3rd AIAA CFD Drag Prediction Workshop

Part 2: DPW-W1/W2

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San Francisco, June 3-4, 2006

DPW-W1/W2 Simulations

- Fluent 6.3 - Unstructured Solver

- Boeing Grid
  - Single point grid sensitivity study for M=0.76, α=0.5 on provided point-matched Boeing grids, DPW-W1/W2
    - Coarse grid,   1.51M hex
    - Medium grid,   4.03M hex
    - Medium-fine grid, 8.33M hex
    - Fine grid,   14.34M hex
  - Drag polar for M=0.76, Re=5.0x10^6 on provided point-matched medium Boeing grid, fully turbulent

Fluent 6.3 – Solver

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

DPW-W1/W2 Convergence

Boeing Grid, M=0.76, Re=5.0x10^6

- Robust convergence on highly stretched grids for Density Based Implicit Solver in Fluent 6.3
- Typically 200- 400 iterations for forces to converge on medium grid

Medium W1grid, α=1.0^o

1 count
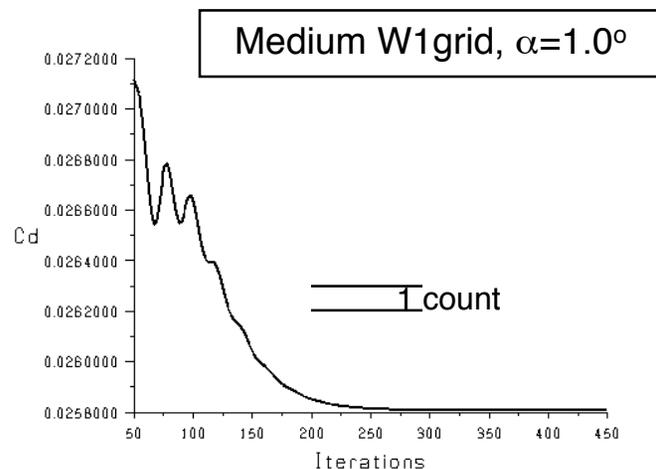
Drag Convergence History — Jun 01, 2006 — FLUENT 6.3 [3d, dp, dbns imp, rke]
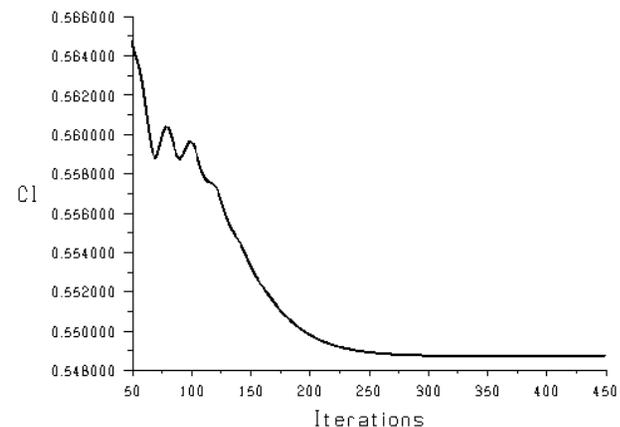
Lift Convergence History — Jun 01, 2006 — FLUENT 6.3 [3d, dp, dbns imp, rke]

Convergence

Boeing Grid, M=0.76, Re=5.0x10^6

- DPW-W1
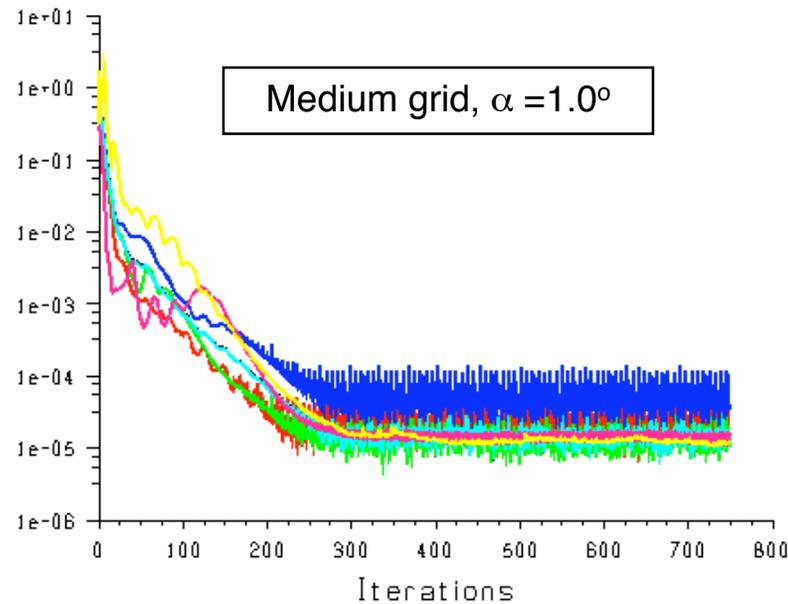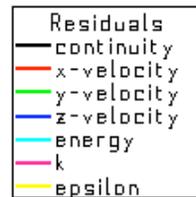
Consistent residual reduction by 4-5 orders of magnitude

Medium grid, $\alpha = 1.0^o$

Grid Convergence, α=0.5

Boeing Grid, M=0.76, Re=5.0x10^6
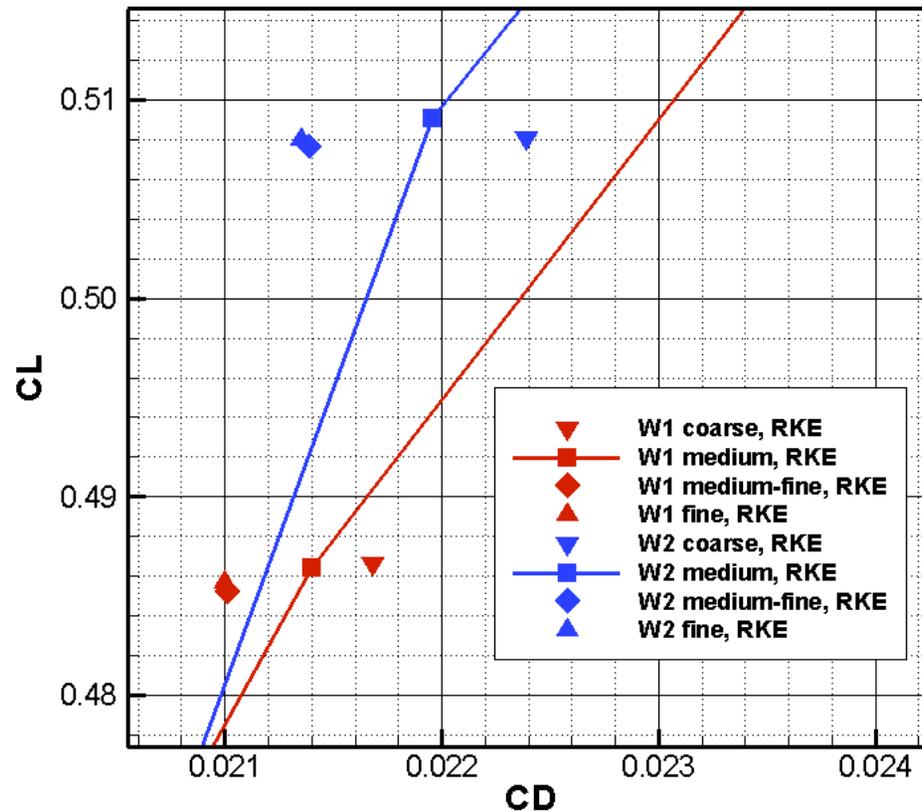
- Practically no difference between medium-fine and fine grids

Grid Convergence, α=0.5

Boeing Grid, M=0.76, Re=5.0x10^6
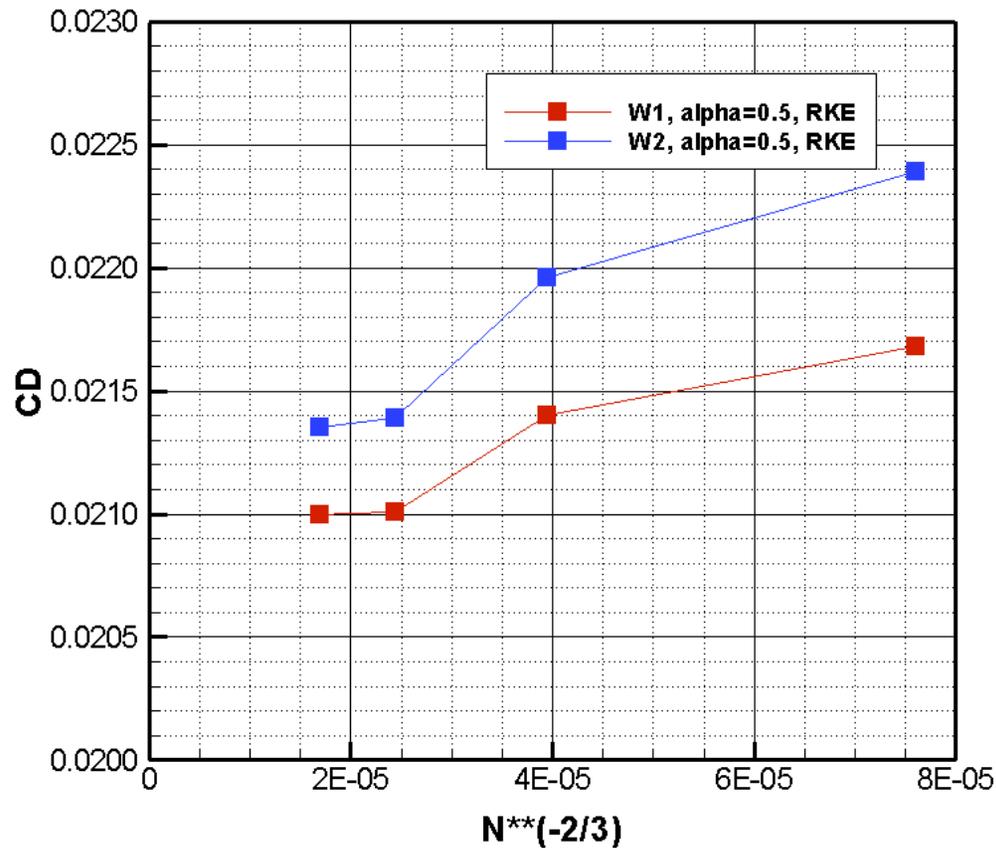
- Monotonic decrease of drag with increasing grid resolution
- Very similar convergence behavior for W1 and W2
- Inconsistent grid refinement for W1 and W2?

Grid Convergence, α=0.5

Boeing Grid, M=0.76, Re=5.0x10^6
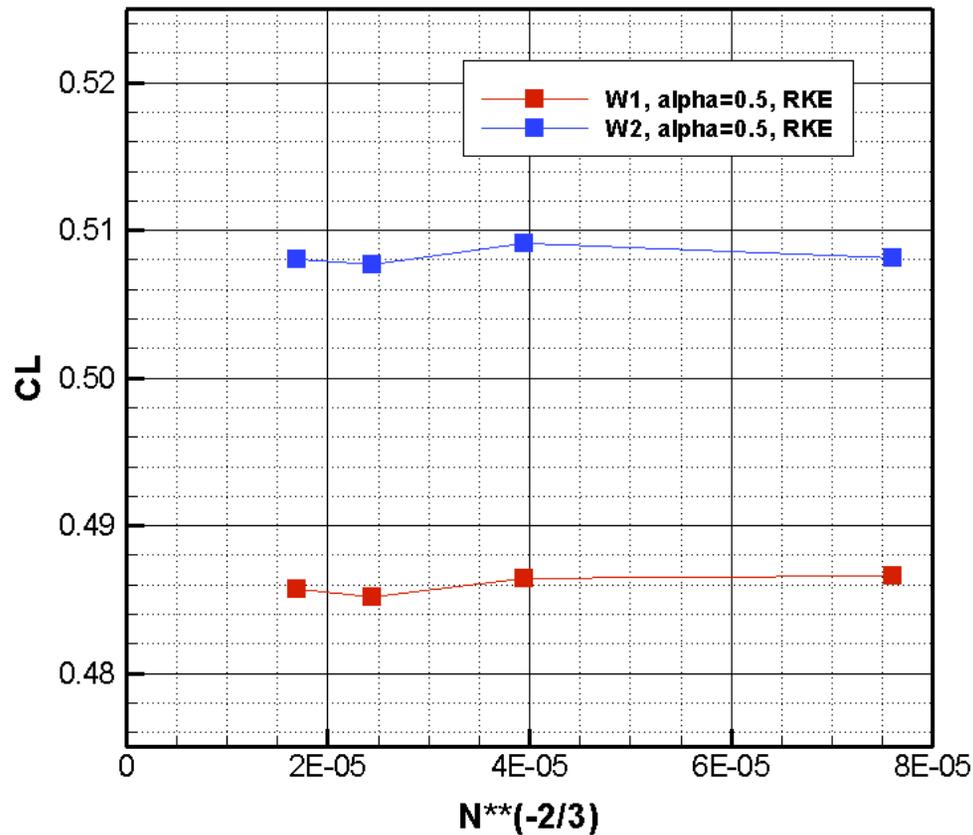
- Very similar convergence behavior for W1 and W2
- Inconsistent grid refinement for W1 and W2?

Grid Convergence, α=0.5

Boeing Grid, M=0.76, Re=5.0×10^6
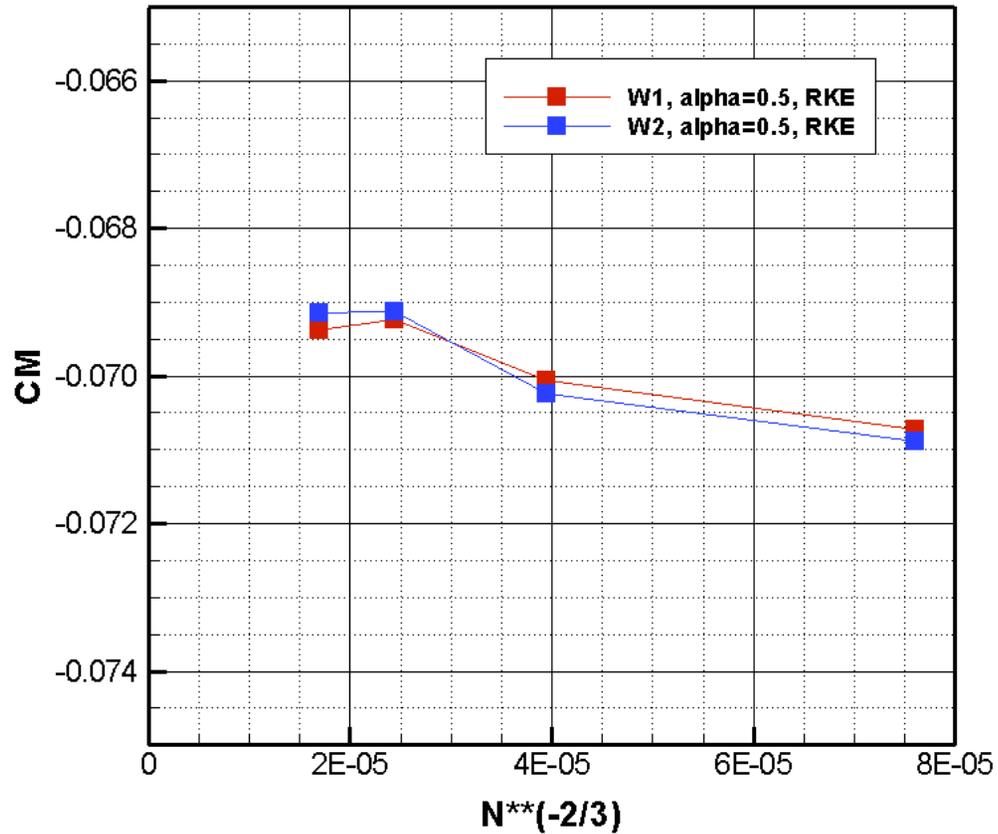
Grid Convergence, α=0.5

Boeing Grid, M=0.76, Re=5.0x10^6

	CL	CD	CD_SF	CM
W1 coarse	0.4866	0.02168	0.00629	-0.07072
W1 medium	0.4864	0.02140	0.00630	-0.07006
W1 med-fine	0.4852	0.02101	0.00631	-0.06924
W1 fine	0.4857	0.02100	0.00631	-0.06938
W2 coarse	0.5081	0.02239	0.00625	-0.07088
W2 medium	0.5091	0.02196	0.00627	-0.07024
W2 med-fine	0.5077	0.02139	0.00628	-0.06913
W2 fine	0.5080	0.02135	0.00628	-0.06915

Grid Convergence, DPW-W1, α=0.5

Boeing Grid, M=0.76, Re=5.0x10^6
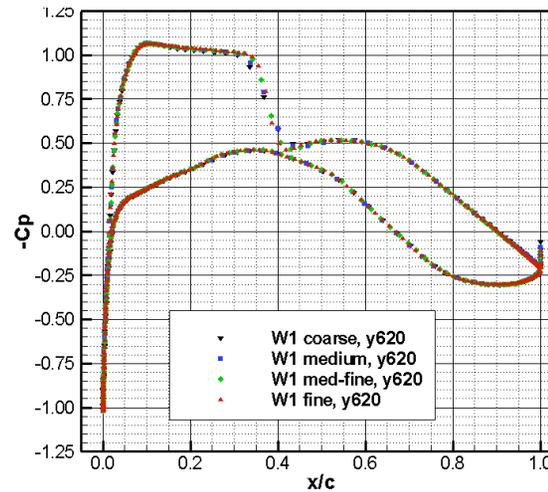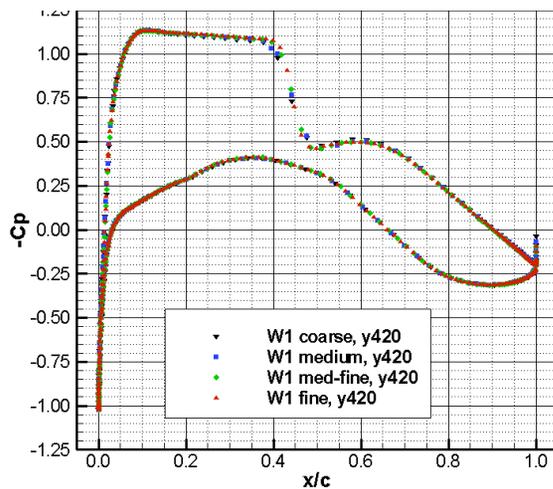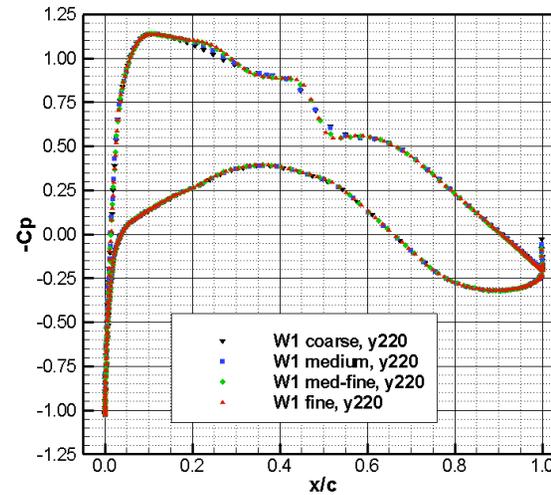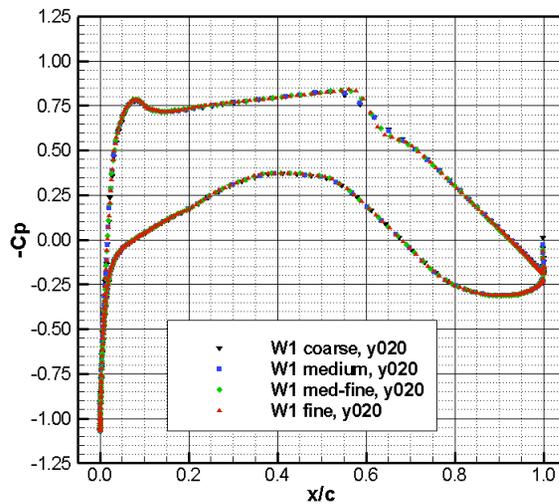
Wall Distance

Boeing Grid, DPW-W1
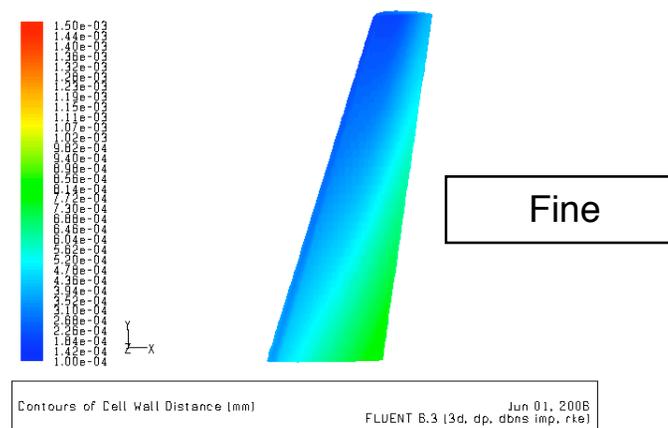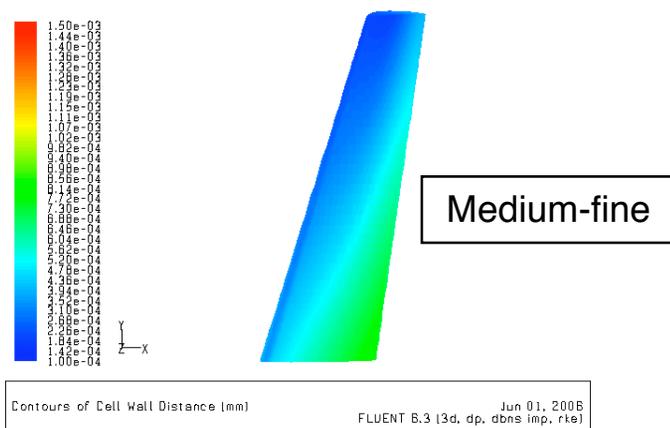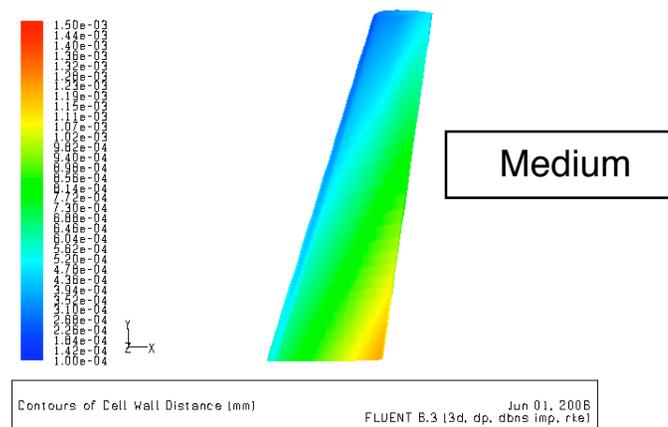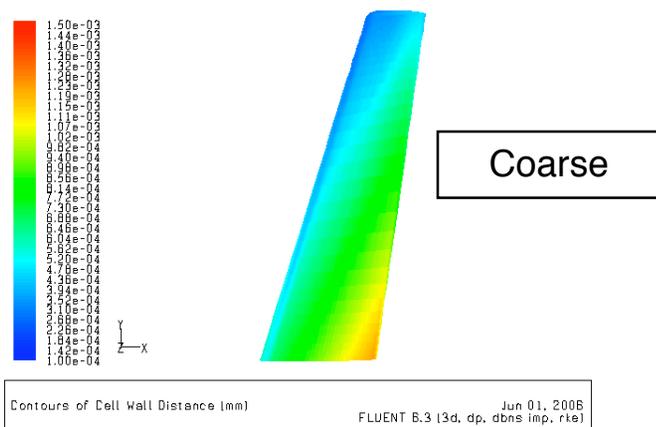
- **Non-uniform first grid spacing, for both W1 and W2**
- **Inconsistent wall distance refinement for grid family**

Wall Distance, y+

Boeing Grid, DPW-W1, M=0.76, Re=5.0x10^6 , α=0.5
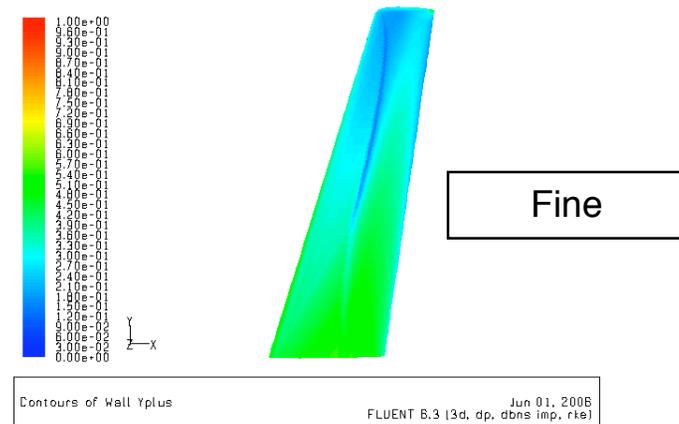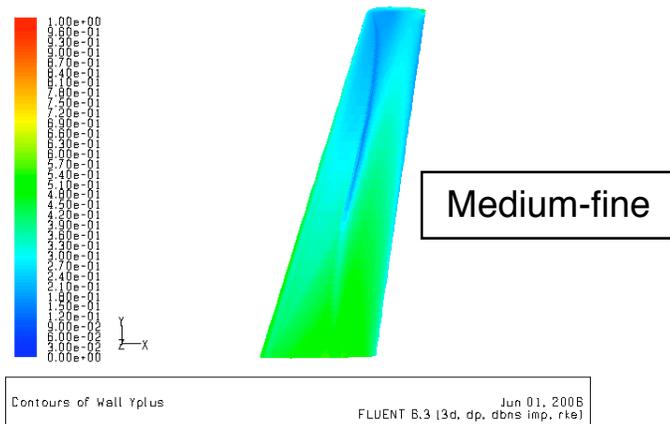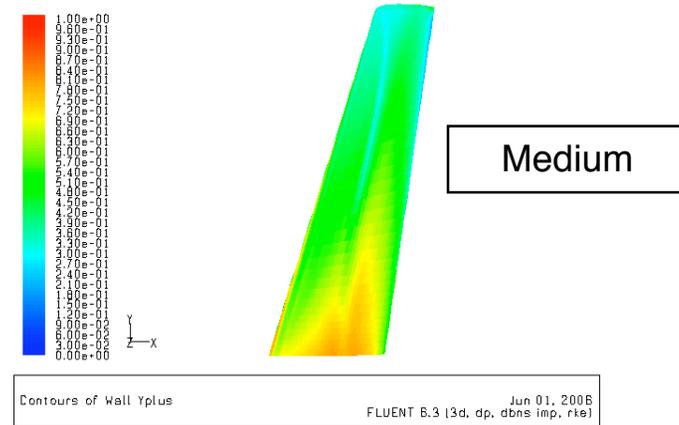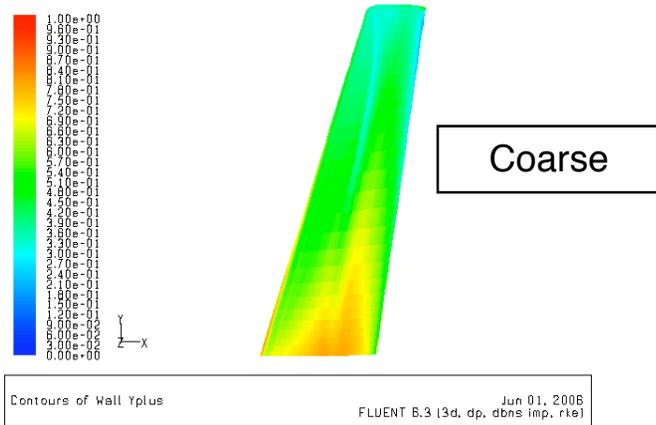
- Inconsistent wall distance refinement for grid family

Grid Convergence

Boeing Grid
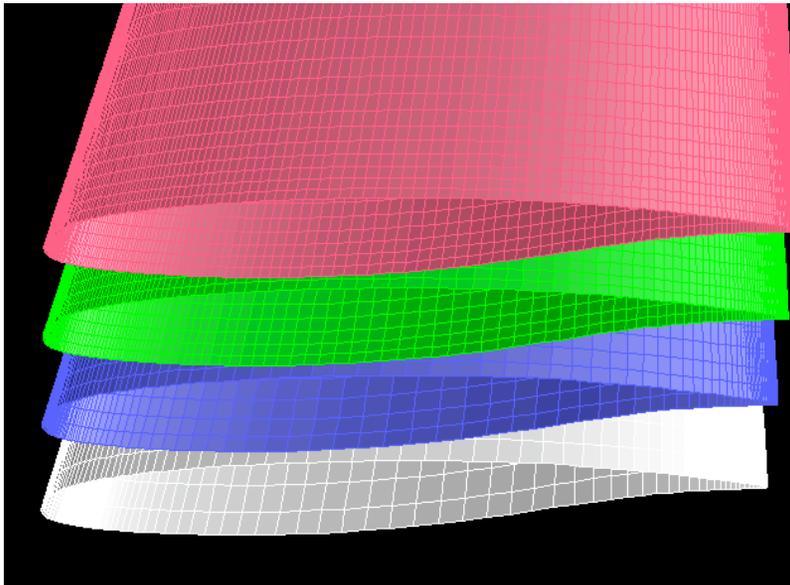
DPW-W1   DPW-W2
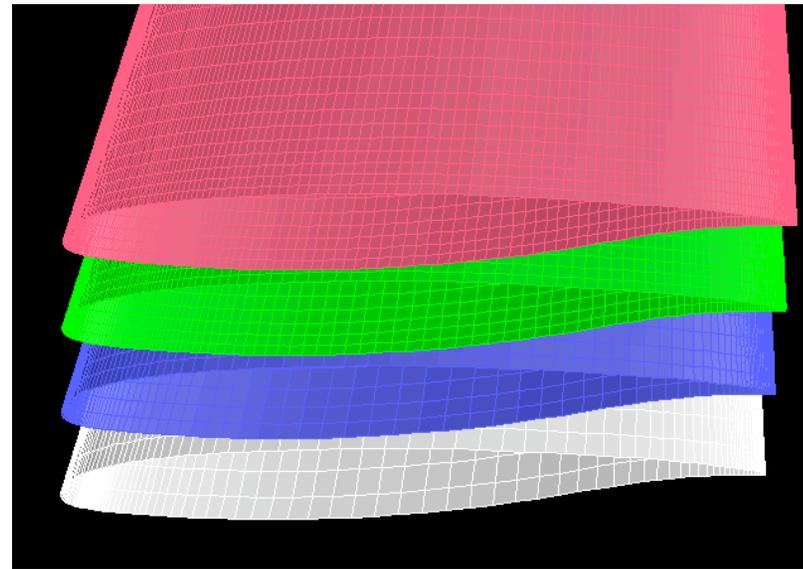
- Coarse and medium grids have same streamwise spacing at mid-chord

Turbulence Model

Boeing Grid, M=0.76, Re=5.0×10^6, α=0.5
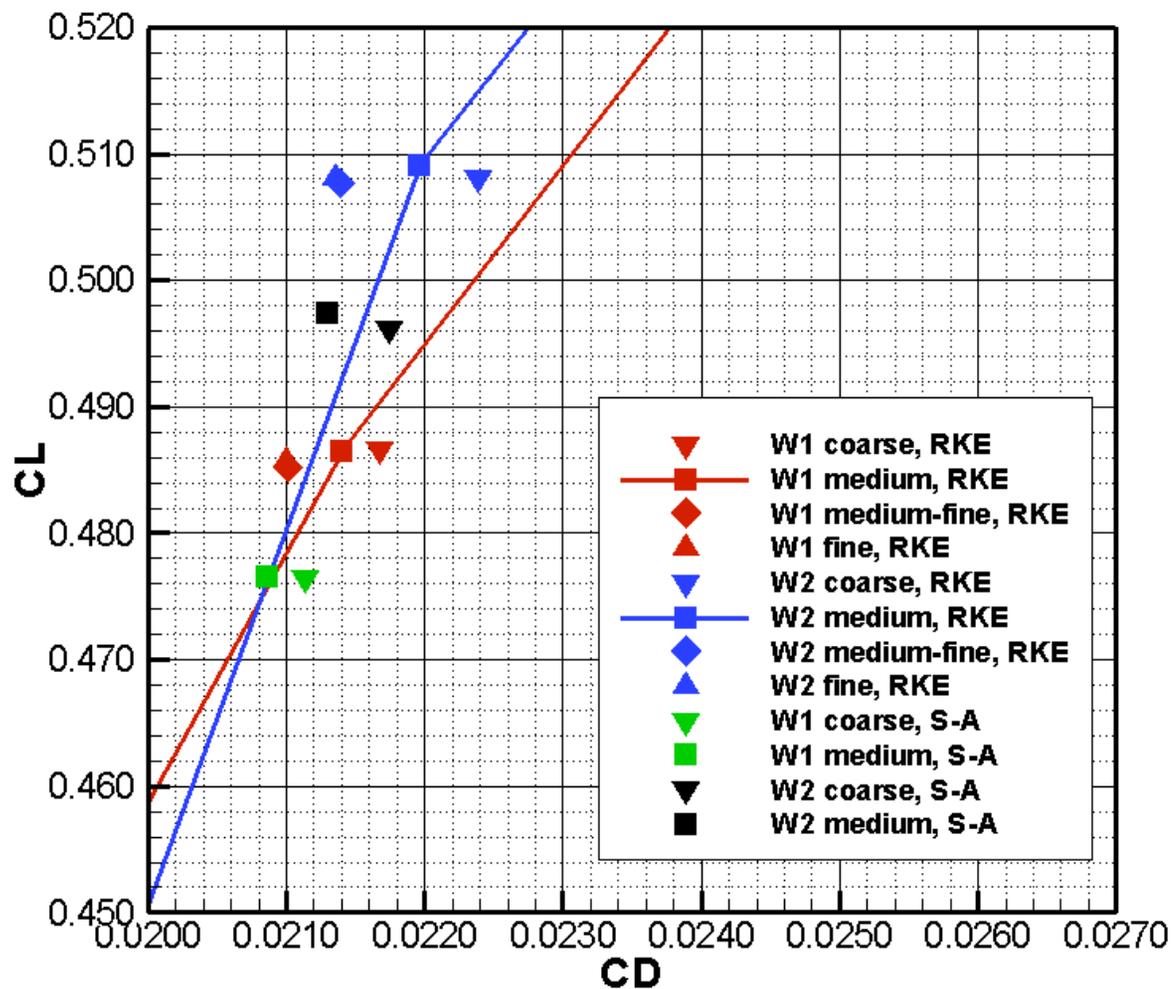
Surface Pressure, C_P
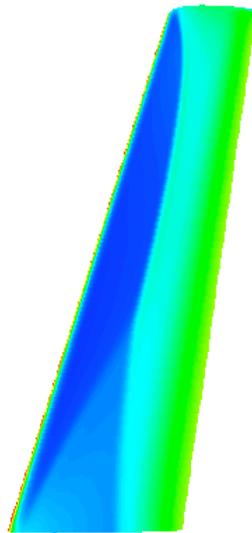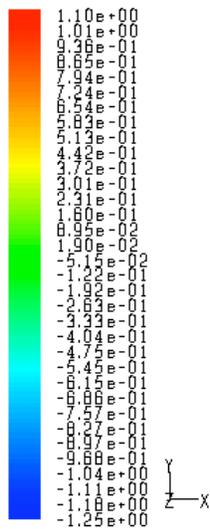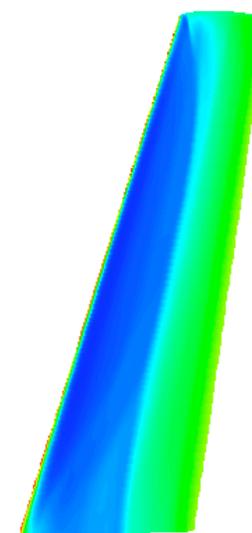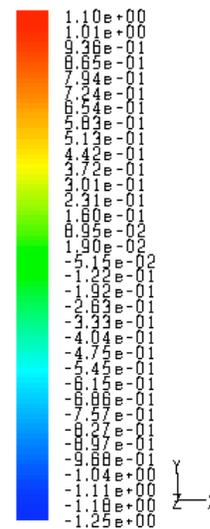
Boeing Grid, M=0.76, Re=5.0x10^6, α=0.5

DPW-W1

DPW-W2

Surface Pressure, C$_P$

Boeing Grid, M=0.76, Re=5.0x10^6, α=0.5
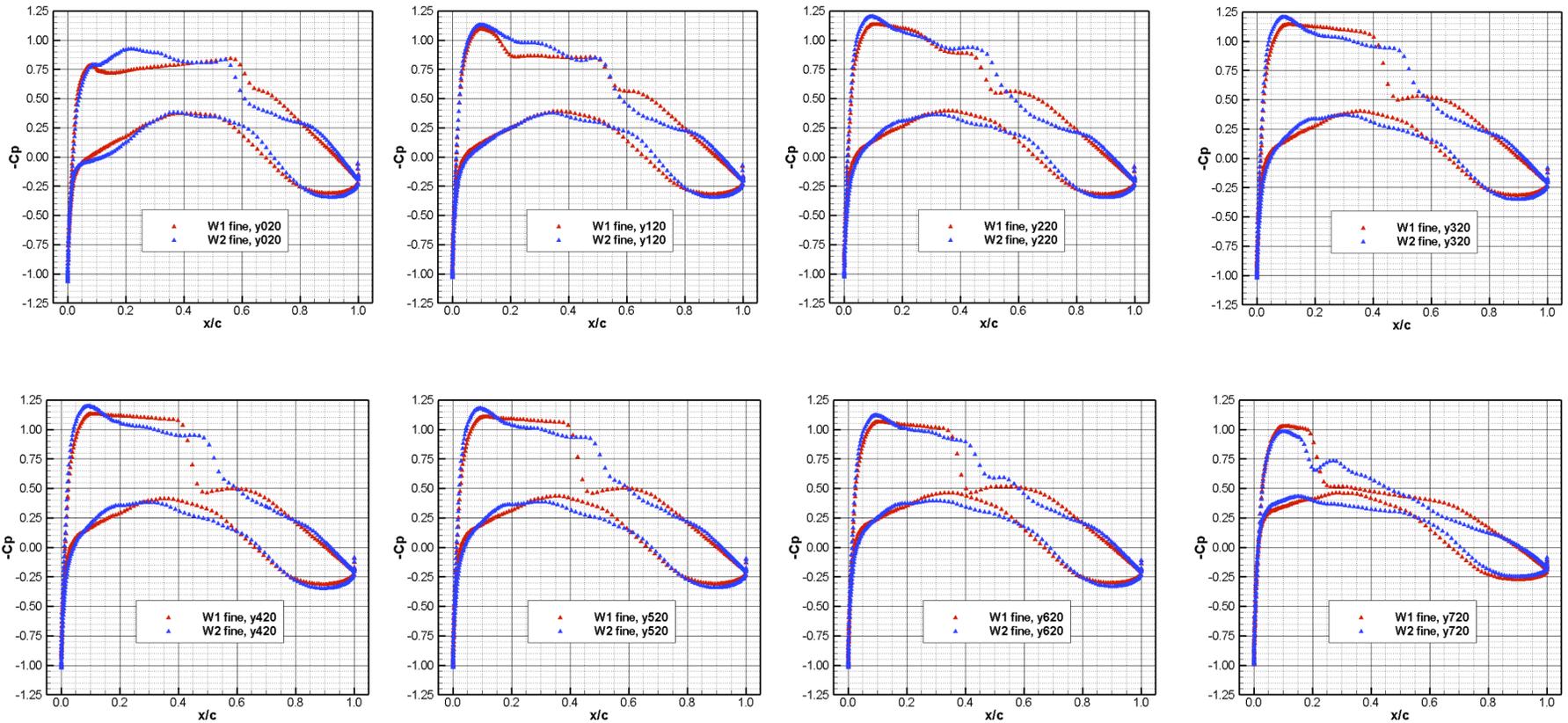
Drag Polar, C_L-C_D

Medium Boeing Grid, M=0.76, Re=5.0x10⁶
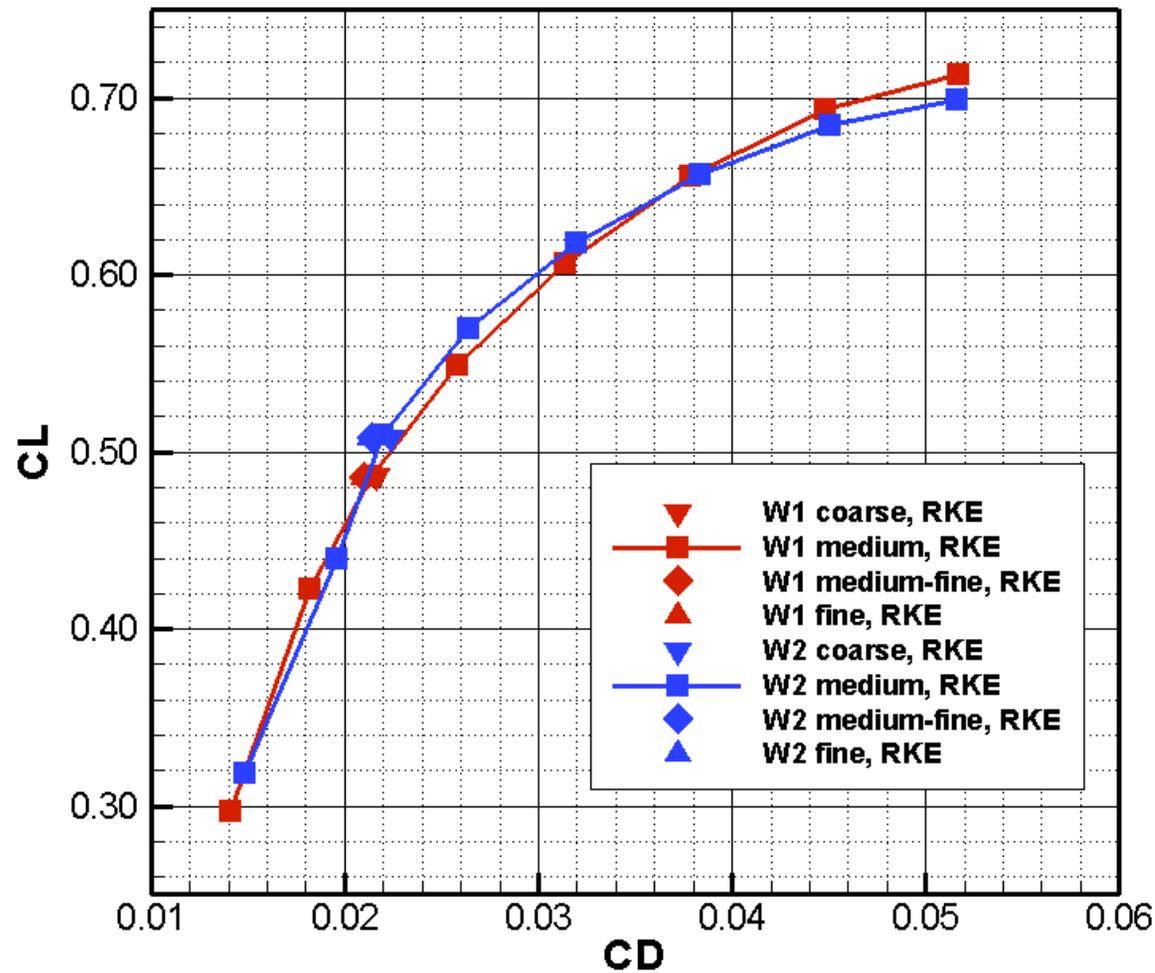
Viscous Drag, C_{D_SF}

Medium Boeing Grid, M=0.76, Re=5.0x10^6
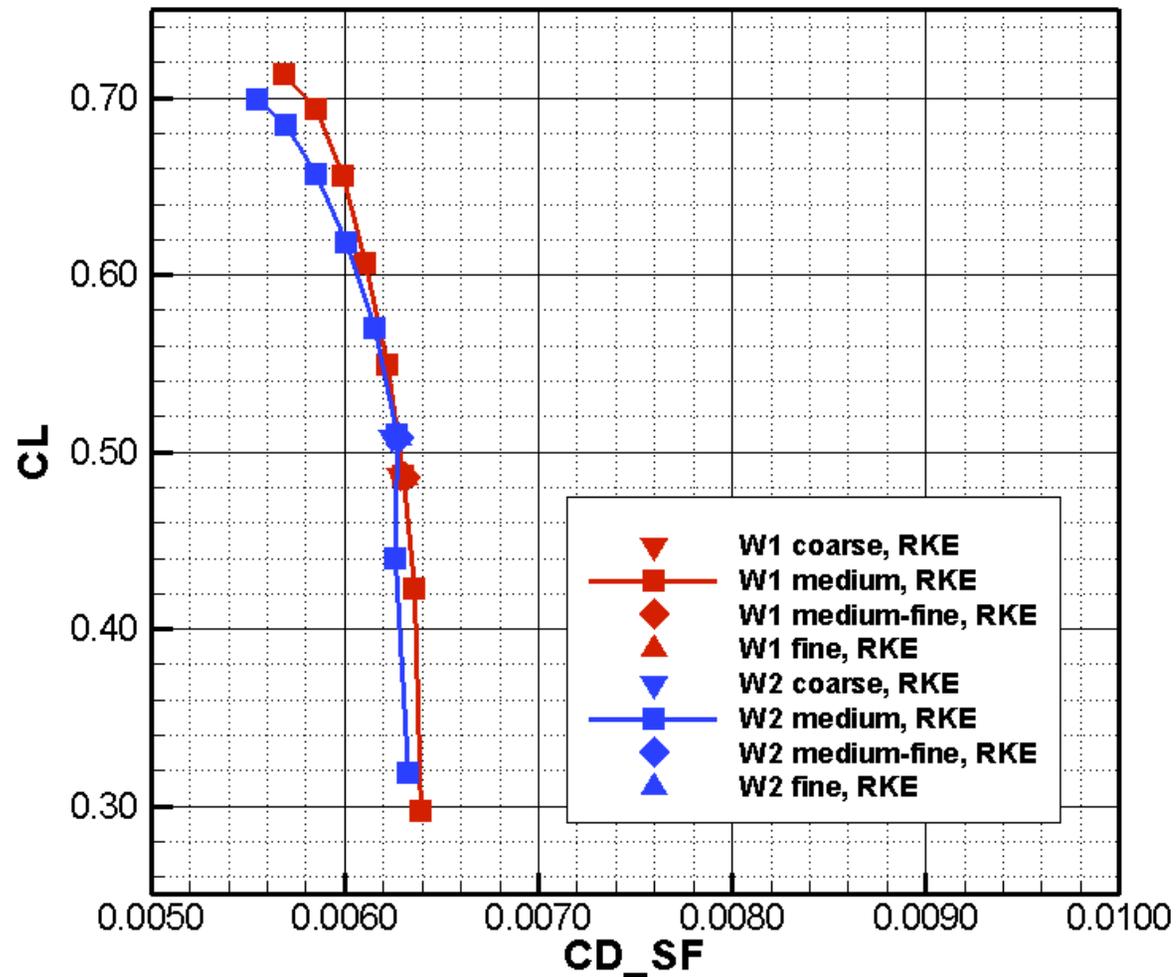
Lift Curve

Medium Boeing Grid, M=0.76, Re=5.0x10^6

Pitching Moment

Medium Boeing Grid, M=0.76, Re=5.0x10^6
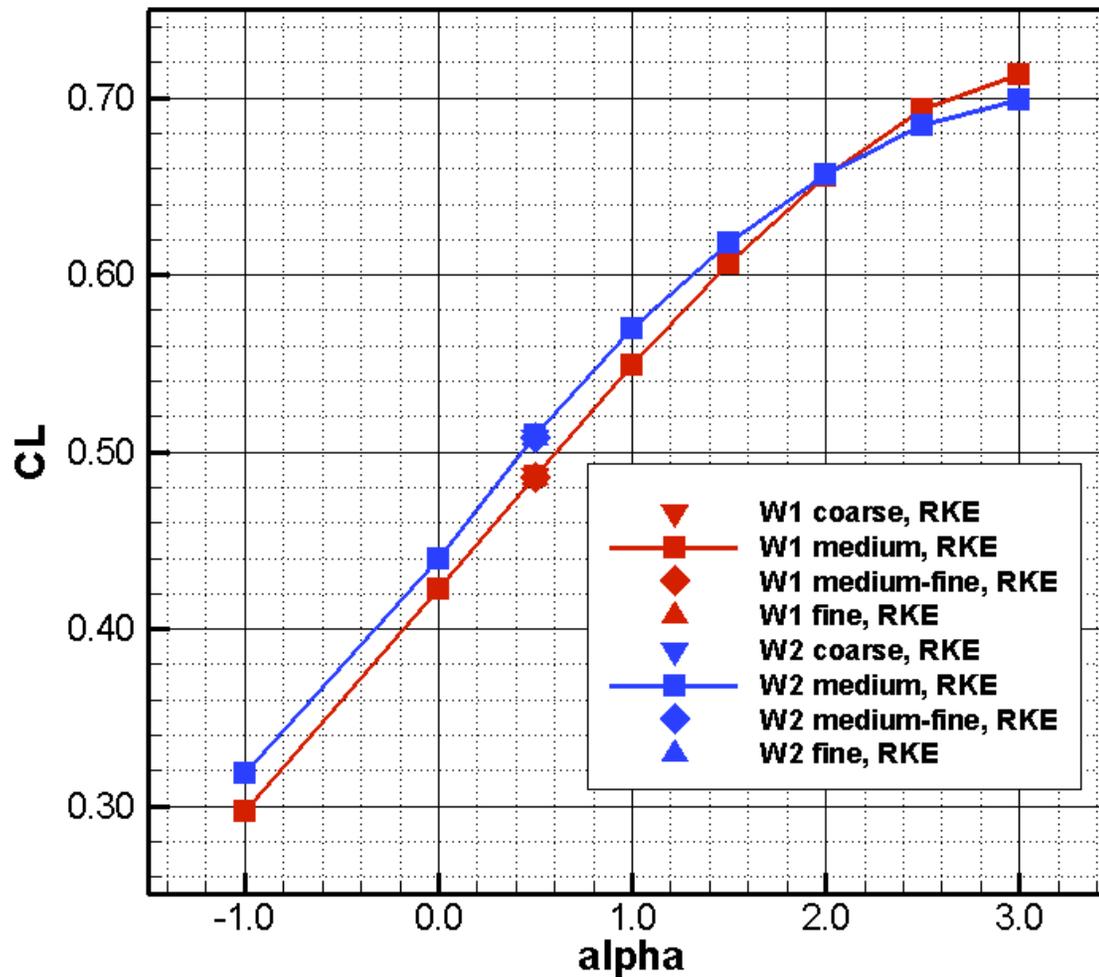
Summary

- Consistent and robust solver convergence was obtained for all DPW-W1/W2 cases
- Blind study and unavailability of experimental data doesn't allow to comment on absolute accuracy
- Expected grid refinement trends are observed
    - Convergence behavior and mesh inspection indicates that grids are still not sufficiently consistent refined
- Generating consistently refined grids is still the bottleneck of this DPW series
- These DPWs are a welcome opportunity for Fluent to continuously refine our solver technology