

3rd AIAA CFD Drag Prediction Workshop

Part 1: DLR-F6/F6-FX2B

Thomas Scheidegger, Laith Zori and Greg Stuckert
Fluent Inc.

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DLR-F6/F6-FX2B Simulations

- Fluent 6.3 - Unstructured Solver
- Embraer Grid
 - Single point grid sensitivity study for $M=0.75$, $C_L=0.5$ on provided point-matched Embraer grid
 - ◆ Coarse grid, 3.55M hex
 - ◆ Medium grid, 8.32M hex
 - ◆ Fine grid, 24.03M hex
 - Drag polar for $M=0.75$, $Re=5.0 \times 10^6$ on provided point-matched medium Embraer grid, fully turbulent
 - Consistent refinement of Embraer grid family not investigated

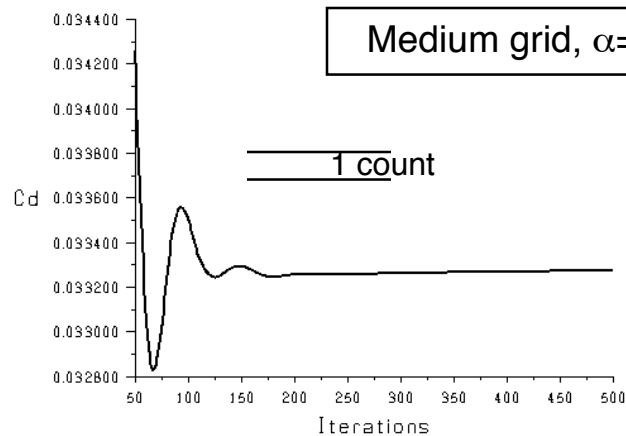
Fluent 6.3 – Solver

- Unstructured, cell-centered
- Several solvers available in Fluent 6.3
 - Pressure based
 - ◆ Segregated (SIMPLE, ...)
 - ◆ Coupled (New in Fluent 6.3, used for F6/F6-FX2B runs)
 - Density based
 - ◆ Implicit (used for DPW-W1/W2 runs, see Part 2)
 - ◆ Explicit
- Second-order upwind reconstruction
- Algebraic Multigrid
- Realizable k- ϵ turbulence model
 - Two-layer zonal model for wall treatment

DLR-F6-FX2B Convergence

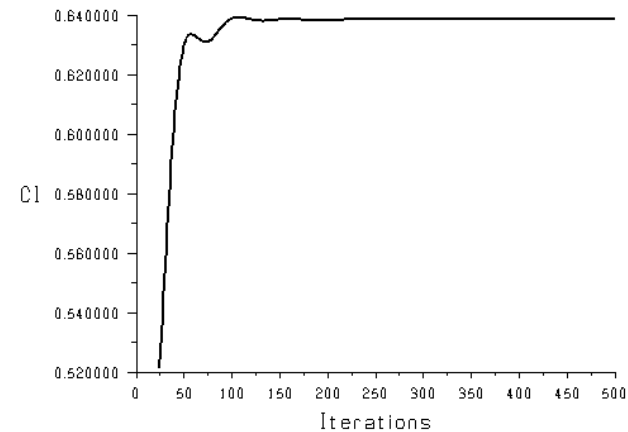
Embraer Grid, $M=0.75$, $Re=5.0 \times 10^6$

- Fast convergence for Pressure Based Coupled Solver on high aspect ratio and skewed meshes
- Typically less than 200 iterations for drag to converge to within one drag count of final value



Drag Convergence History

Jun 01, 2006
FLUENT 6.3 [3d, dp, pbns, rke]



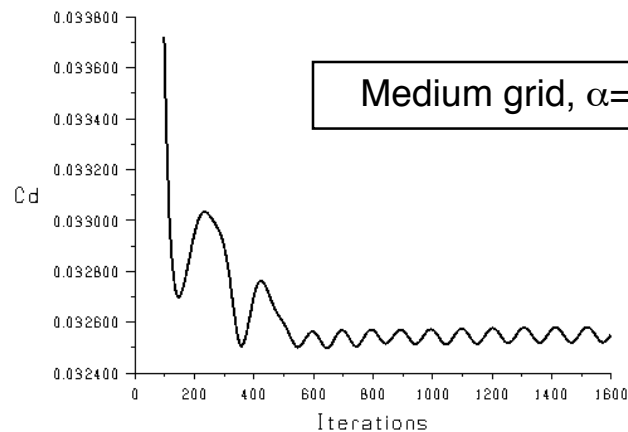
Lift Convergence History

Jun 01, 2006
FLUENT 6.3 [3d, dp, pbns, rke]

DLR-F6 Convergence

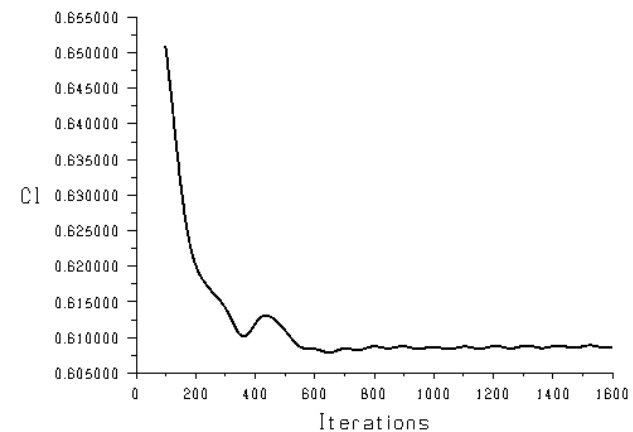
Embraer Grid, $M=0.75$, $Re=5.0 \times 10^6$

- None of the DLR-F6 cases converged in lift and drag completely
- Force oscillations depend on solver settings
 - Drag coefficient oscillates about $\pm 8 \times 10^{-5}$
 - Lift coefficient oscillates $\pm 5 \times 10^{-4}$



Drag Convergence History

Jun 01, 2006
FLUENT 6.3 (3d, dp, pbns, rke)



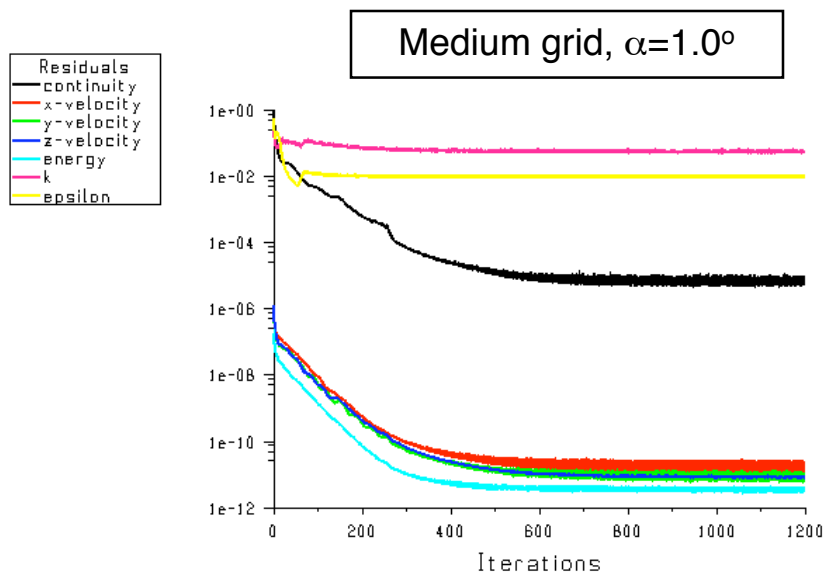
Lift Convergence History

Jun 01, 2006
FLUENT 6.3 (3d, dp, pbns, rke)

Convergence

Embraer Grid, $M=0.75$, $Re=5.0 \times 10^6$

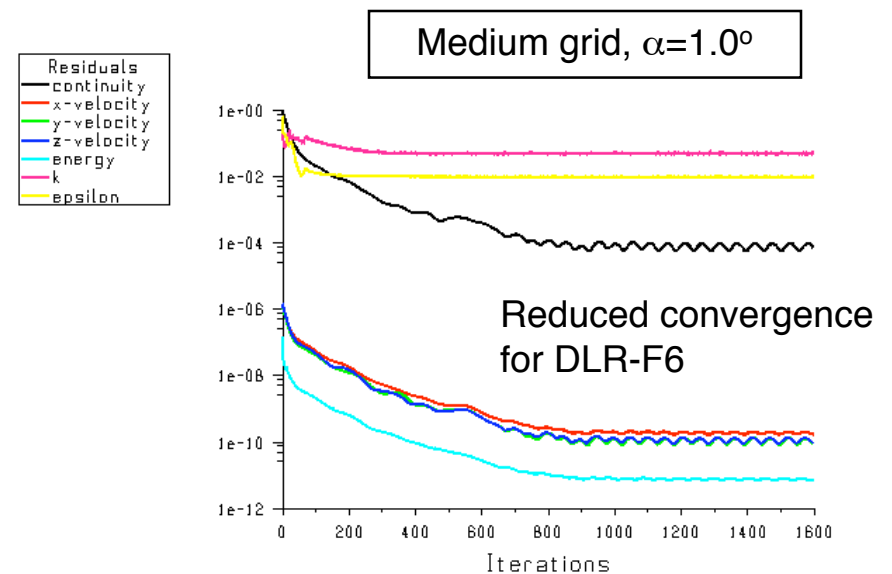
■ DLR-F6-FX2B



Scaled Residuals

Jun 01, 2006
FLUENT 6.3 (3d, dp, pbns, rke)

■ DLR-F6

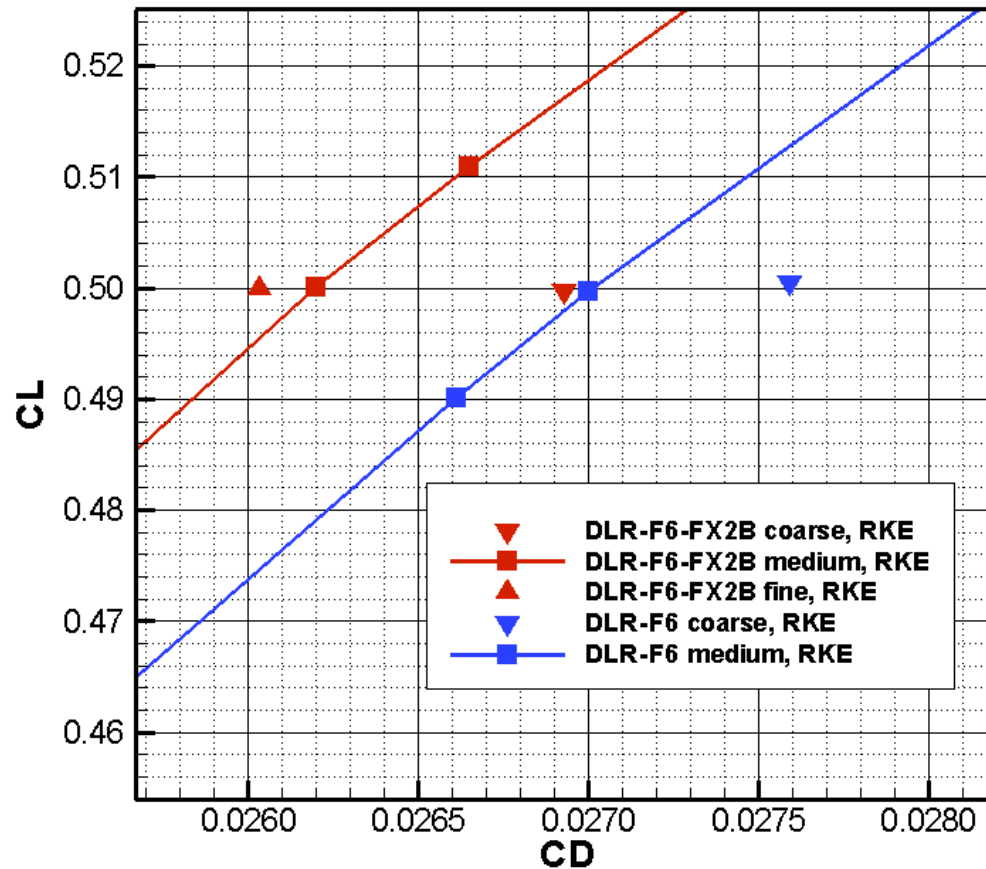


Scaled Residuals

Jun 01, 2006
FLUENT 6.3 (3d, dp, pbns, rke)

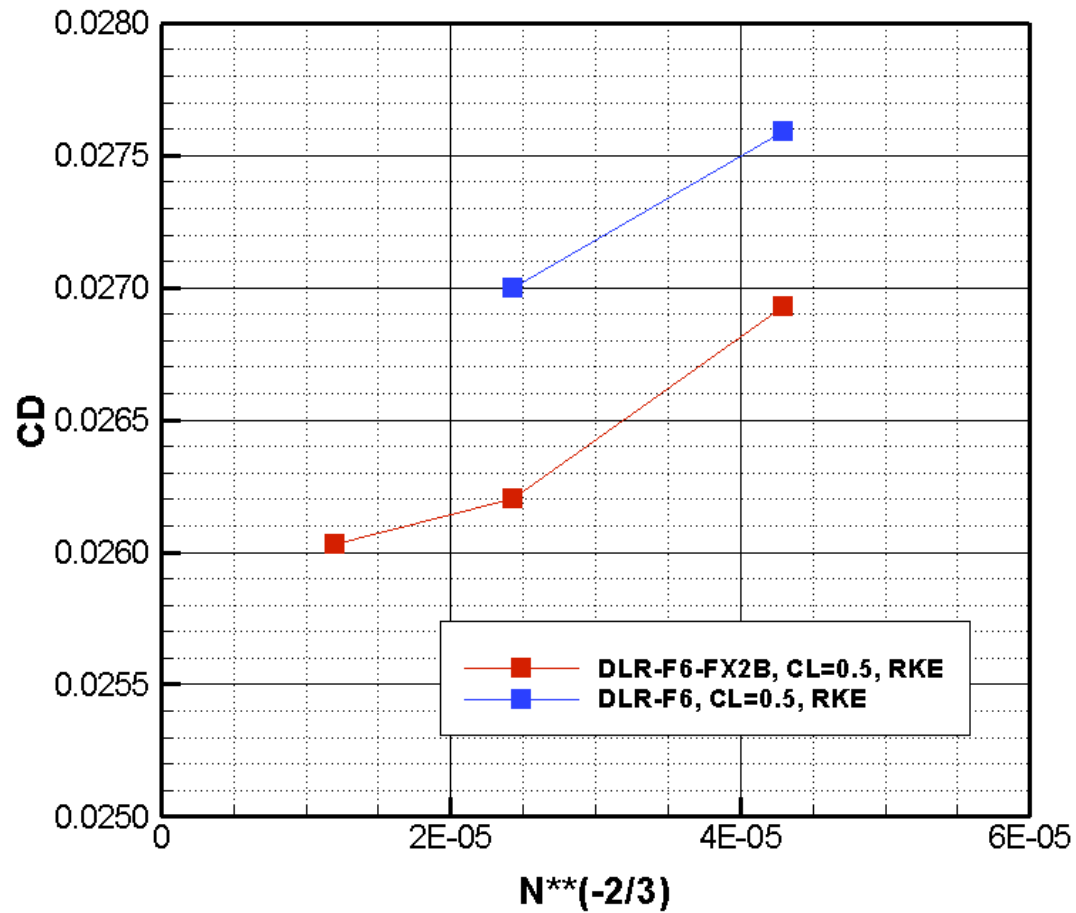
Grid Convergence, $C_L = 0.5$

Embraer Grid, $M=0.75$, $Re=5.0 \times 10^6$



Grid Convergence, $C_L = 0.5$

Embraer Grid, $M=0.75$, $Re=5.0 \times 10^6$



Grid Convergence, $C_L = 0.5$

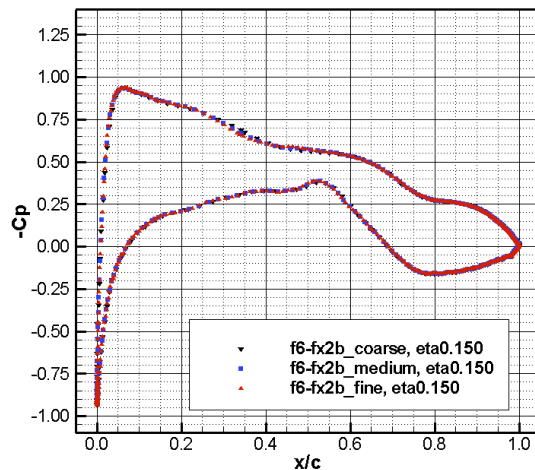
Embraer Grid, $M=0.75$, $Re=5.0 \times 10^6$

| | alpha | CD | CD_SF | CM |
|-------------------|--------|---------|---------|---------|
| F6 coarse | 0.004 | 0.02759 | 0.01187 | -0.1440 |
| F6 medium | 0.086 | 0.02700 | 0.01186 | -0.1421 |
| F6-FX2B coarse | -0.085 | 0.02693 | 0.01205 | -0.1448 |
| F6-FX2B medium | -0.089 | 0.02620 | 0.01203 | -0.1473 |
| F6-FX2B fine | -0.075 | 0.02603 | 0.01205 | -0.1477 |

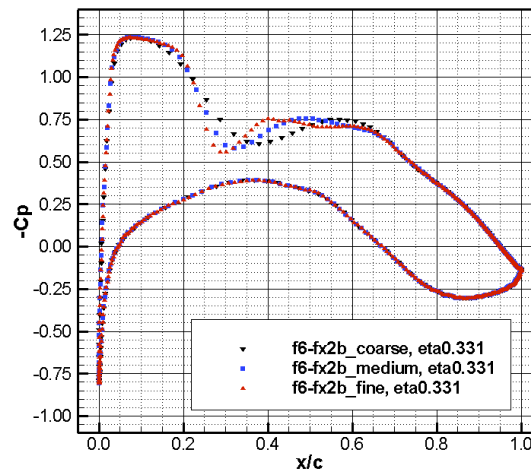
Grid Convergence, F6-FX2B, $C_L = 0.5$

Embraer Grid, $M=0.75$, $Re=5.0 \times 10^6$

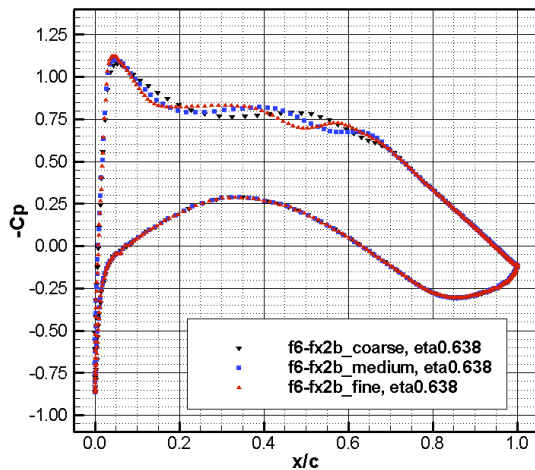
$\eta=0.150$



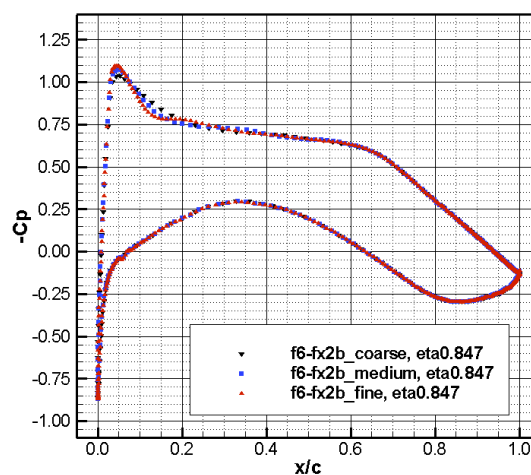
$\eta=0.331$



$\eta=0.638$



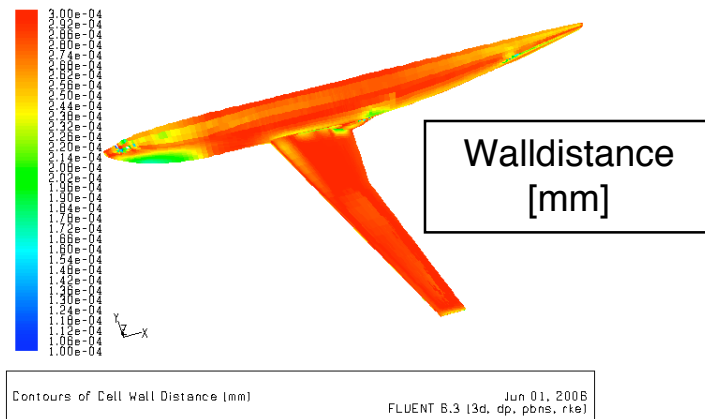
$\eta=0.847$



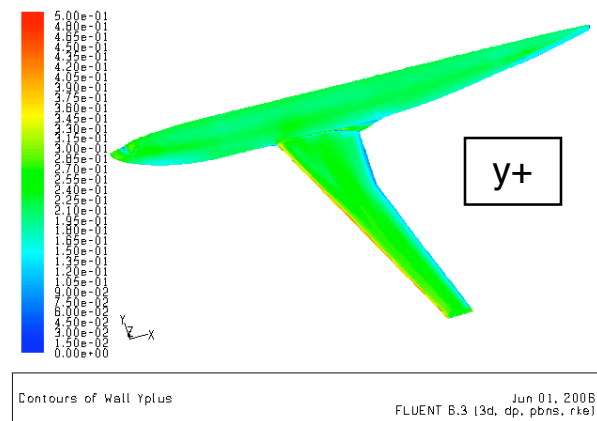
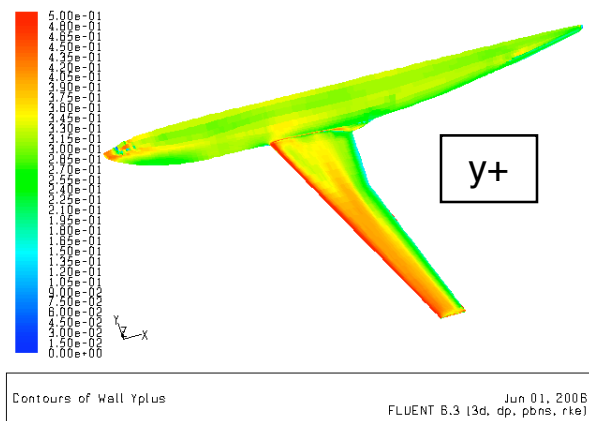
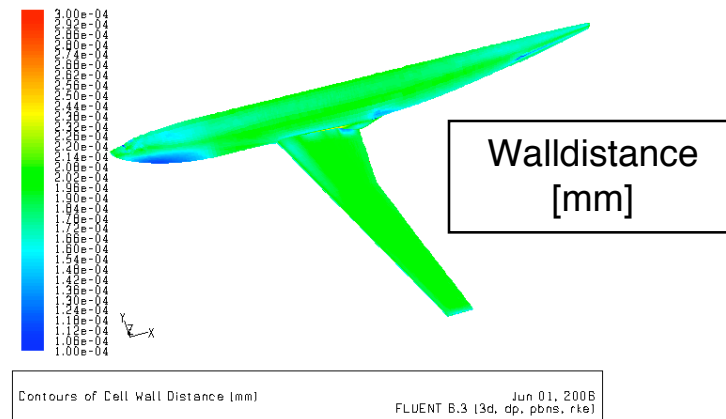
Wall Distance

Embraer Grid, F6-FX2B, $M=0.75$, $Re=5.0 \times 10^6$, $C_L=0.5$

Coarse grid, F6-FX2B

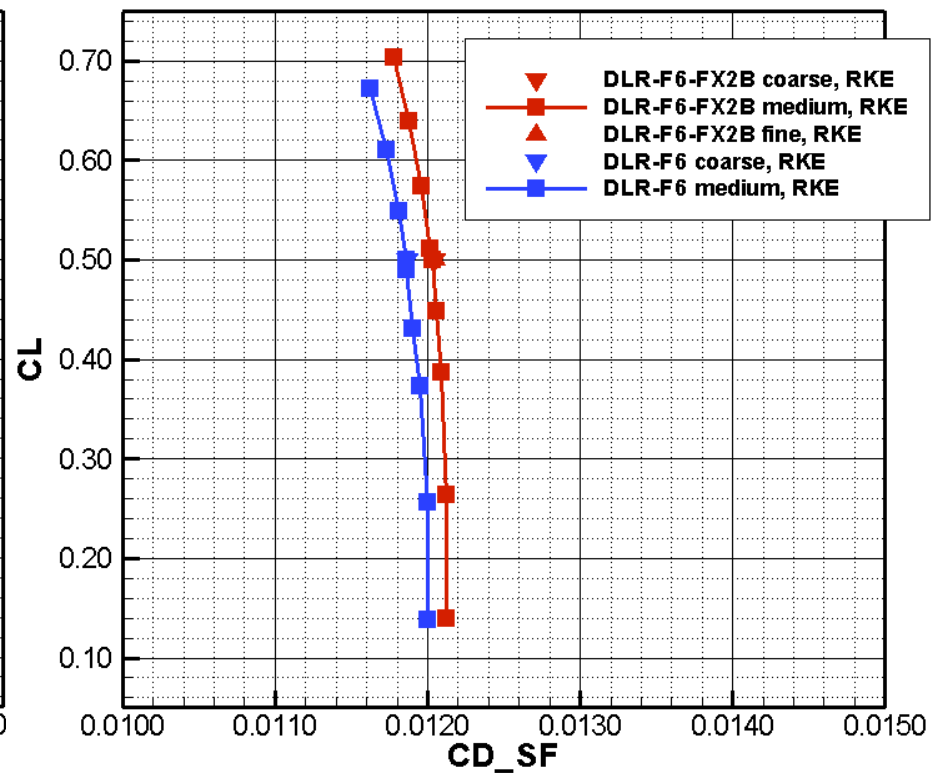
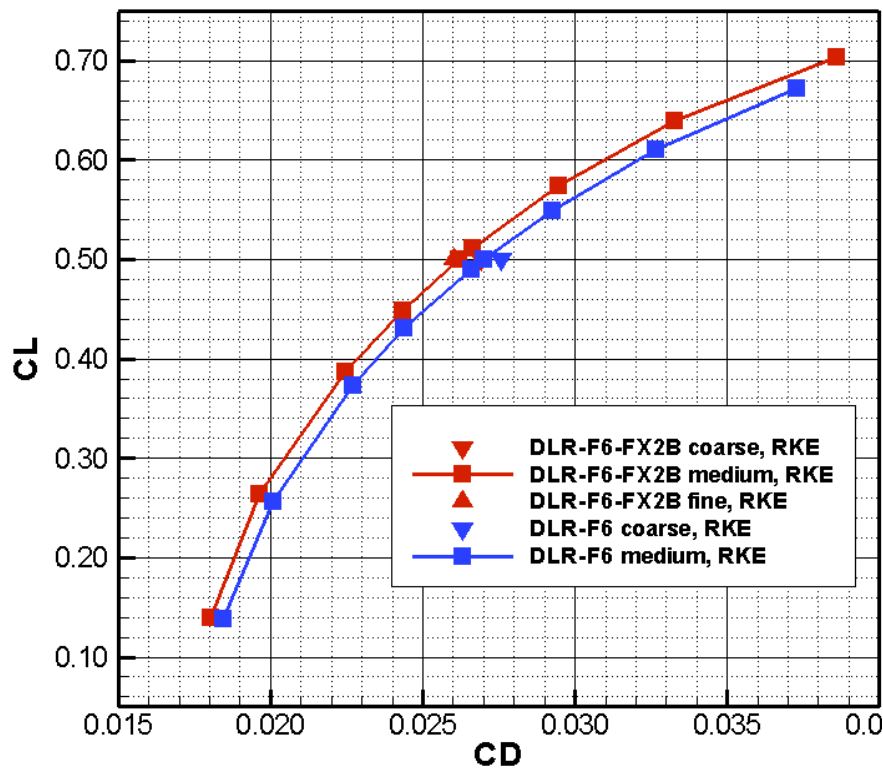


Medium grid, F6-FX2B



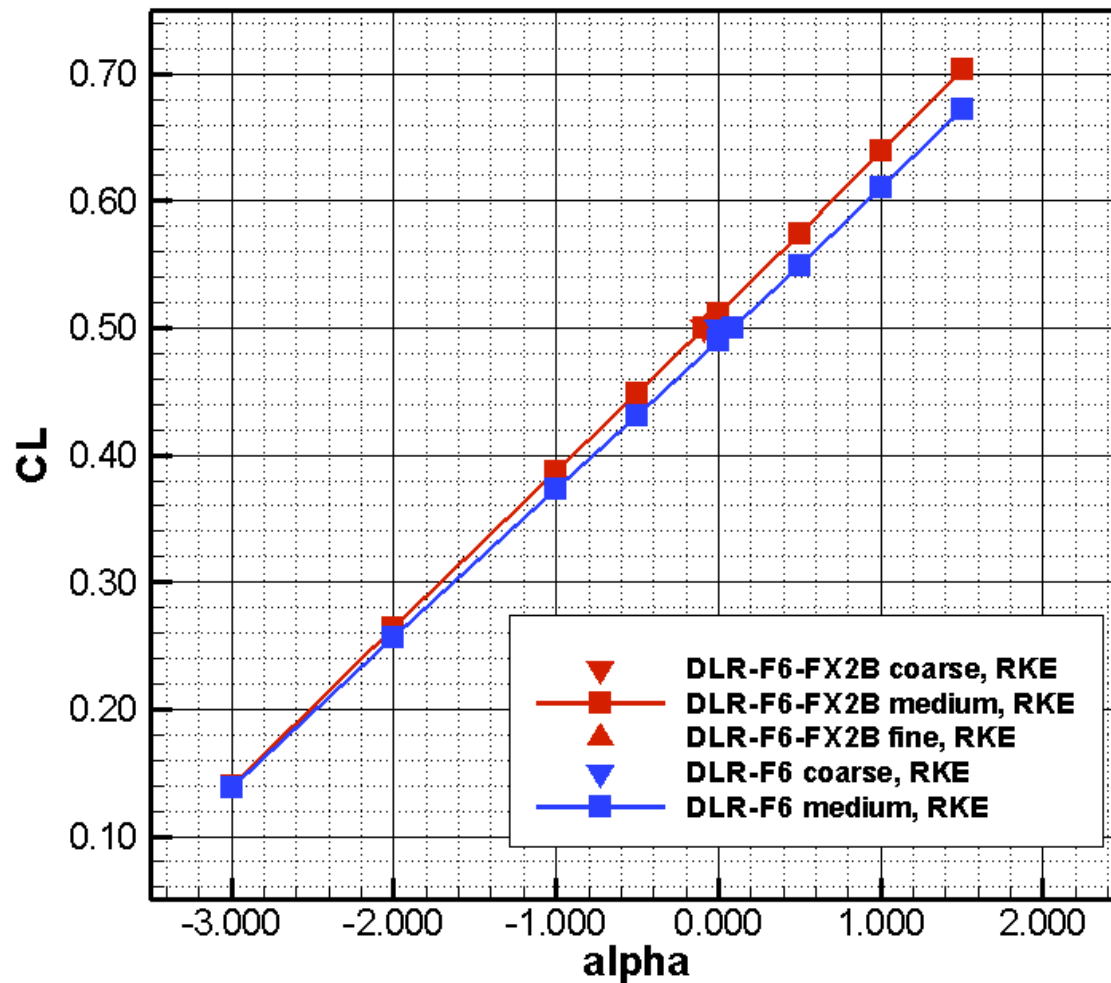
Drag Polar, $C_L - C_D$

Medium Embraer Grid, $M=0.75$, $Re=5.0 \times 10^6$



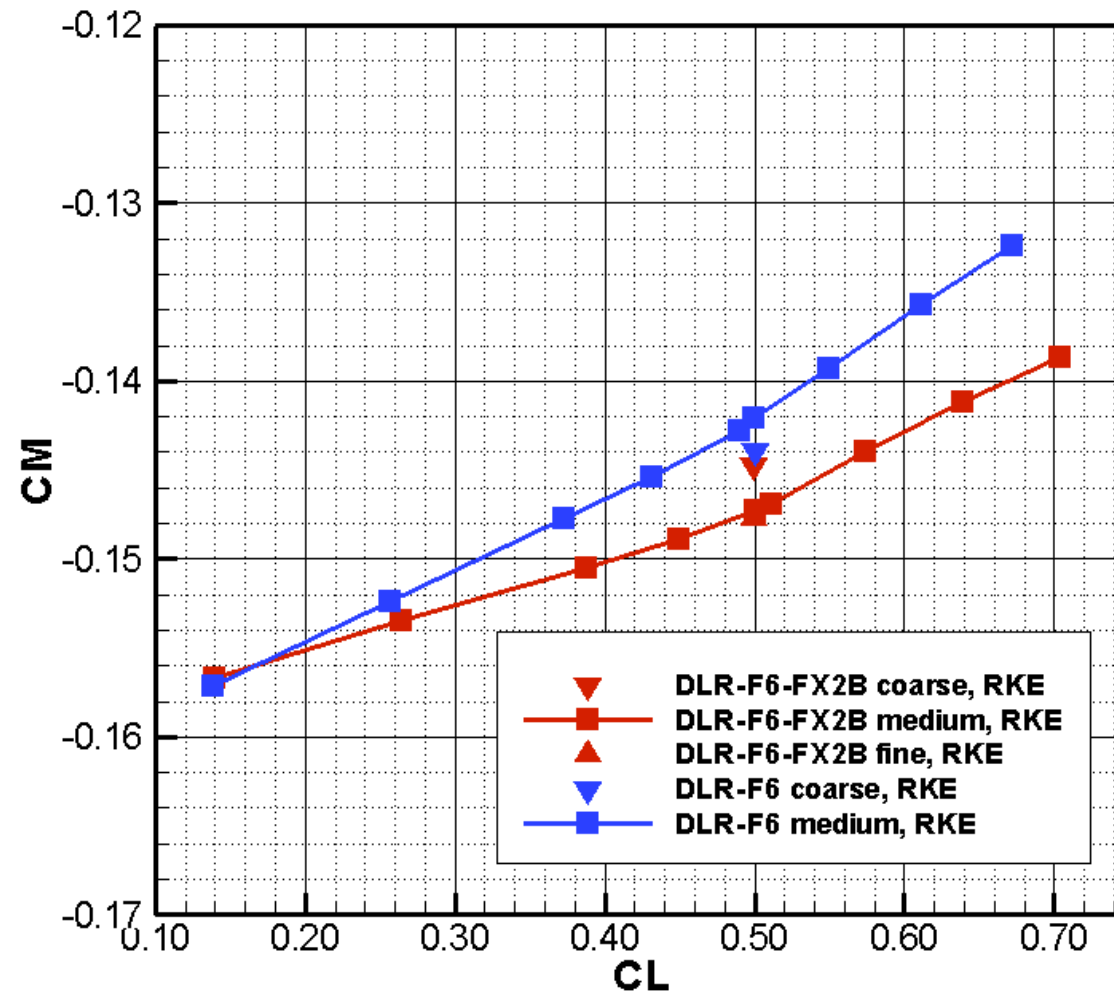
Lift Curve

Medium Embraer Grid, $M=0.75$, $Re=5.0 \times 10^6$



Pitching Moment

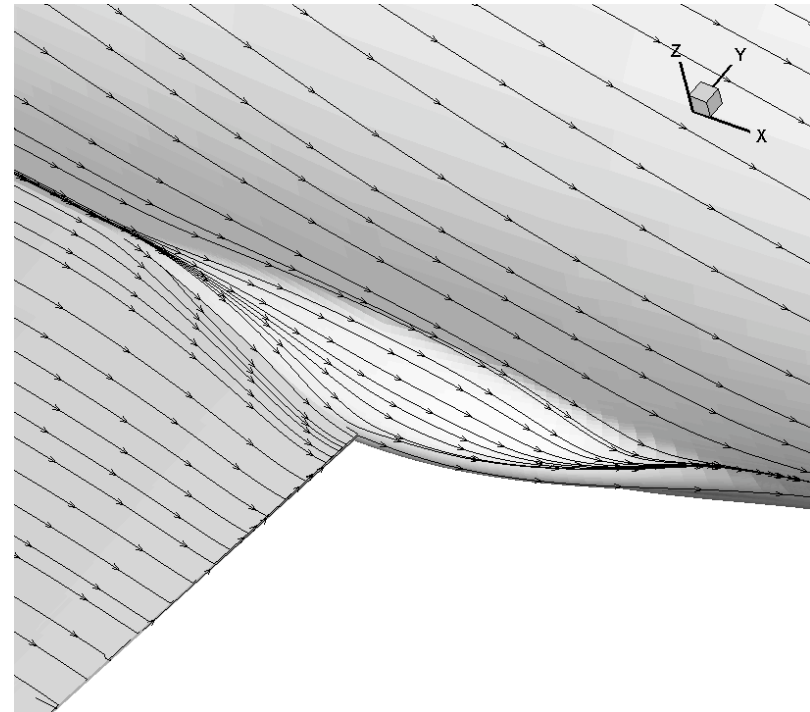
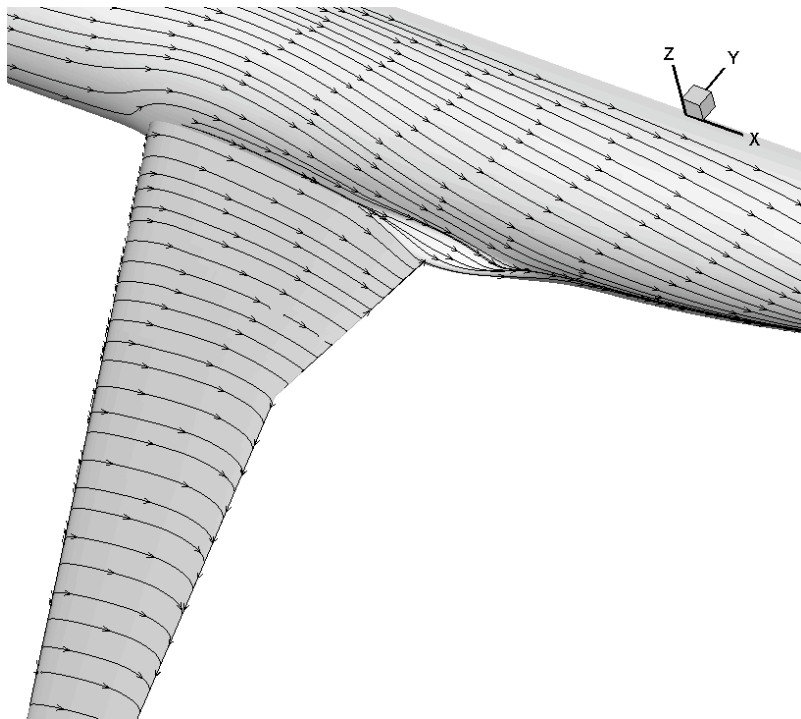
Medium Embraer Grid, $M=0.75$, $Re=5.0 \times 10^6$



Streamlines, F6-FX2B

Fine Embraer Grid, $C_L=0.5$, $M=0.75$, $Re=5.0 \times 10^6$

- No trailing edge separation observed for both F6 and F6-FX2B



Summary

- Robust solver convergence was obtained for the F6-FX2B cases. However, all DLR-F6 runs exhibited weak force oscillations.
- Expected grid refinement trends are observed
 - The Embraer grid family was not inspected in terms of consistent grid refinement
- No trailing edge separation was observed
- Generating suitable DPW grids is a difficult task