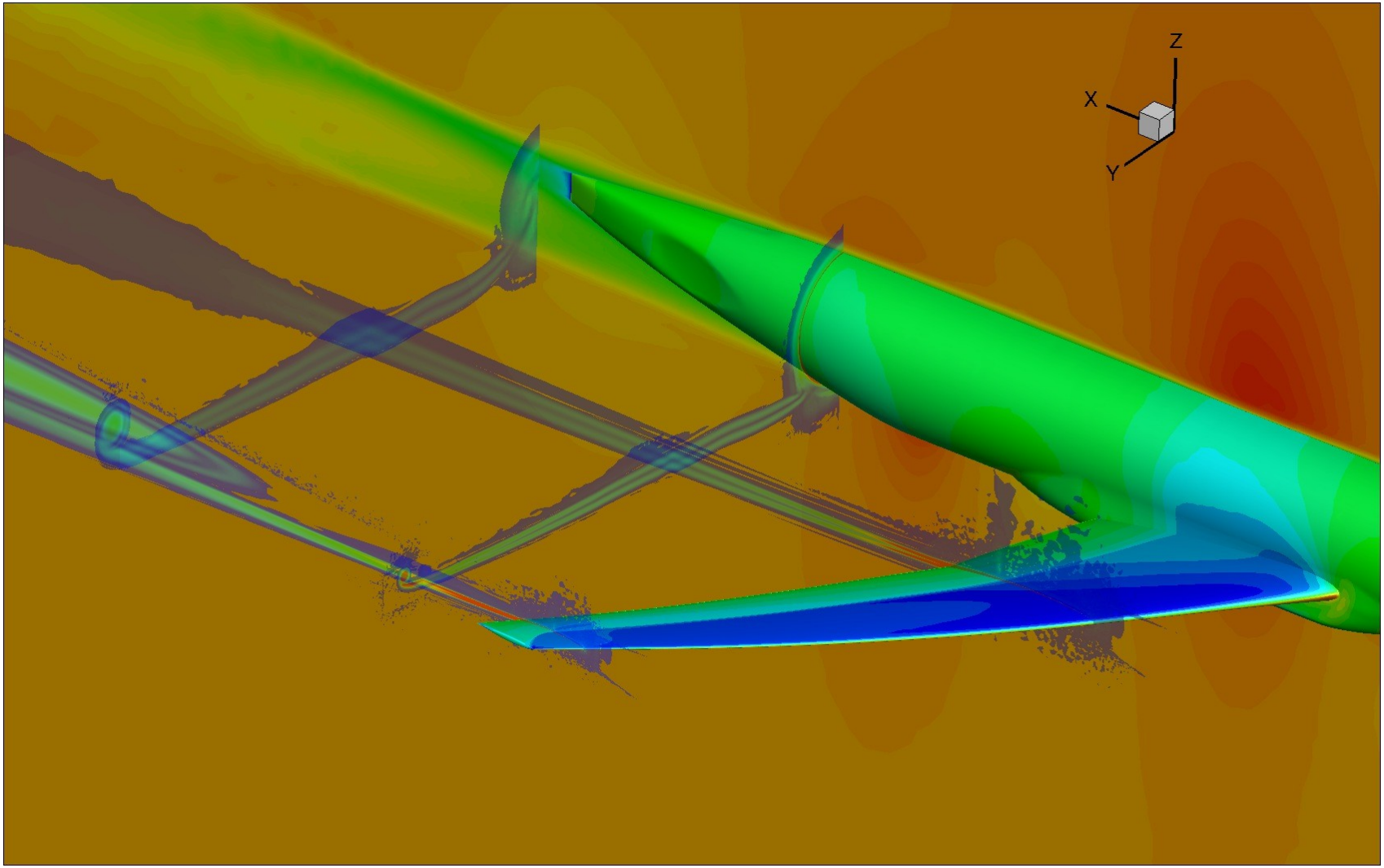

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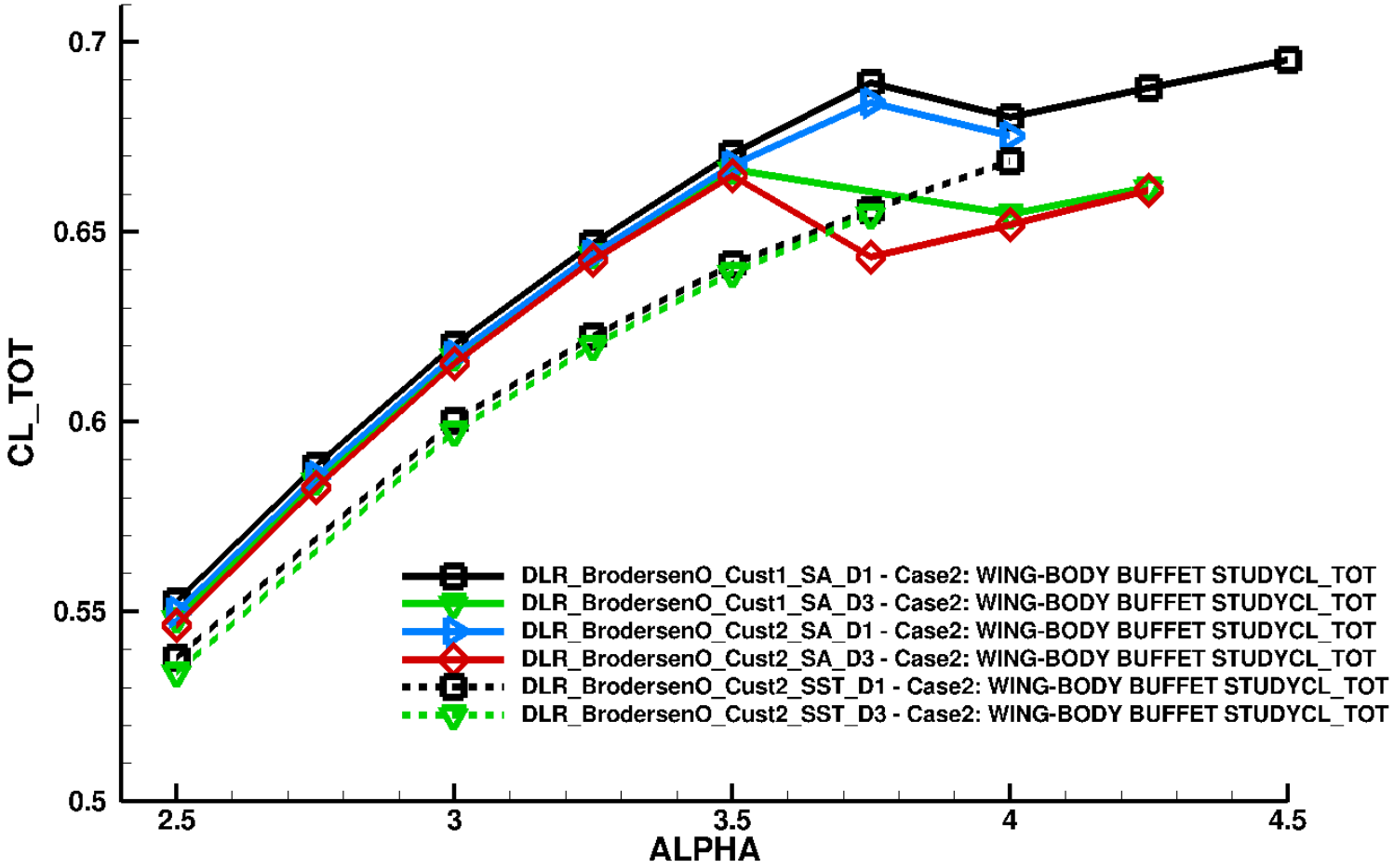

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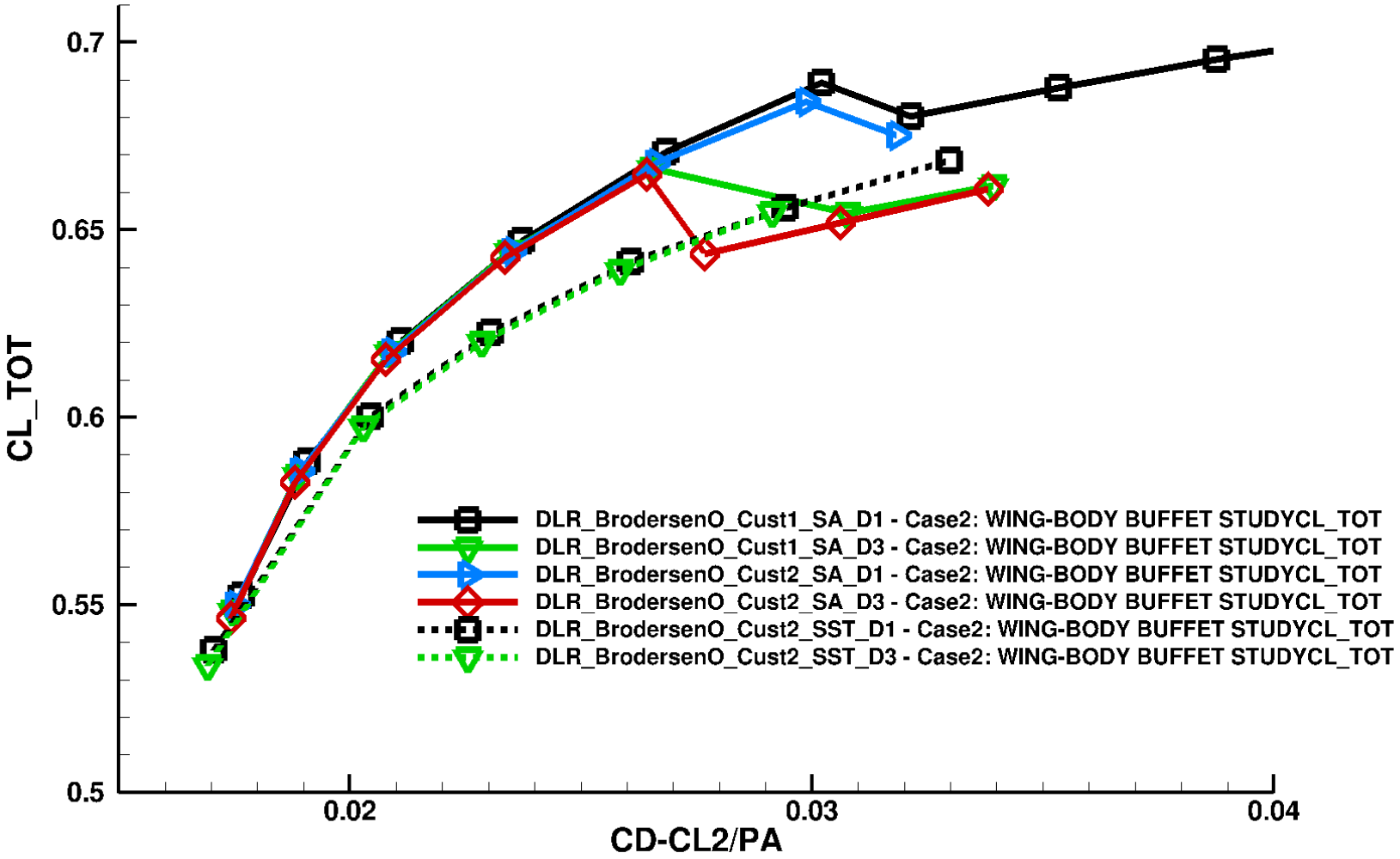

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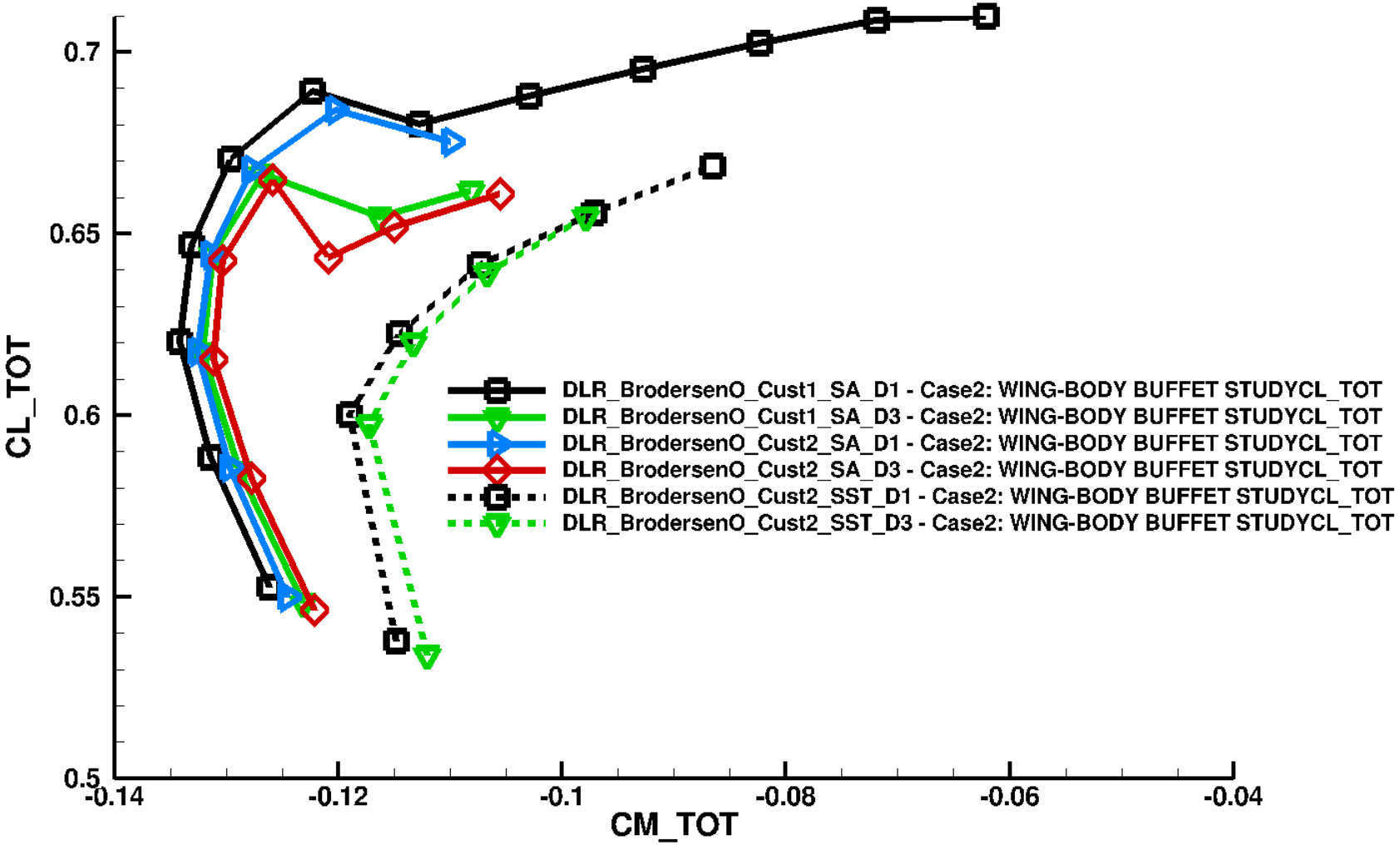
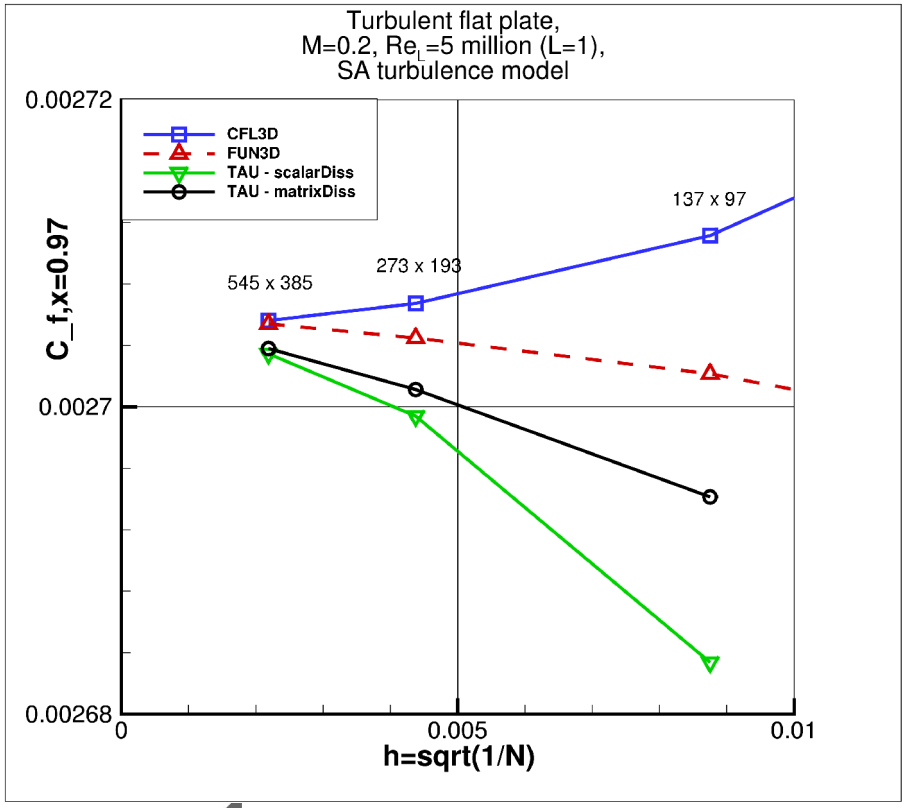
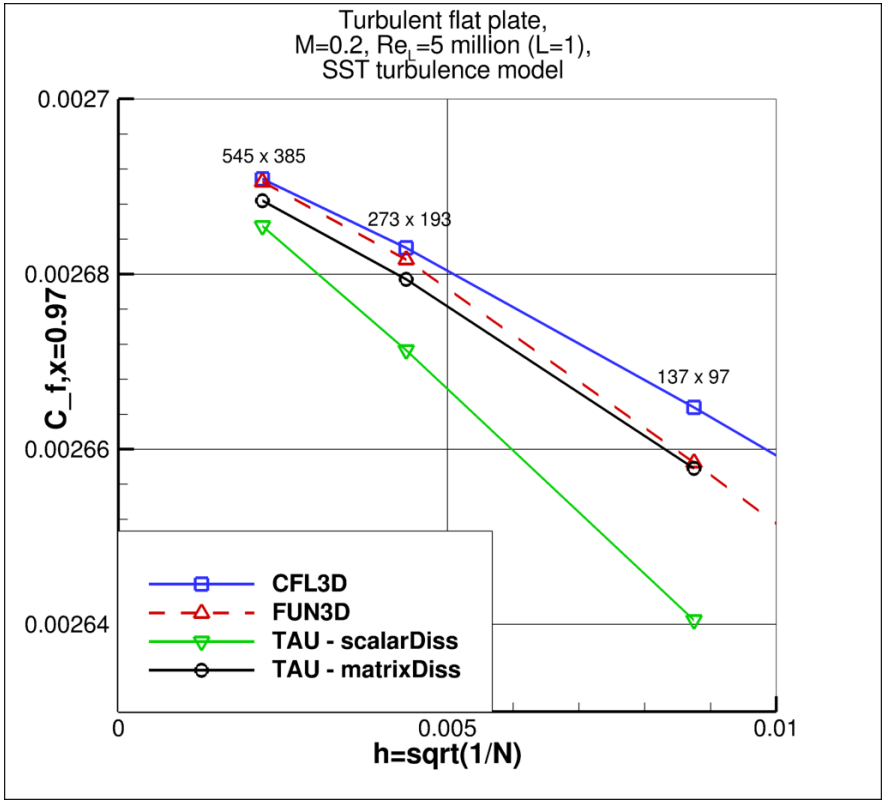


Case 3

- Case 3.1 (turb. flat plate)
- Case 3.2 (2D bump), see Case 3 presentation by C. Rumsey





Conclusions & Outlook

- Good grid convergence properties of common grids
- CDPR vs CDSF counteract to seemingly grid-independent CDTOT
- At design point, extrapolated CDTOT very similar for all cases
- At off-design, strong impact of SOB resolution on alpha @ CL-drop
- Wake resolution impact is small on aero coefficients

- Improve on modeling at separation onset
- Formulate recommendations for Solar development