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HiLiftPW-3

Results from the CFD++ software suite

Brian A. Edge

Metacomp Technologies, Inc.

PID: 006

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Summary of Completed Cases

Case: B2-HLCRM_UnstrPrismTet_PW	$\alpha = 8$ Fully turb, Grid study,	$\alpha = 16$ Fully turb, Grid study,	Other
1a (full gap)	yes	yes	
1b (full gap w adaption)	no	no	
1c (partial seal)	no	no	
1d (partial seal w adaption)	no	no	

Case: D-JSM_UnstrMixed_JAXA, C2-JSM_UnstrMixed_VGRID E-JSM_UnstrMixed_ANSA (OPTIONAL fine)	Polar, Fully turb	Polar, Specified transition	Polar, w Transition prediction	Other
2a (no nacelle)	yes	no	no	
2b (no nacelle w adaption)	no	no	no	
2c (with nacelle)	yes	no	no	
2d (with nacelle w adaption)	no	no	no	

Case	2D Verification study	Other
3	yes	

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Summary of code and numerics used

- Software used: CFD++ Software Suite
- CFD++ Basic Algorithms:
  - Unified unstructured linearity-preserving TVD interpolation convection scheme
  - Positivity-preserving Riemann solver-based flux computation
  - Advanced algebraic multi-grid agglomeration linear solver
- CFD++ includes a wide variety of turbulence models. The specific turbulence model used for this study:
  - Spalart-Allmaras with:
    - Rotation/Curvature Correction (RC)
    - Quadratic Constitutive Relation (QCR)
- New $\alpha - \beta$ sweep capability to automate the simulation over a range of angles of attack

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Brief overview of grid system(s)

Grid System	Cases	Problems or Issues
B2-HLCRM_UnstrPrismTet_PW	1a	None
C2-JSM_UnstrMixed_VGRID	2a, 2c	None
D-JSM_UnstrMixed_JAXA	2a, 2c	Negative volume cells
E-JSM_UnstrMixed_ANSA (OPTIONAL fine)	2a, 2c	Negative volume cells

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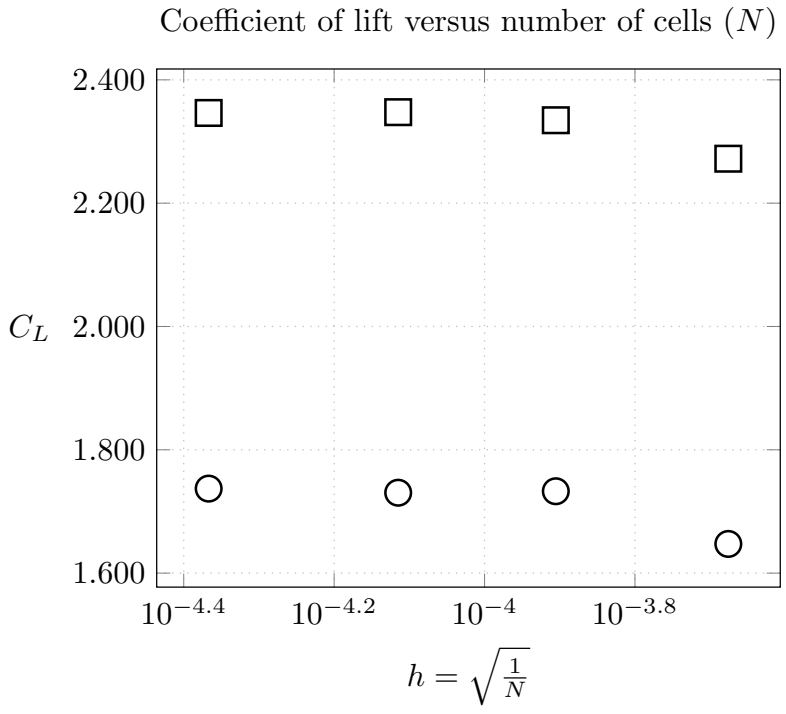
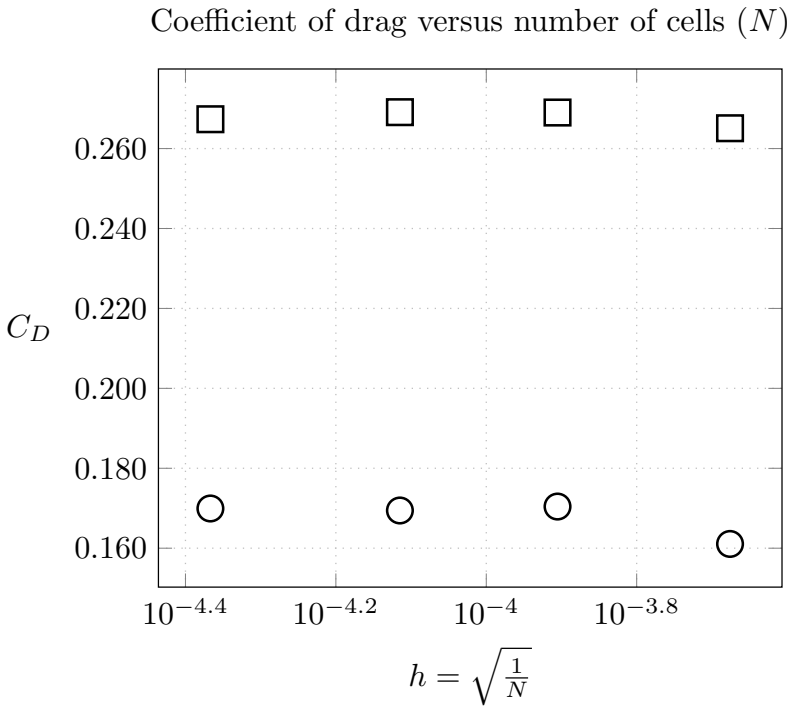
Results from Case 1a (HL-CRM): Lift and Drag





○ $\alpha = 8\,\mathrm{deg}$
□ $\alpha = 16\,\mathrm{deg}$

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Overview of Case 2a and Case 2c Results

JAXA Standard Model (JSM)

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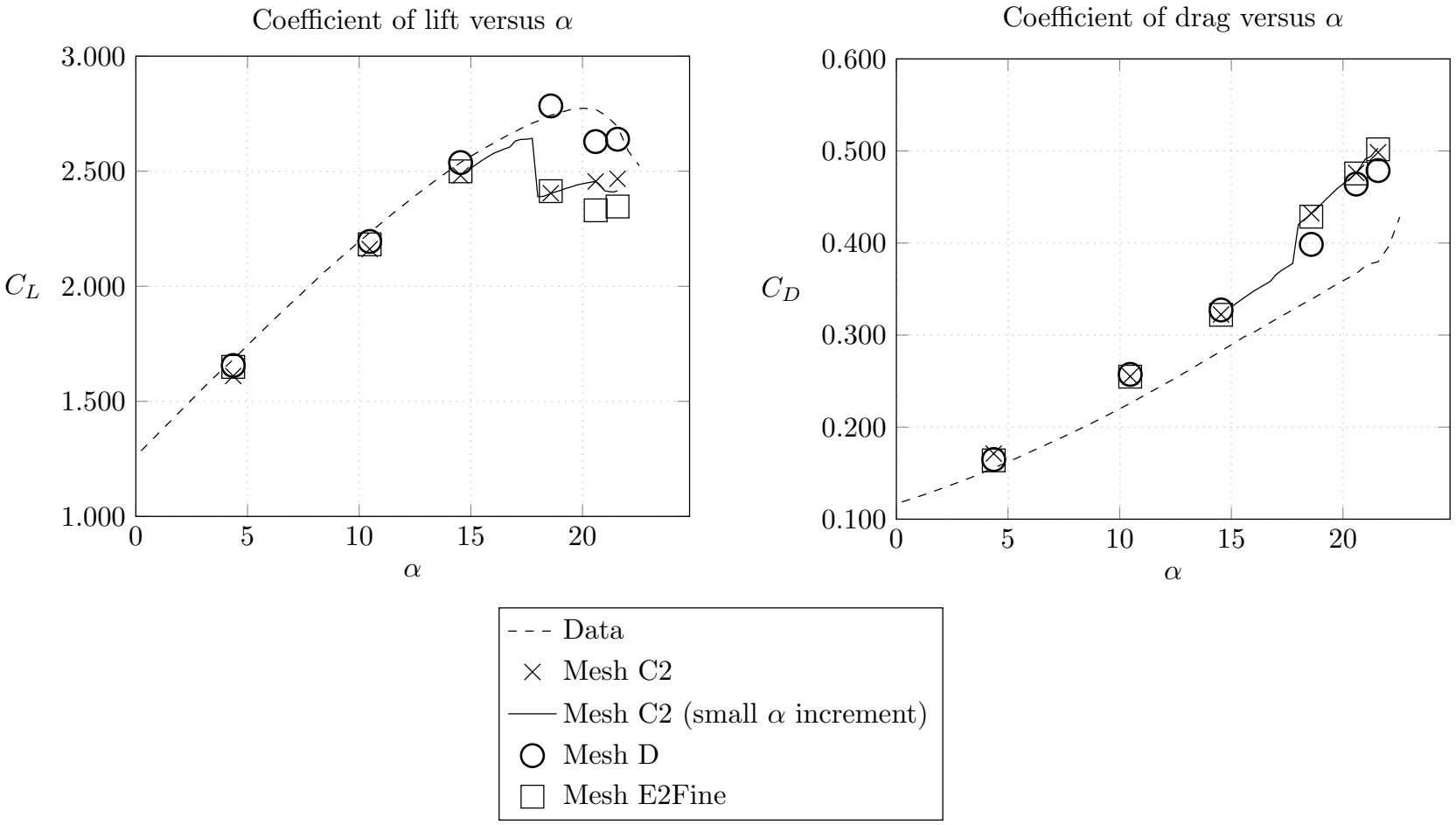
Case 2a (Without Nacelle/Pylon)

$$\alpha = 4.36, 10.47, 14.54, 18.58, 20.59, 21.57$$



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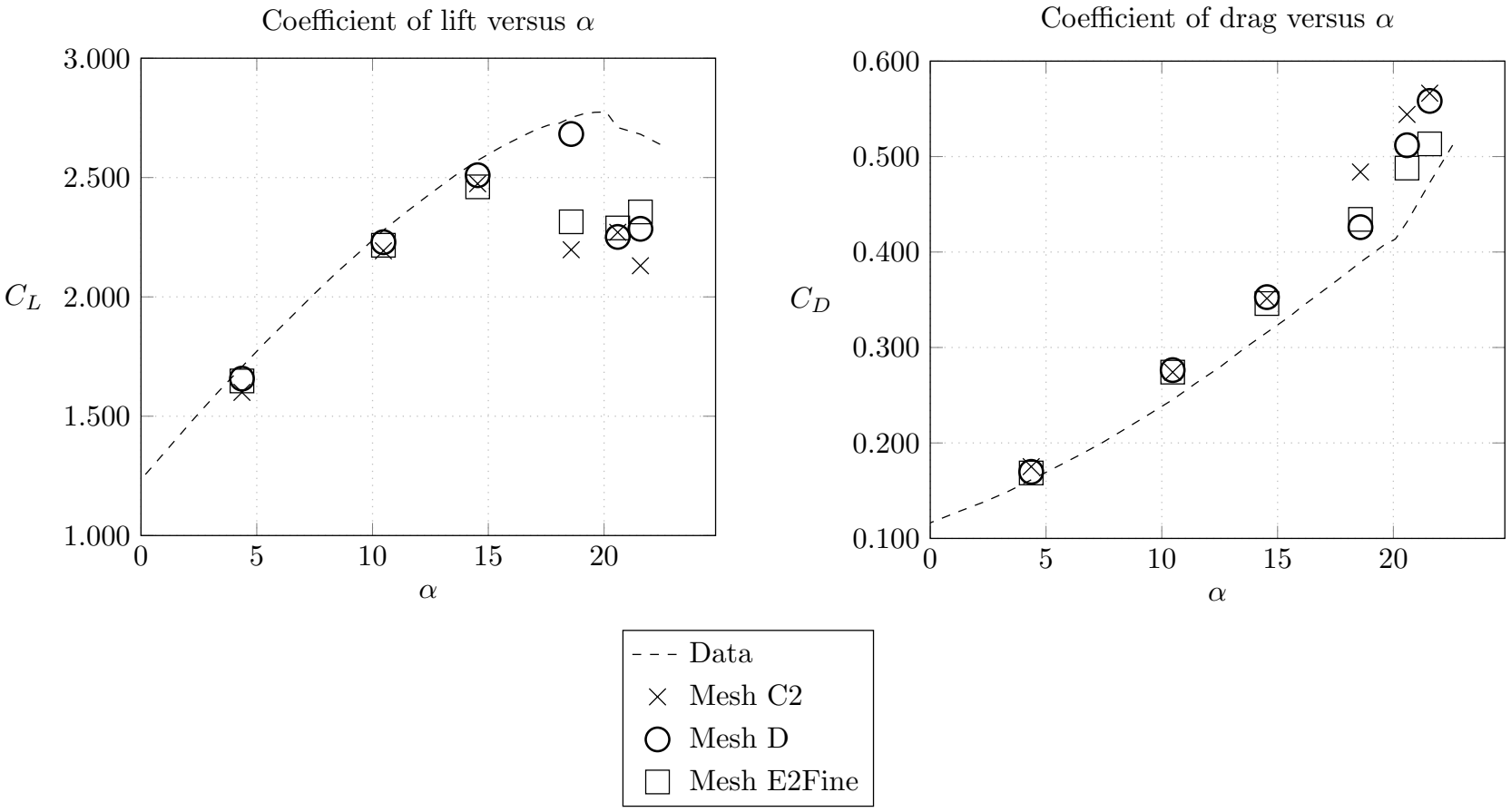
Case 2c (*With* Nacelle/Pylon)

$$\alpha = 4.36, 10.47, 14.54, 18.58, 20.59, 21.57$$



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Comparison of C2 Mesh, D Mesh, and Data

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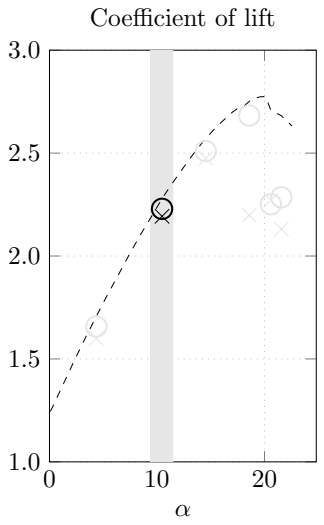
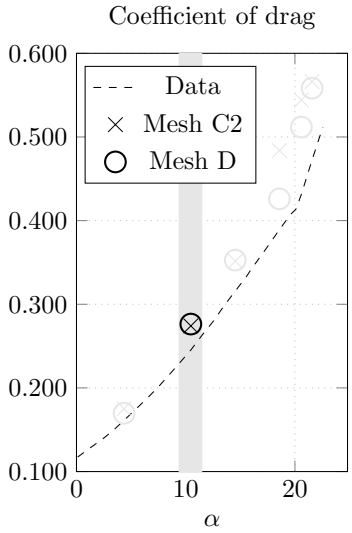
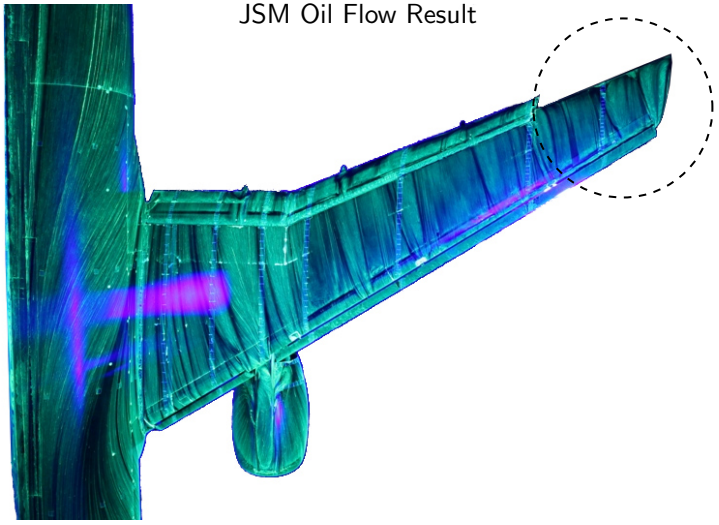
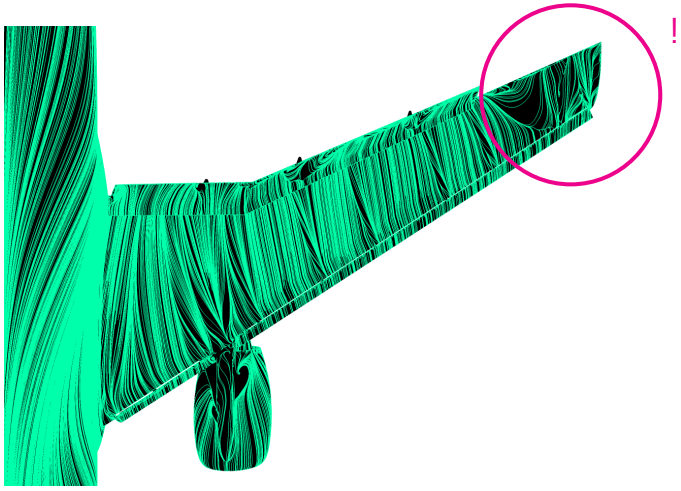
Streaklines from Case 2c: $\alpha = 10.47$

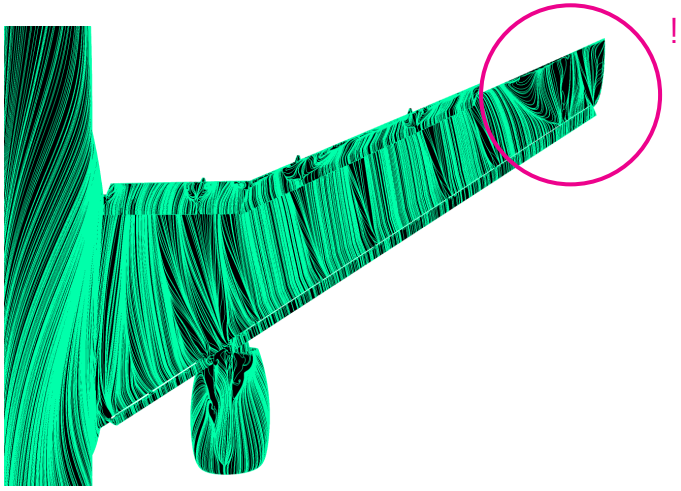








C2 Mesh



D Mesh

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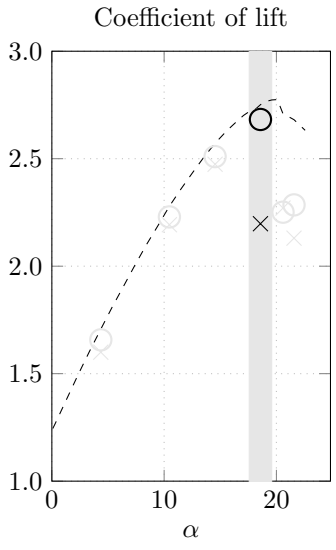
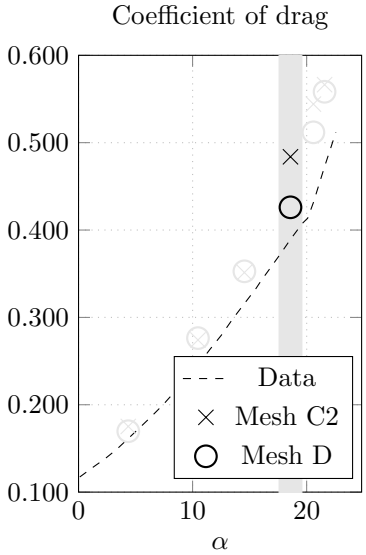
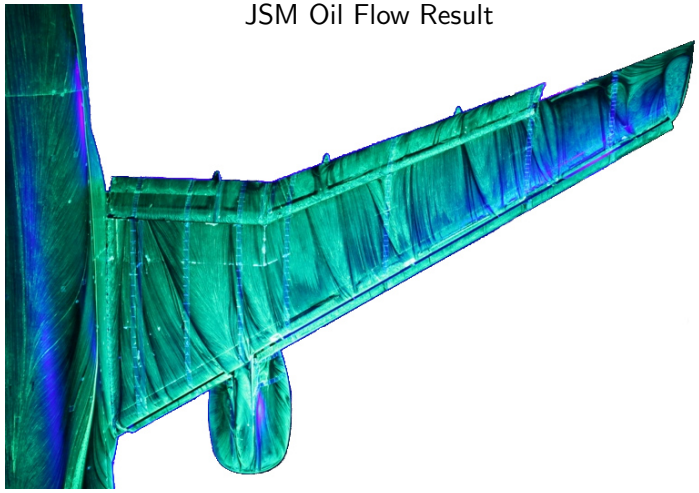
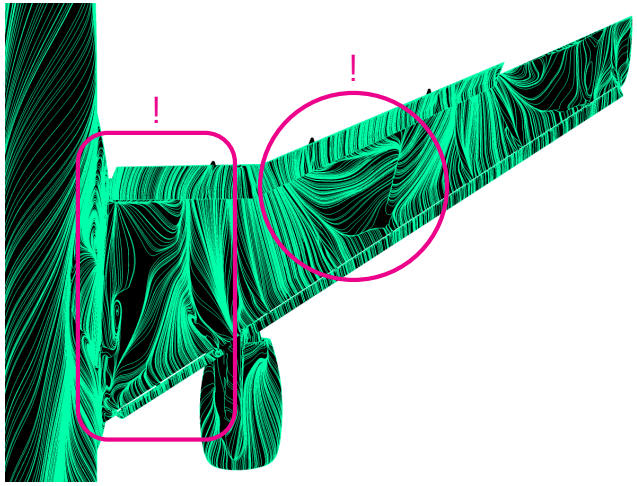
Streaklines from Case 2c: $\alpha = 18.58$

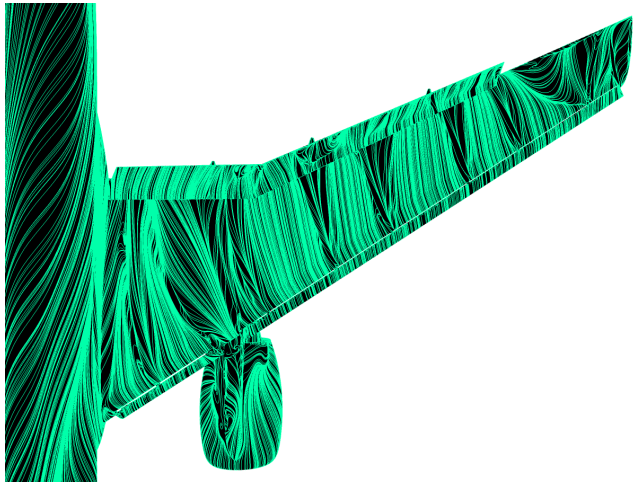








C2 Mesh



D Mesh

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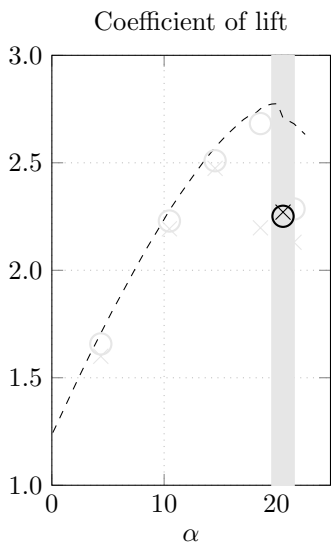
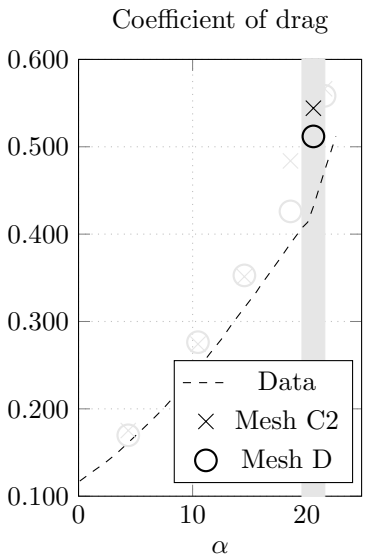
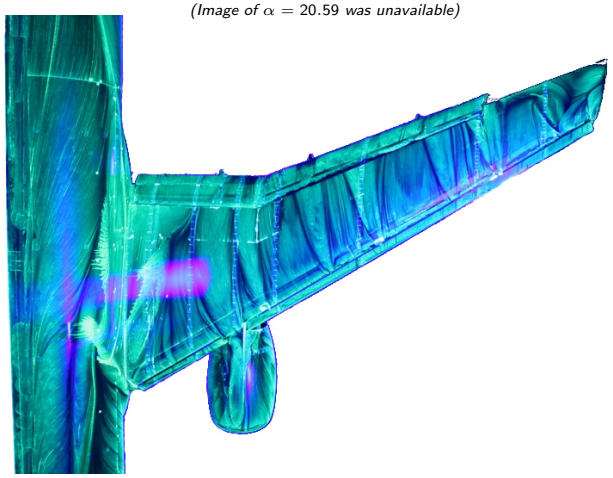
Streaklines from Case 2c: $\alpha = 20.59$

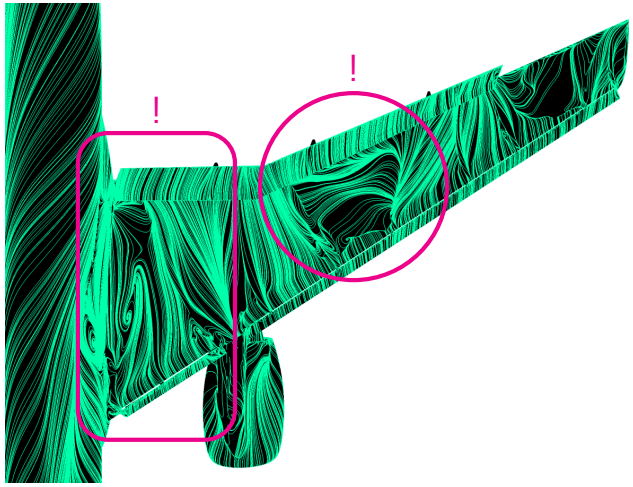




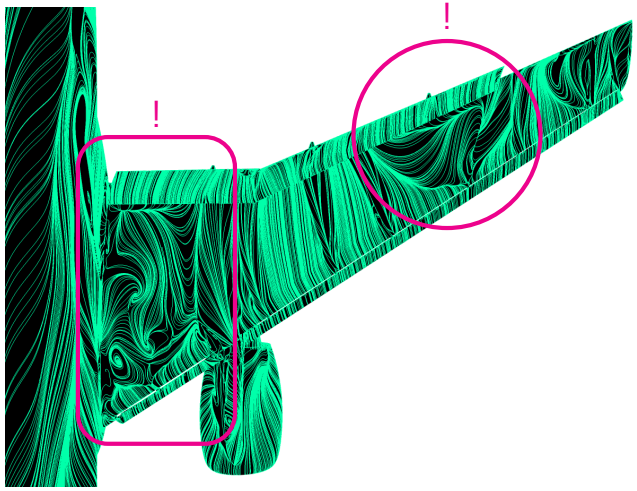
JSM Oil Flow Result ($\alpha = 21.57$)

(Image of $\alpha = 20.59$ was unavailable)





C2 Mesh, $\alpha = 20.59$



D Mesh, $\alpha = 20.59$

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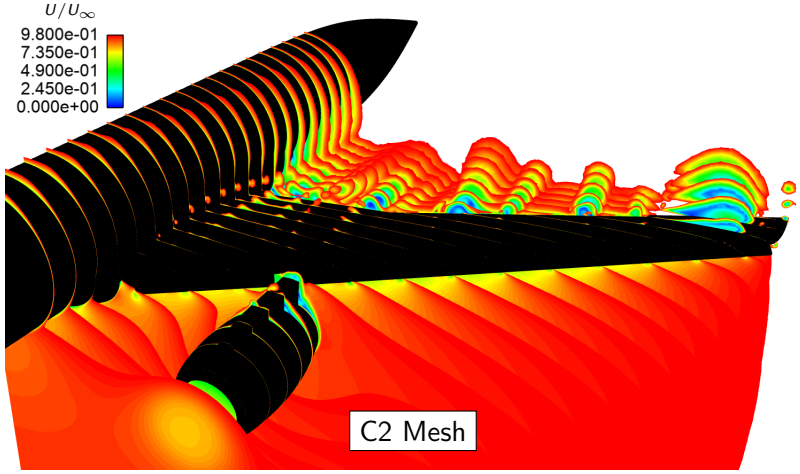
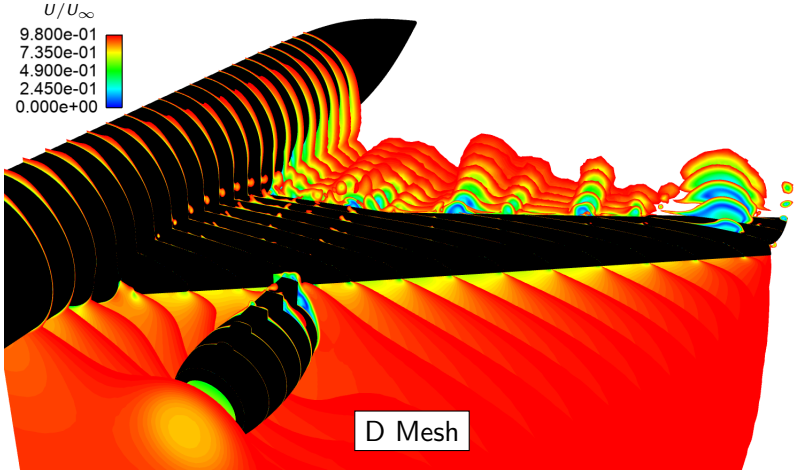
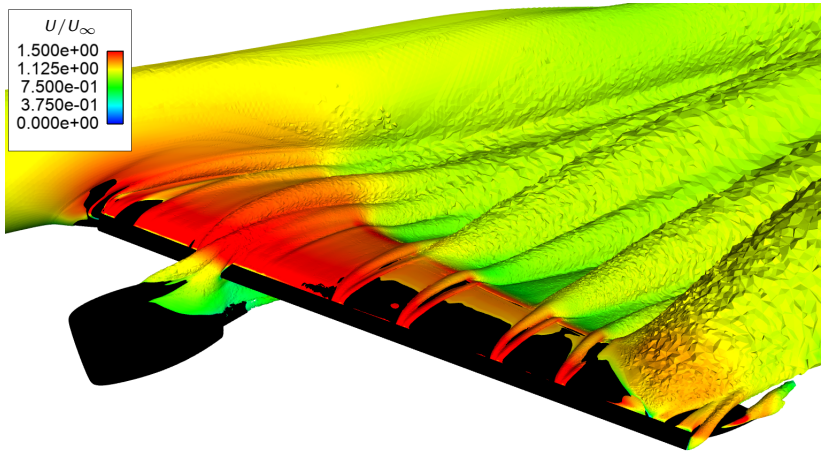
Case 2c: $\alpha = 10.47$

Cut views showing $U/U_\infty < 0.98$

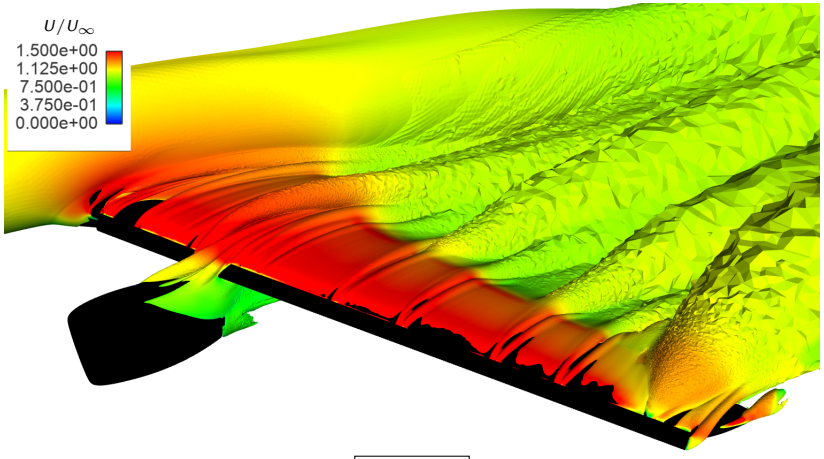




Isosurfaces of $\mu_t/\mu = 100$ colored by U/U_∞



C2 Mesh



D Mesh

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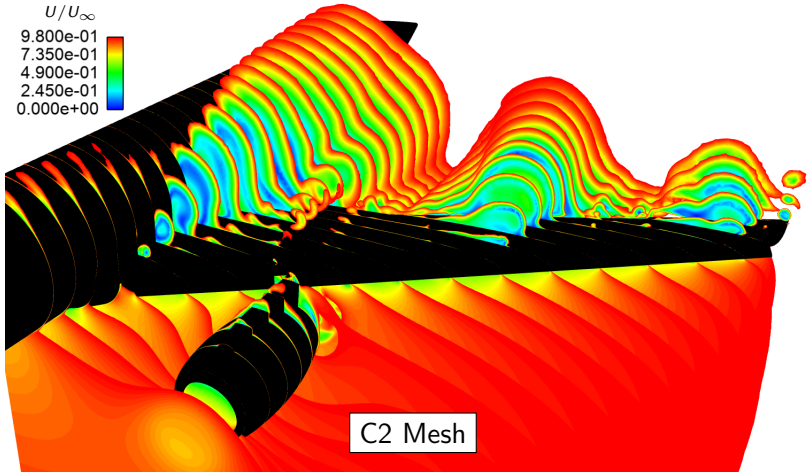
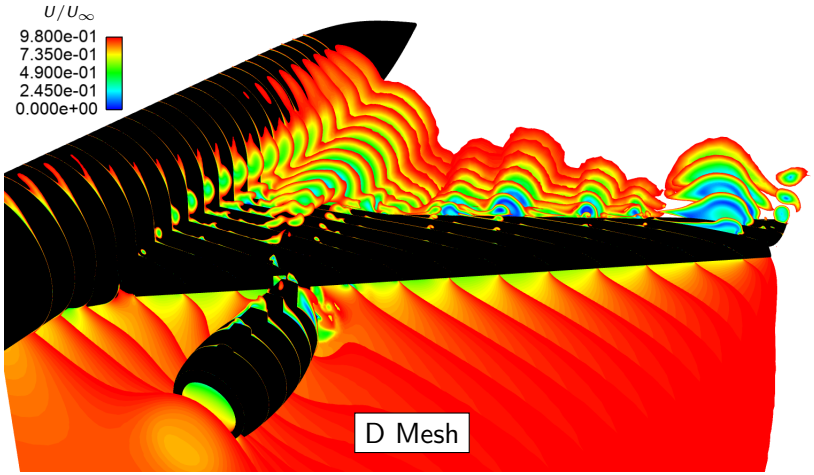
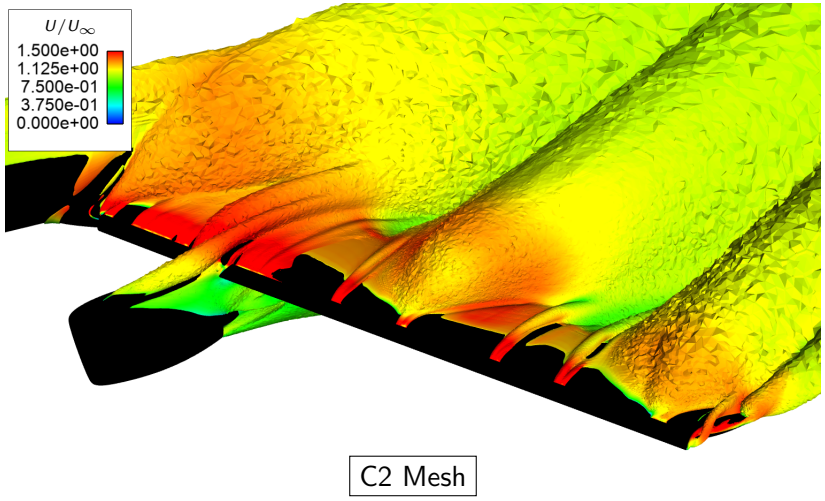
Case 2c: $\alpha = 18.58$

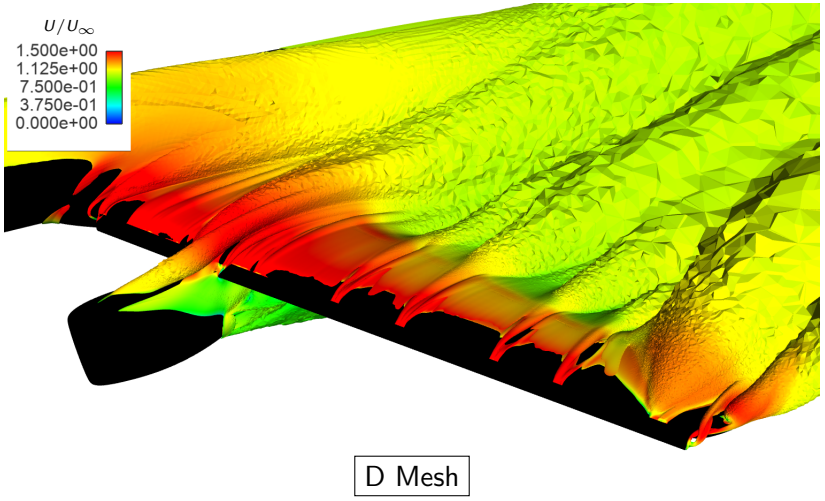
Cut views of $U/U_\infty < 0.98$





Isosurfaces of $\mu_t/\mu = 100$ colored by U/U_∞





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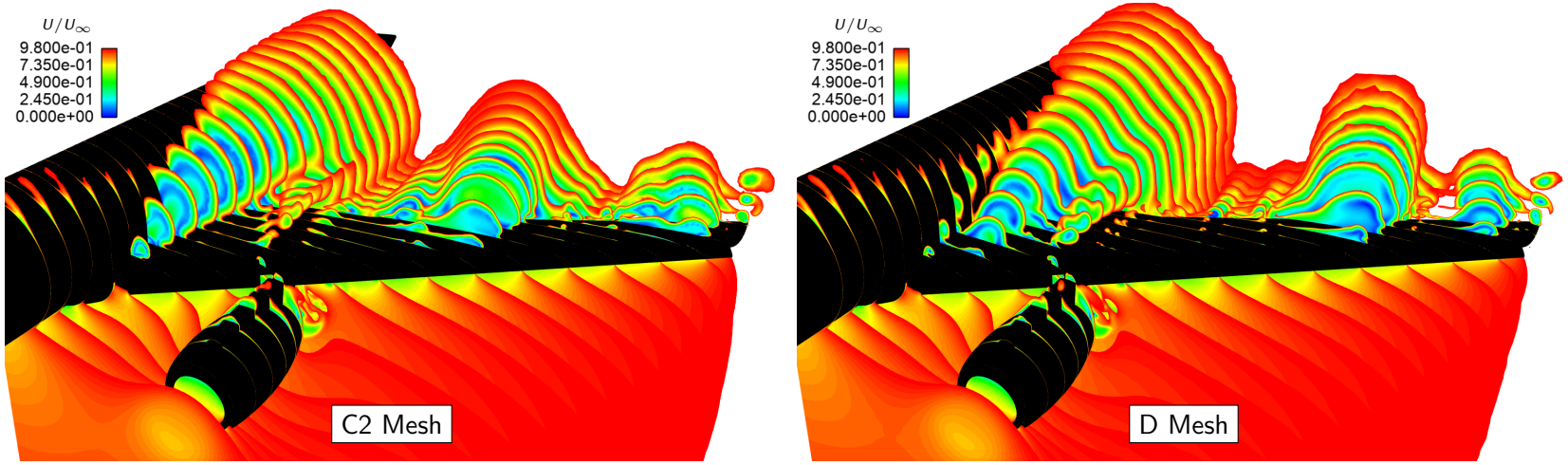
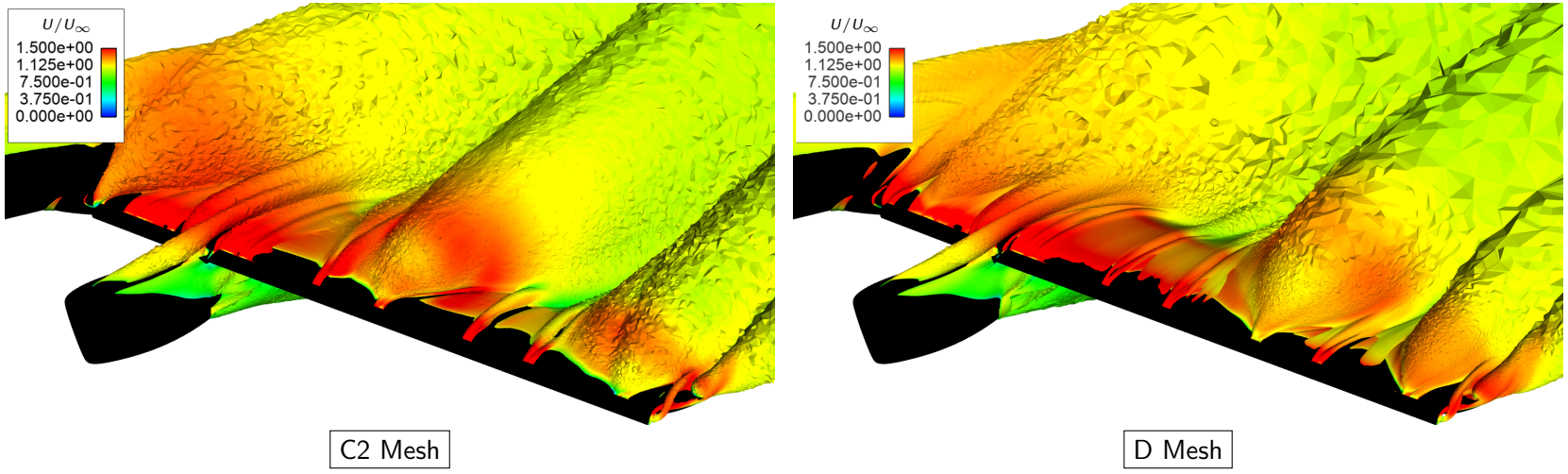
CFD++ MIME MetaFSI CSM++ CAA++

Case 2c: $\alpha = 20.59$

Cut views of $U/U_\infty < 0.98$



Isosurfaces of $\mu_t/\mu = 100$ colored by U/U_∞



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CFD++ MIME MetaFSI CSM++ CAA++

C_P Plots
(D Mesh Only)

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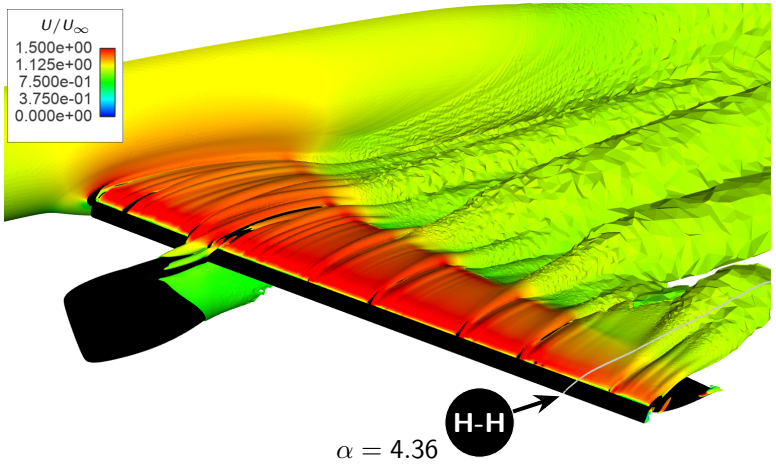
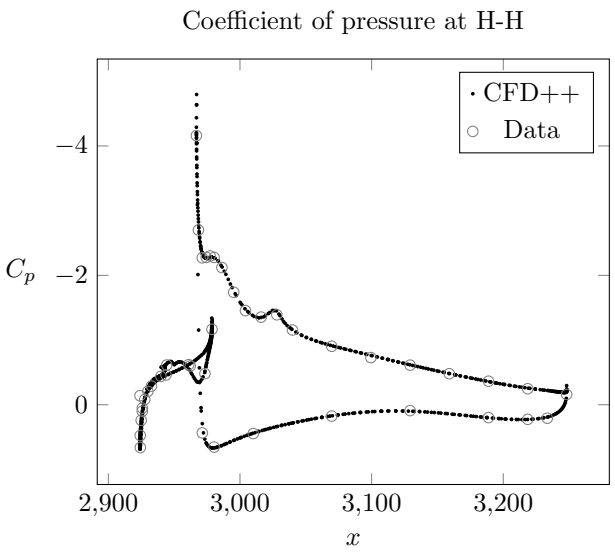
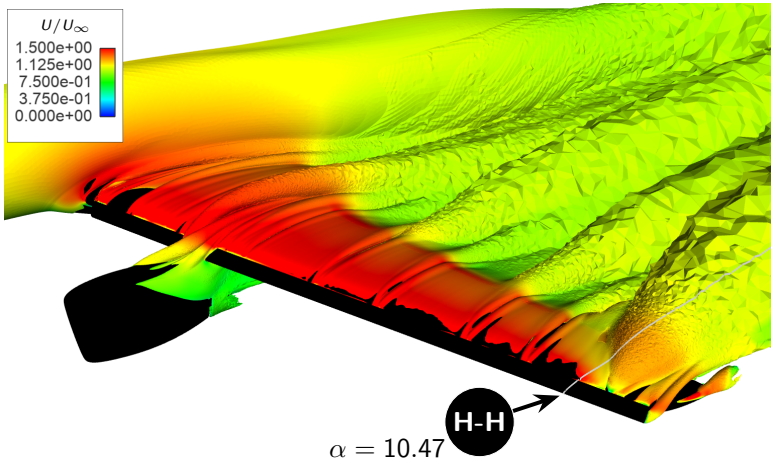
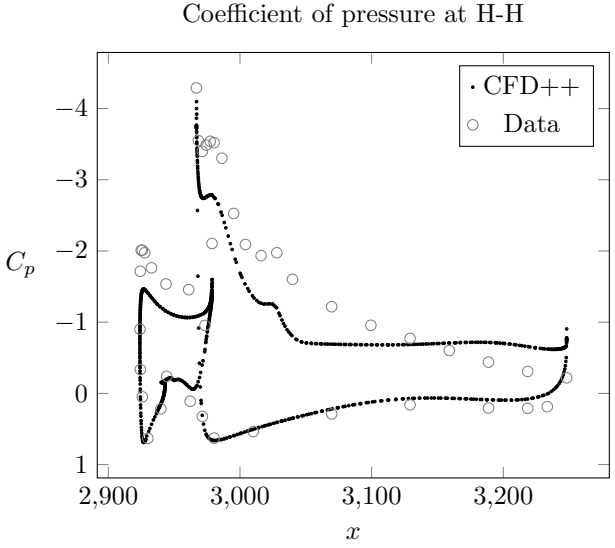
Case 2c (D Mesh): C_P at cut H-H









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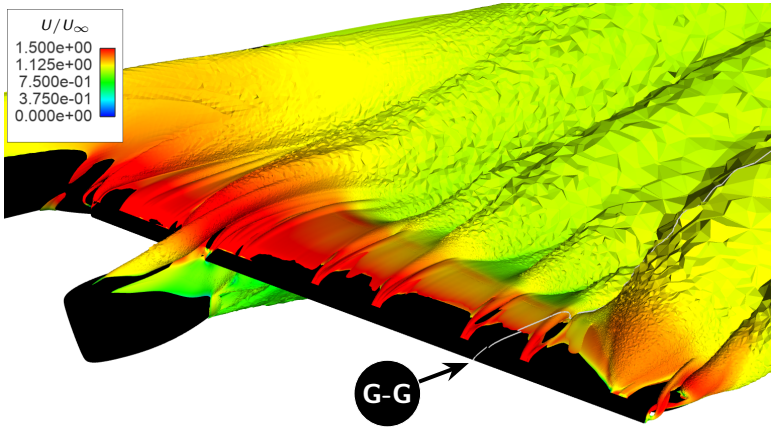
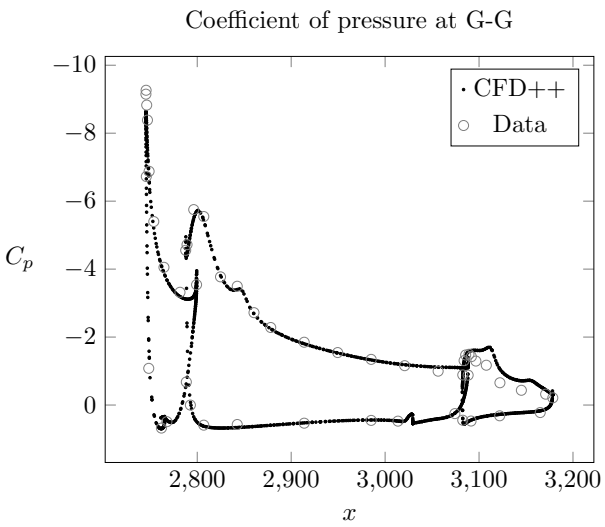
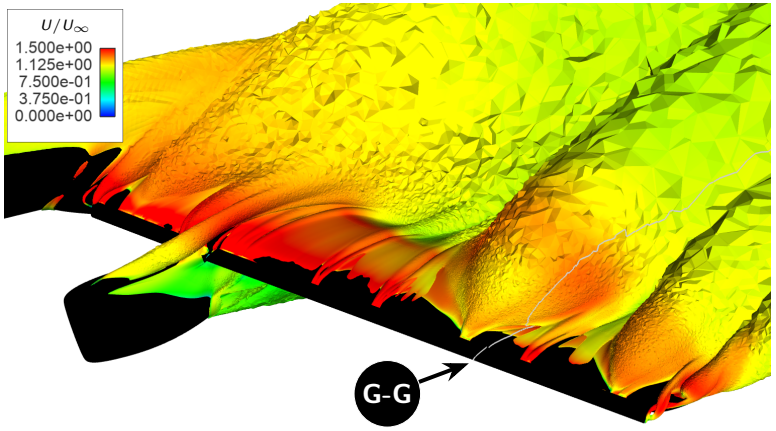
Case 2c (D Mesh): C_P at cut G-G



$\alpha = 18.58$





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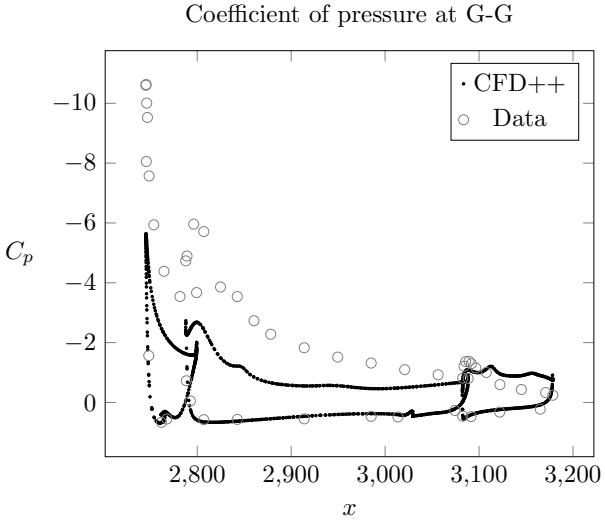

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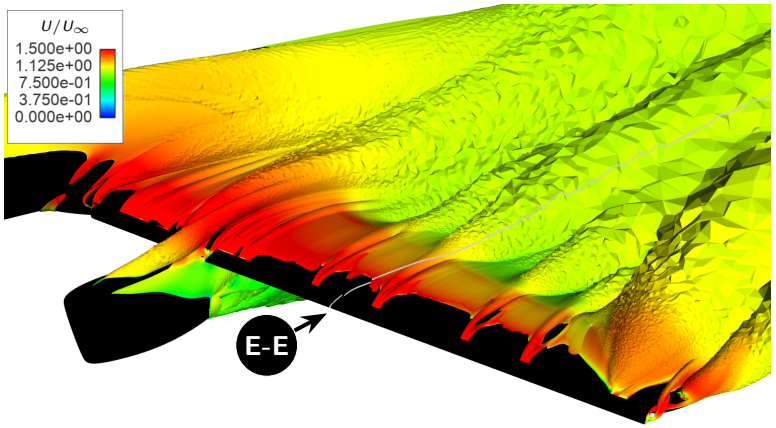
Case 2c (D Mesh): C_P at cut E-E



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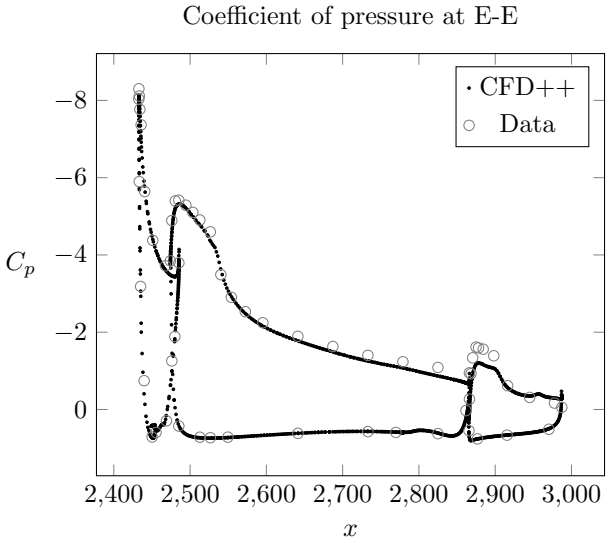

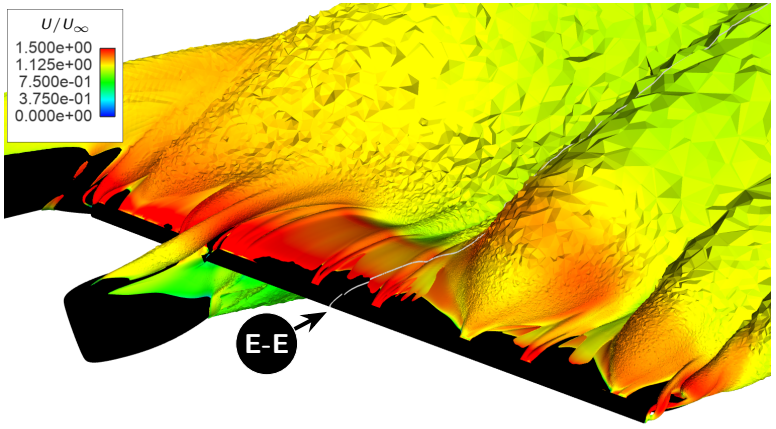

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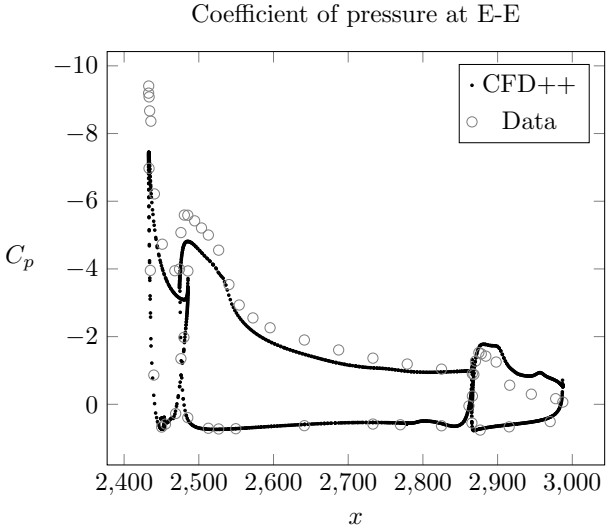

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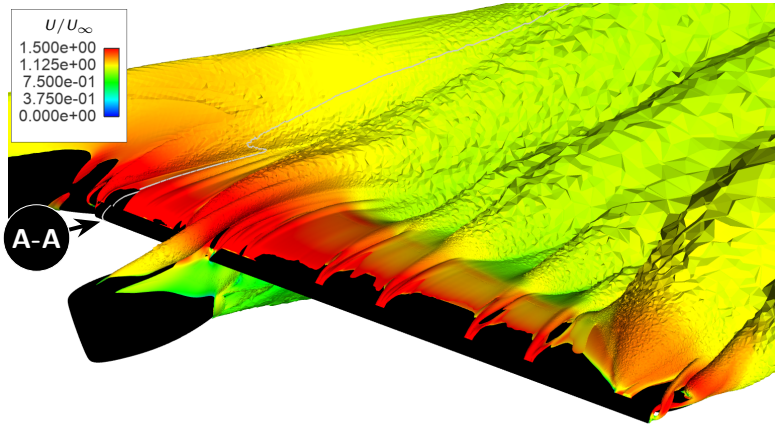
Case 2c (D Mesh): C_P at cut A-A



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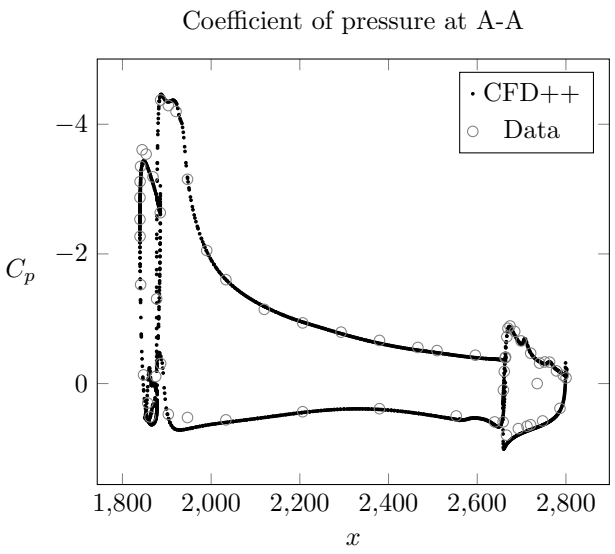
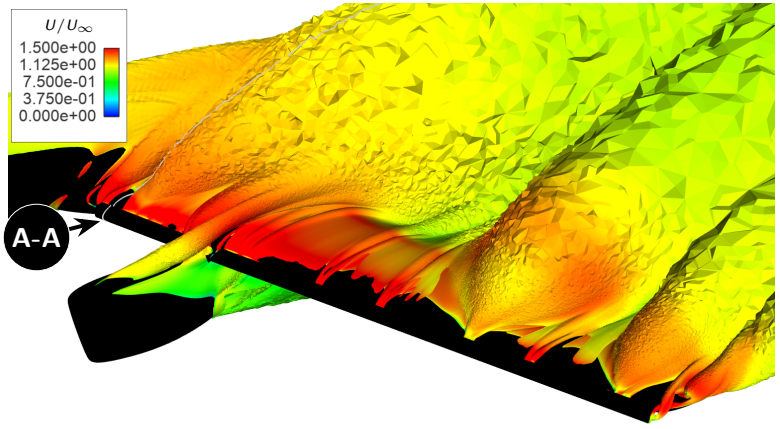
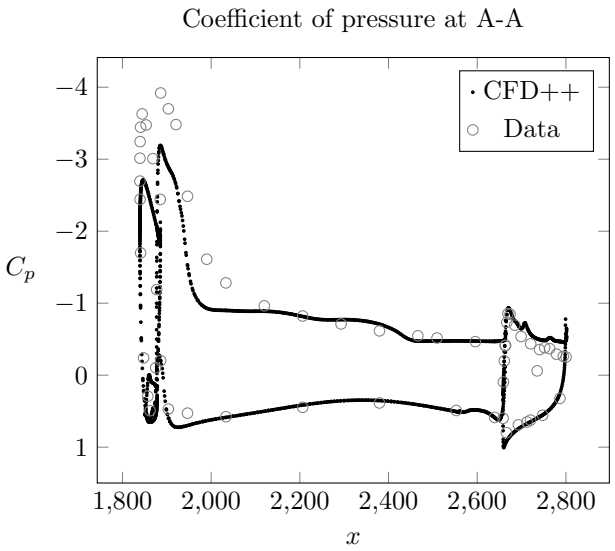




$\alpha = 20.59$



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Closing Summary

JSM Results:

- $C_{L,max}$:

  Difference between the D Mesh results and data is,

  - Case 2a: 0.38%
  - Case 2c: 3.33%

- Smaller alpha increments:

  Predicted $C_{L,max}$ error is reduced by using 1/4 degree alpha increments

- Mesh Issues:

  - Mesh family (mesh resolution) affects predictive capability
  - Early boundary layer separation observed at the wingtip with 3 different mesh families

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Thank You!

Name:	Brian Edge
Email:	edge@metacomptech.com
Phone:	(818) 735-4880
Address:	Metacomp Technologies, Inc. 28632-B Roadside Drive, Suite 255 Agoura Hills, CA 91301

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Backup Slides

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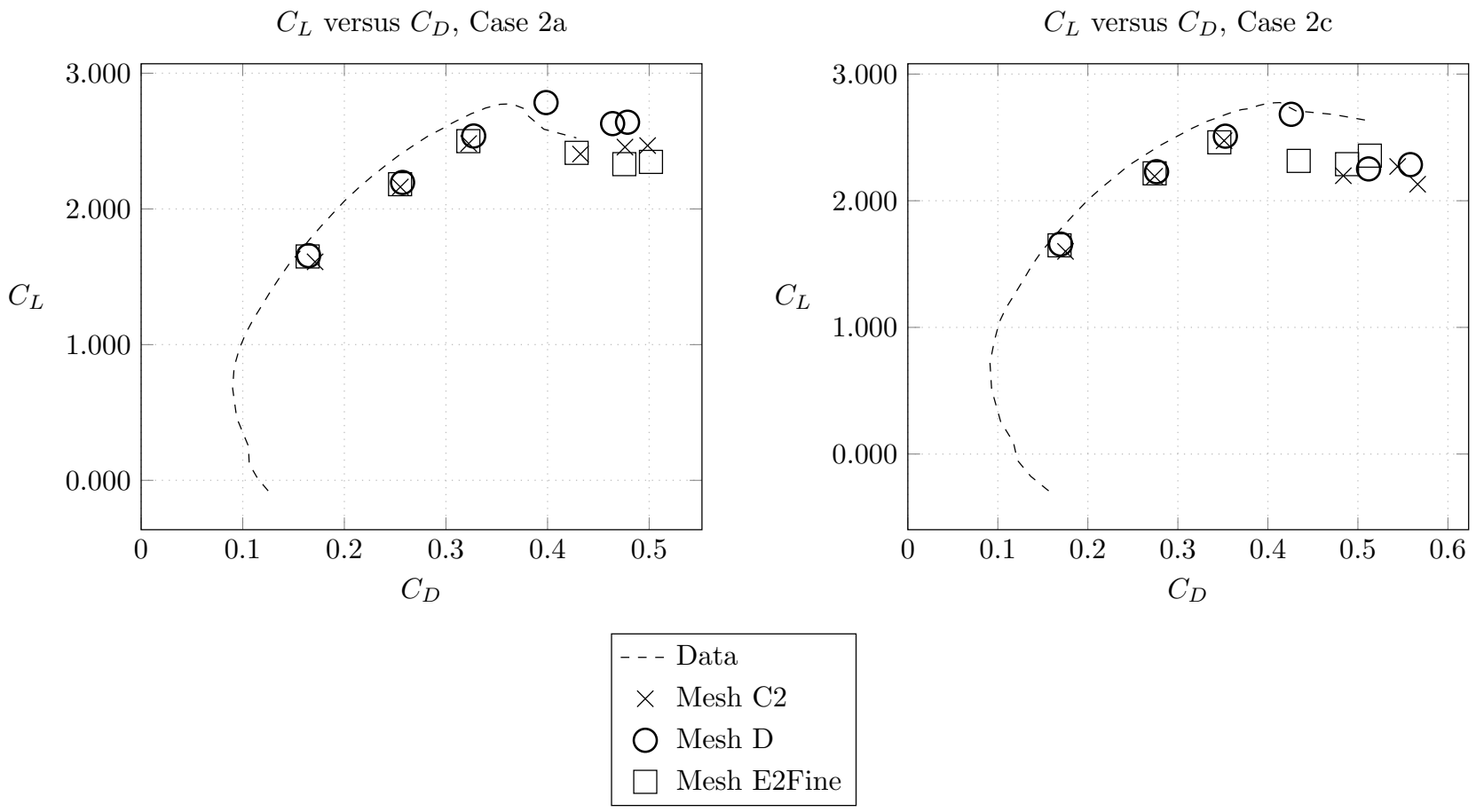
Drag Polar for Case 2a and Case 2c

$$\alpha = 4.36, 10.47, 14.54, 18.58, 20.59, 21.57$$



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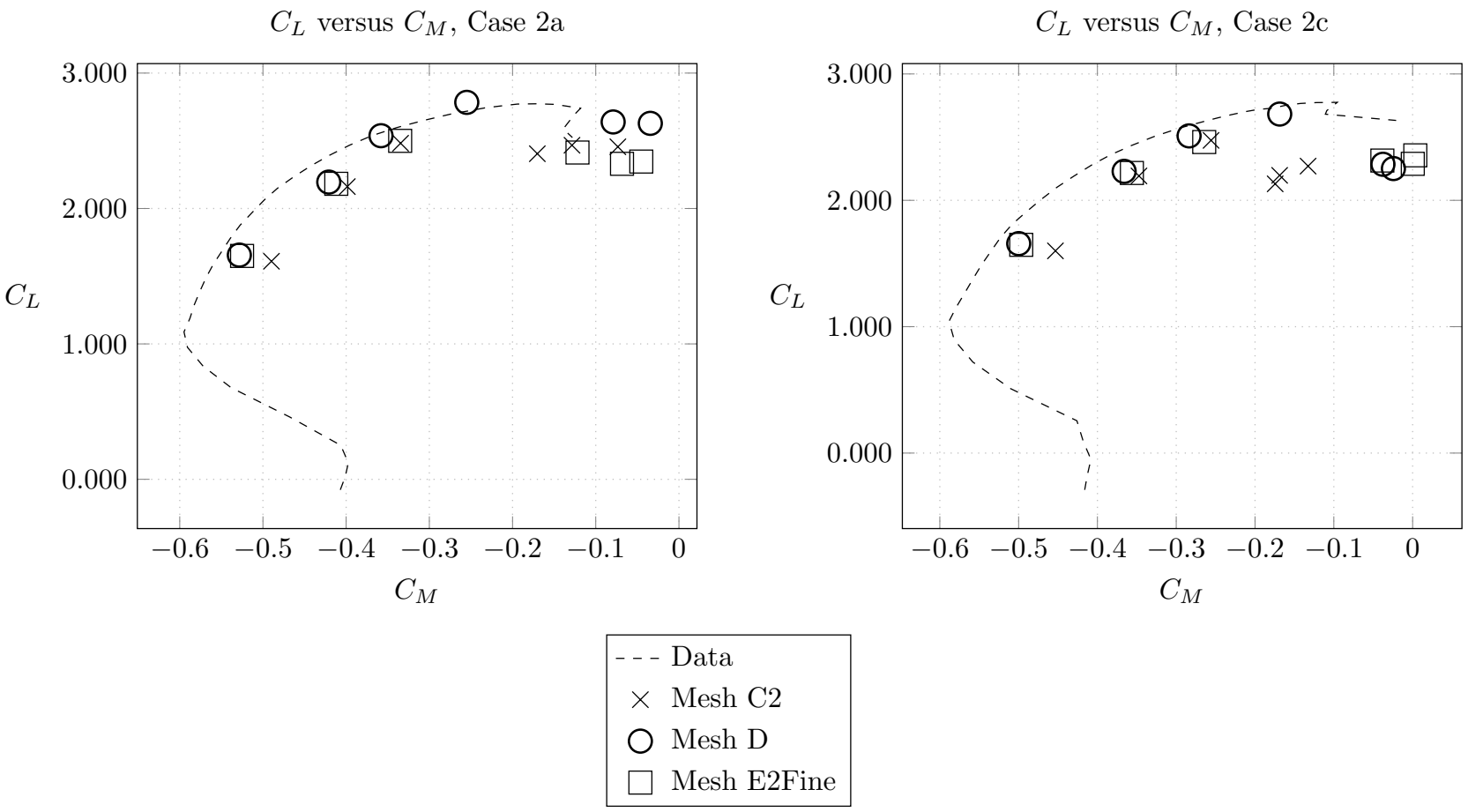
C_L versus C_M for Case 2a and Case 2c

$$\alpha = 4.36, 10.47, 14.54, 18.58, 20.59, 21.57$$



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