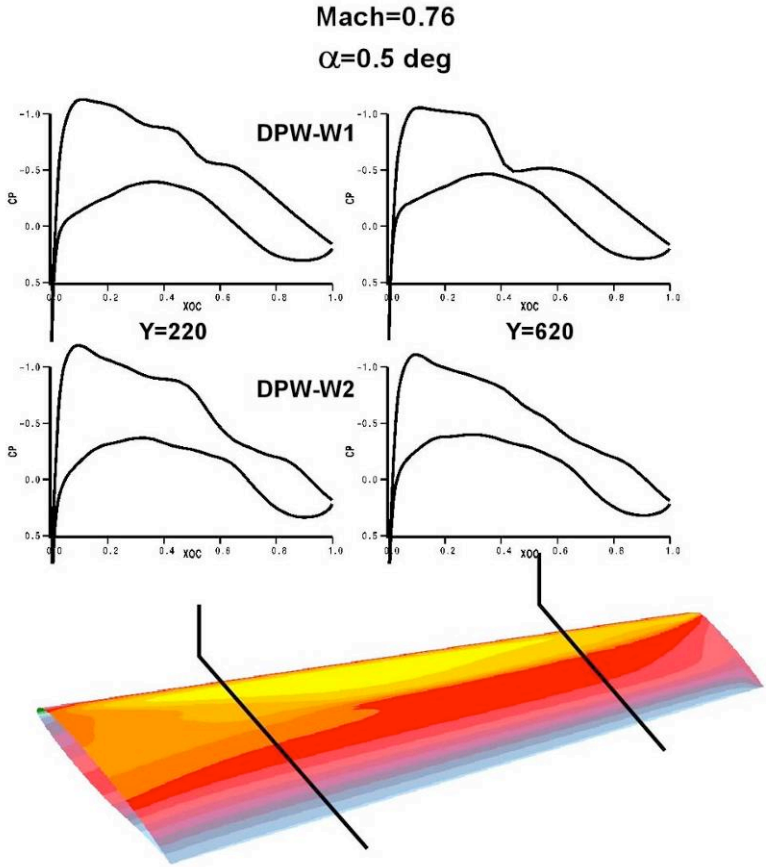
Case 2 DPW-W1/W2 Drag Prediction for the 3rd CFD Drag Prediction Workshop



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Objective

Investigate the use of a "Production Navier-Stokes Analysis System" for CFD Drag Prediction

-Major interest is in the prediction of drag increments

-Use "standard" processes as much as possible

Acknowledgement

None of this work would have been possible without the considerable contributions of:

N. Jong Yu

Tsu-Yi Bernard Su

Tsong-Jhy Kao

Senthan Swaminathan

Moeljo Hong

Emanuel R Setiawan

CFL3D – Thin Layer Navier-Stokes Code

- Developed at NASA Langley (Jim Thomas, Kyle Anderson, Bob Biedron, Chris Rumsey, & …)
- Finite volume
- Upwind biased and central difference
- Multigrid and mesh sequencing for acceleration
- Multiblock with 1-1 blocking, patched grid, and overlap-grid
- Numerous turbulence models
  - Spalart-Almaras SA Model
  - Menter's k-ω SST Model
- Time accurate with dual-time stepping
- Runs efficiently on parallel machines through MPI

Run with ICEM Generated Structured Grids

CFD++ – Unstructured Grid Navier-Stokes Code

- Developed by Metacomp Technogies
- Unified grid, unified physics and advanced numerical discretization and solution framework.
- Finite volume
- Upwind biased
- Multigrid for acceleration
- Arbitrary elements and has overset capabilities.
- Choice of turbulence models
  - Spalart-Almaras SA Model
  - k-ε-Rt Model
- Time accurate with dual-time stepping
- Runs efficiently on parallel machines through MPI

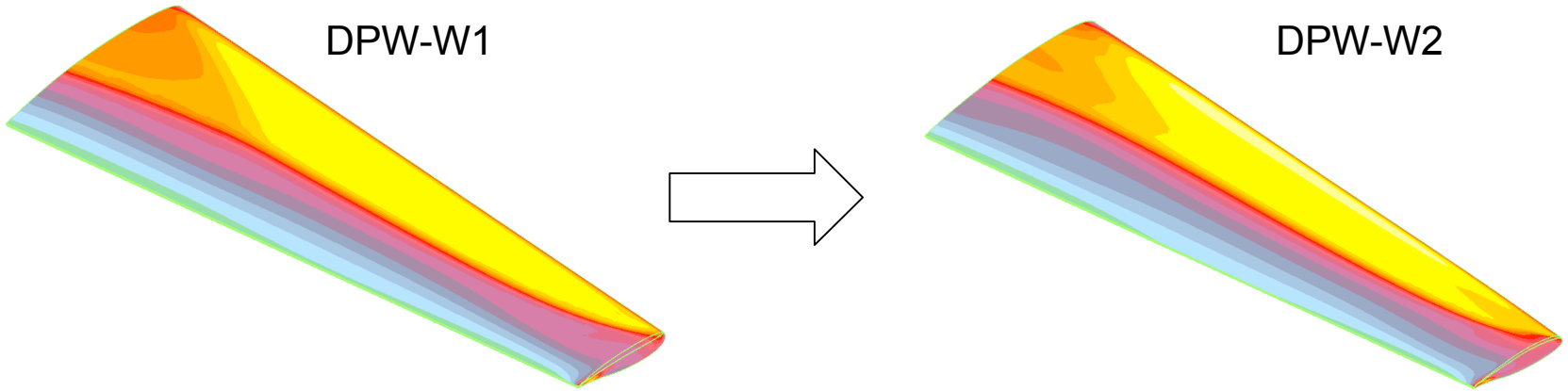
Limited runs with:

- ICEM Structured Grids
- Cessna Unstructured Grids

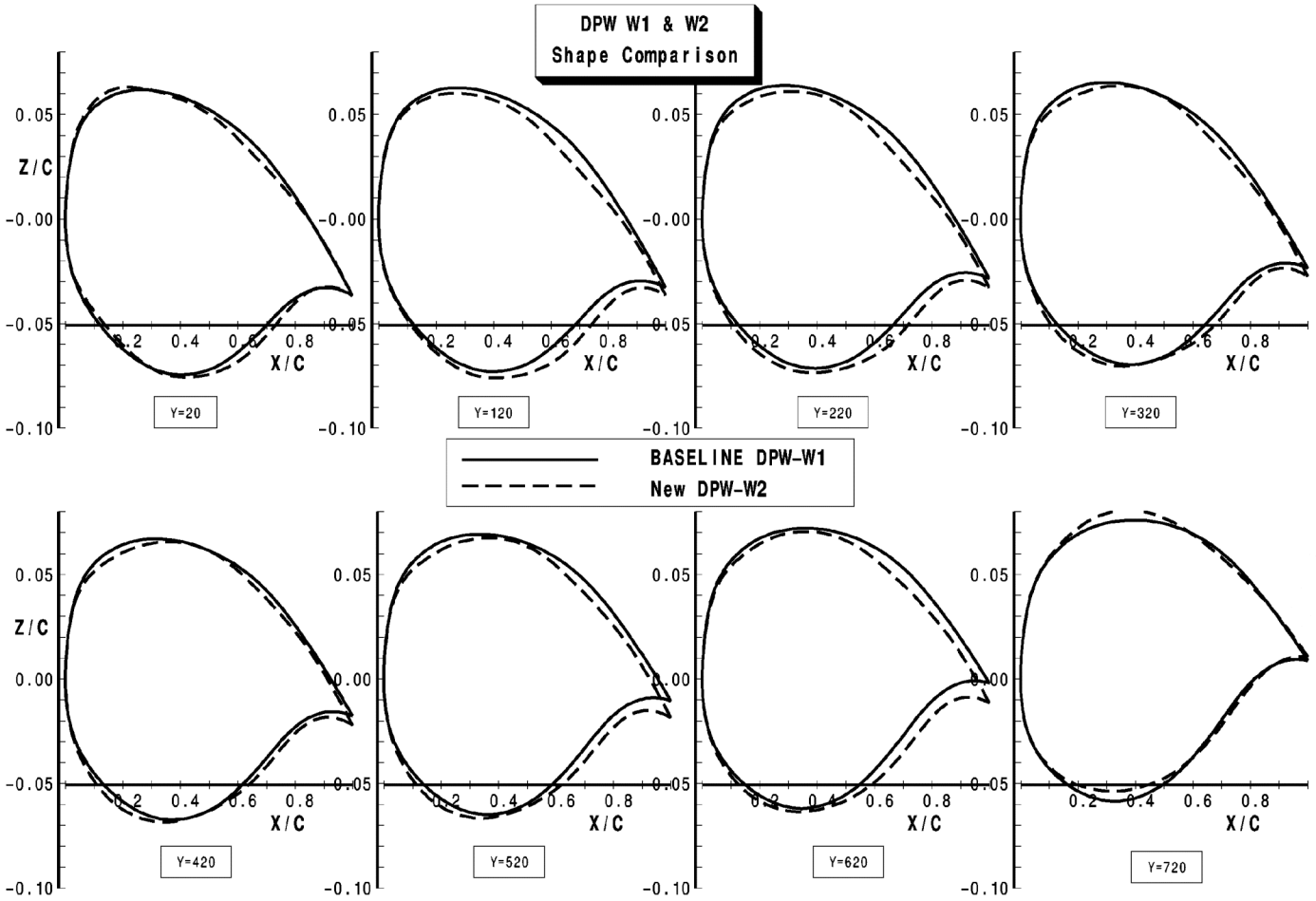
DPW-W2 Creation

Objective: Create a companion wing to DPW-W1 for drag increment prediction

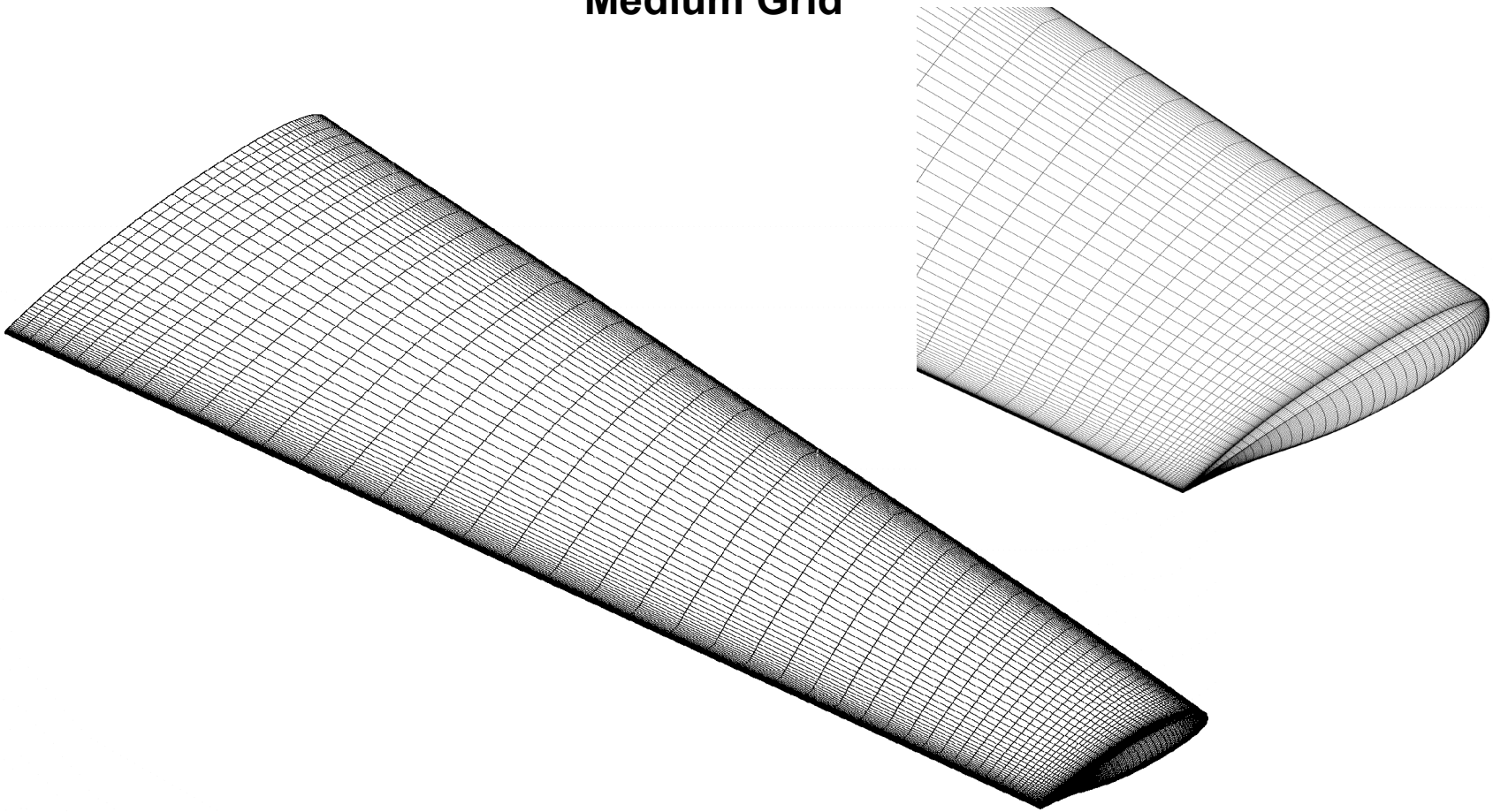
- Maintain the same planform and thickness
- Use optimization to change camber and twist
  - TRANAIR single-point optimization
    - Sequential Quadratic Programming
      - Linear Constraints
      - Nonlinear Objectives
  - Minimize drag at a specified lift
  - Variables: 5 camber variables + twist + shear @ 7 spanwise locations



DPW-W1/W2 Shape Comparisons



DPW-W1/W2 ICEM Structured Grids
Medium Grid



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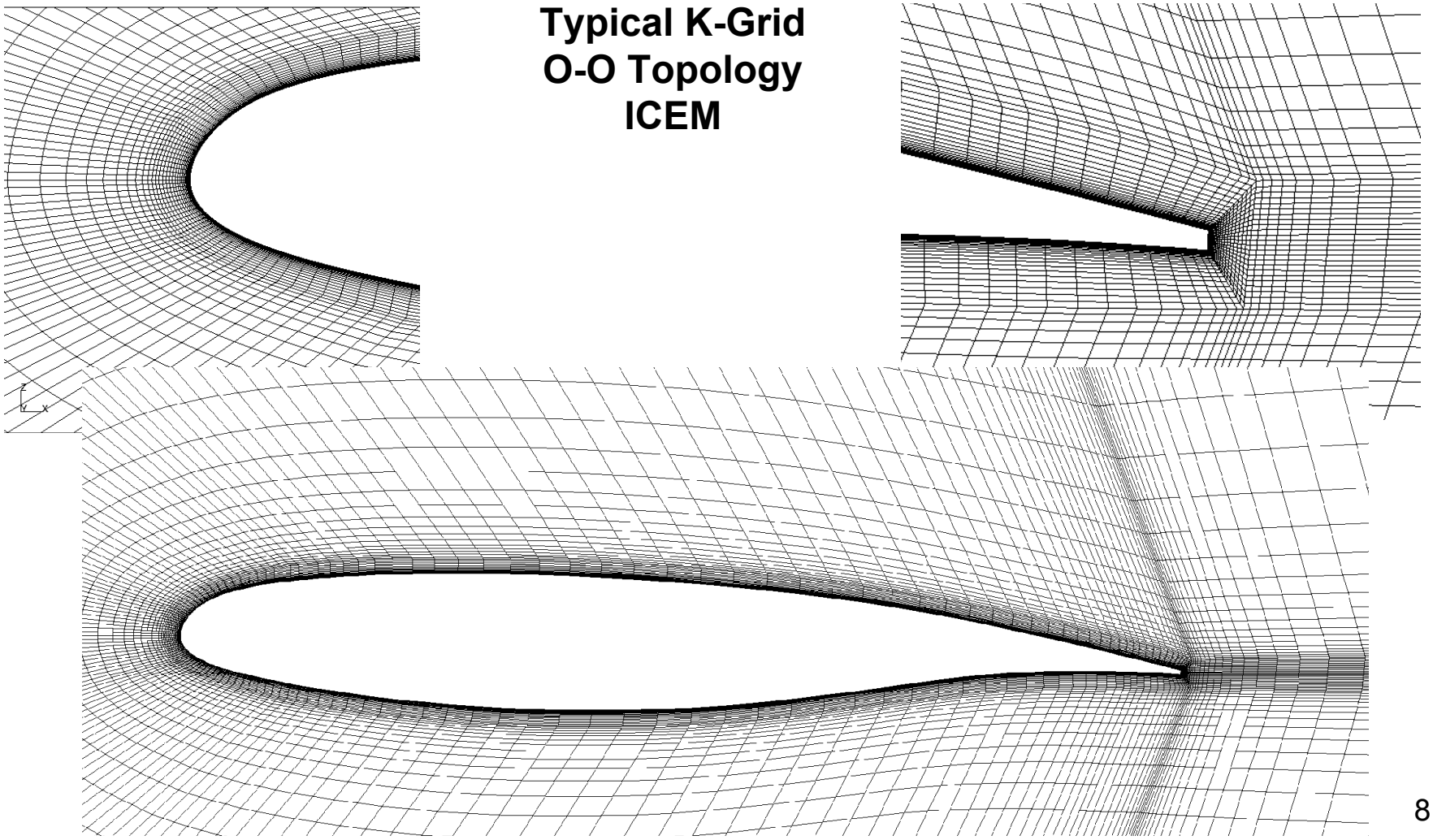
DPW-W1/W2
Typical K-Grid
O-O Topology
ICEM



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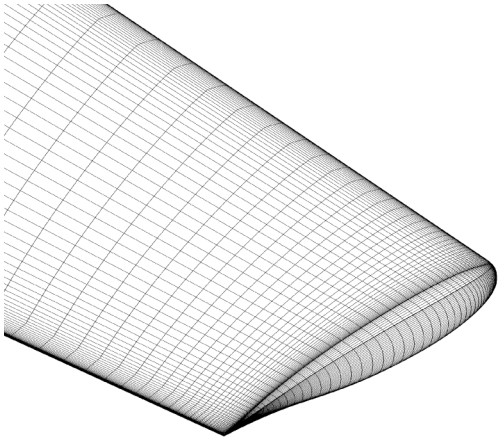
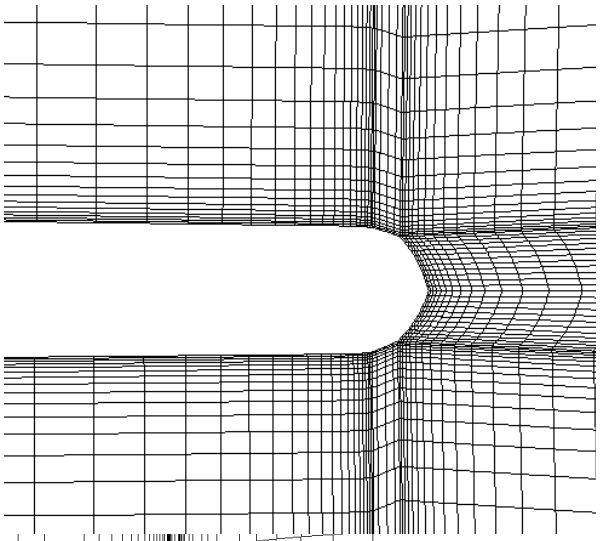
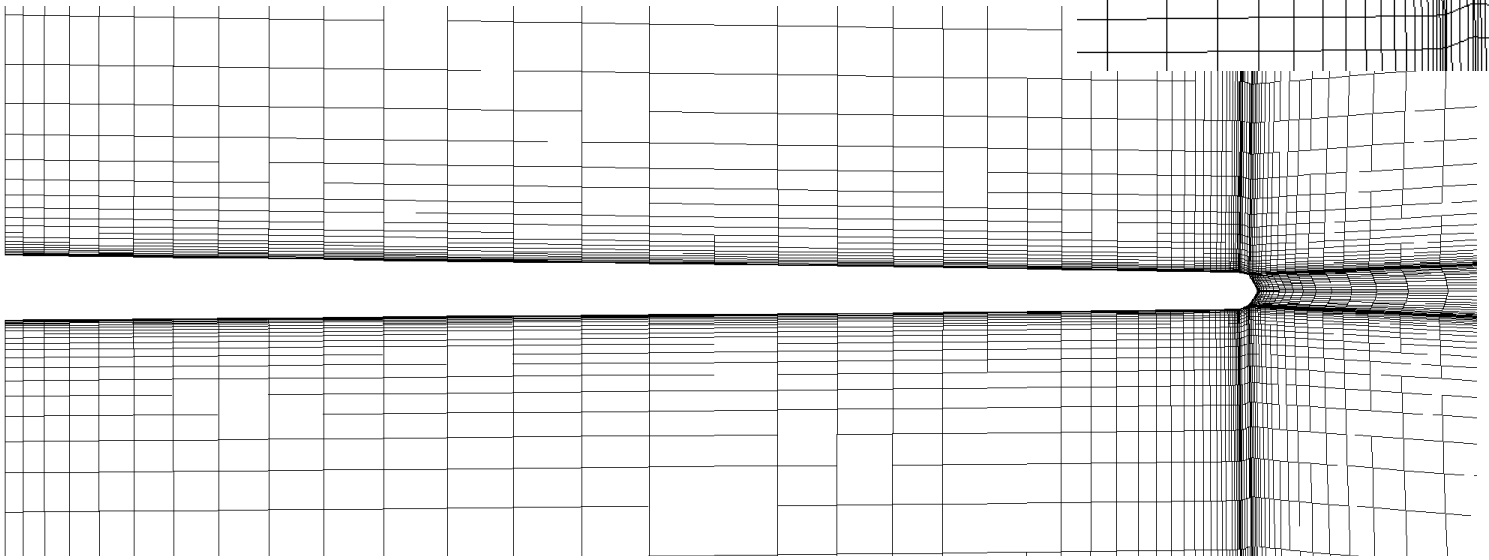
DPW-W1/W2
Typical I-Grid
O Topology
ICEM

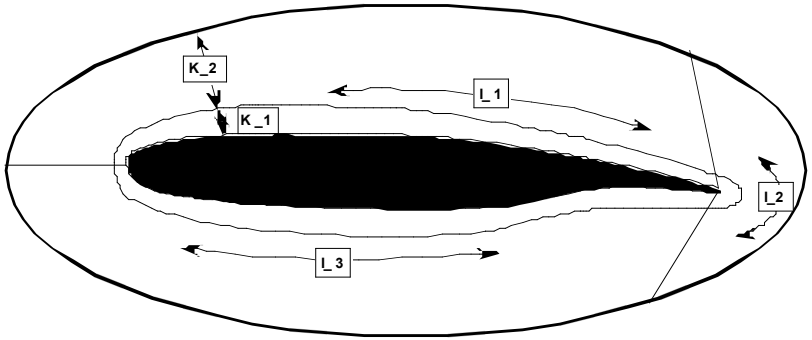


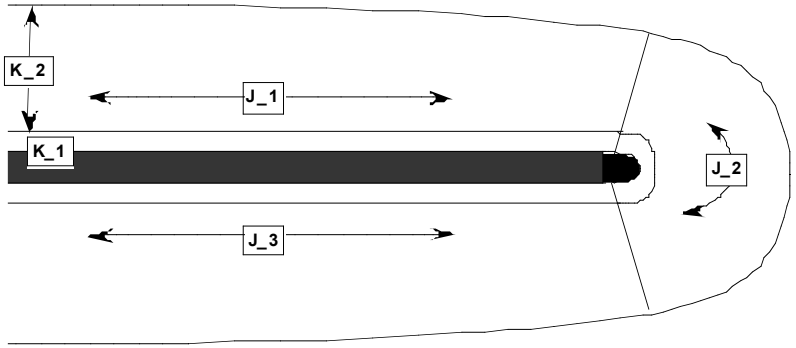




Structured Multi-Block DPW-W1/W2 Grids

Constructed with ICEM

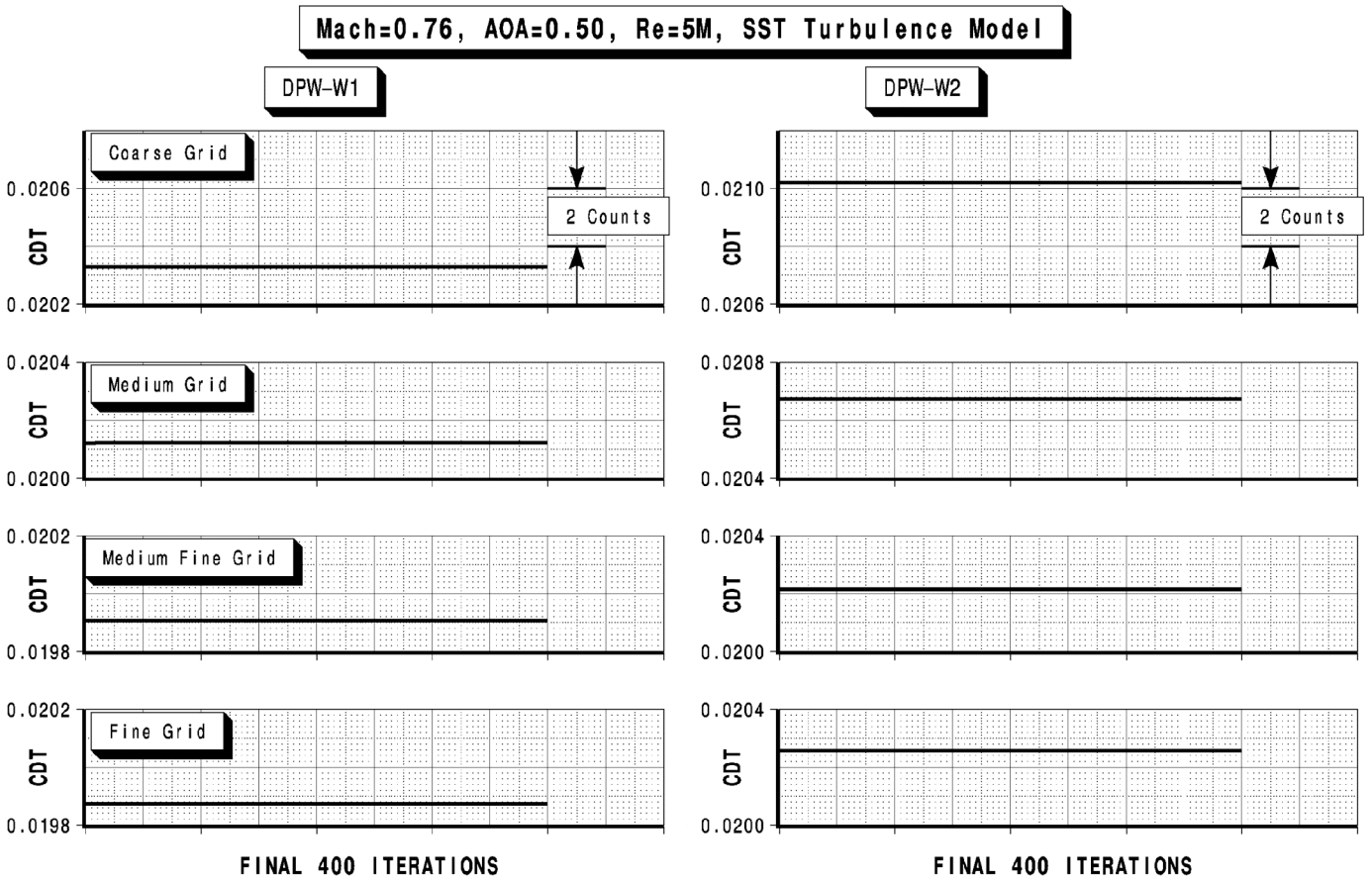




	I_1	I-2	I_3	J_1	J_2	J_3	K_1	K_2	Total Grid Size
Coarse	73	25	73	49	25	49	33	49	1.60E+06
Medium	81	33	81	73	33	73	49	73	4.20E+06
Medium Fine	121	49	121	73	49	73	65	97	8.60E+06
Fine	145	49	145	105	49	105	73	105	1.47E+07

Gridding Guidelines not met - Grids were not uniformly refined!

DPW-W1/W2 – Drag Convergence – CFL3D



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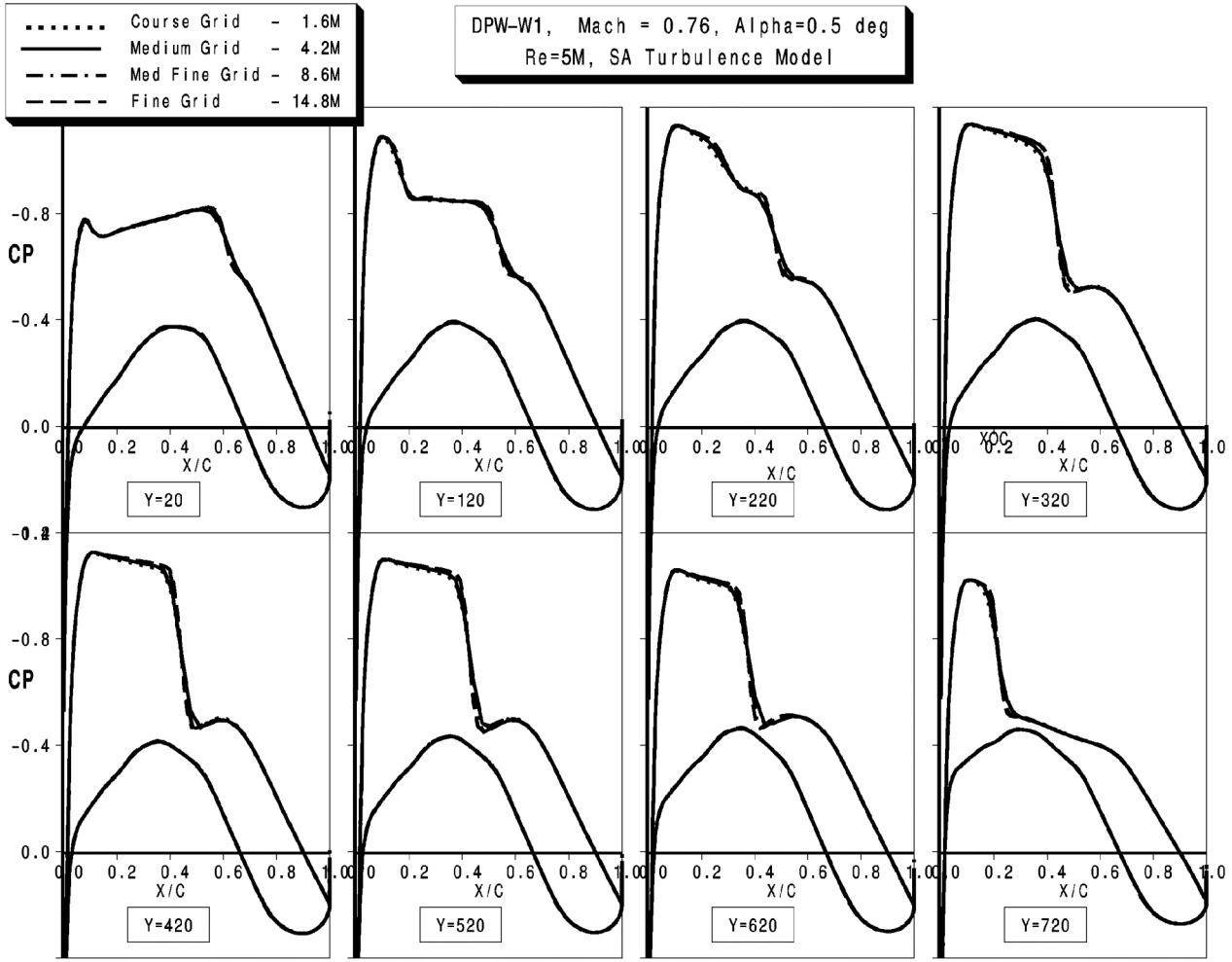
DPW-W1 – Wing Cp's – Grid Convergence – CFL3D



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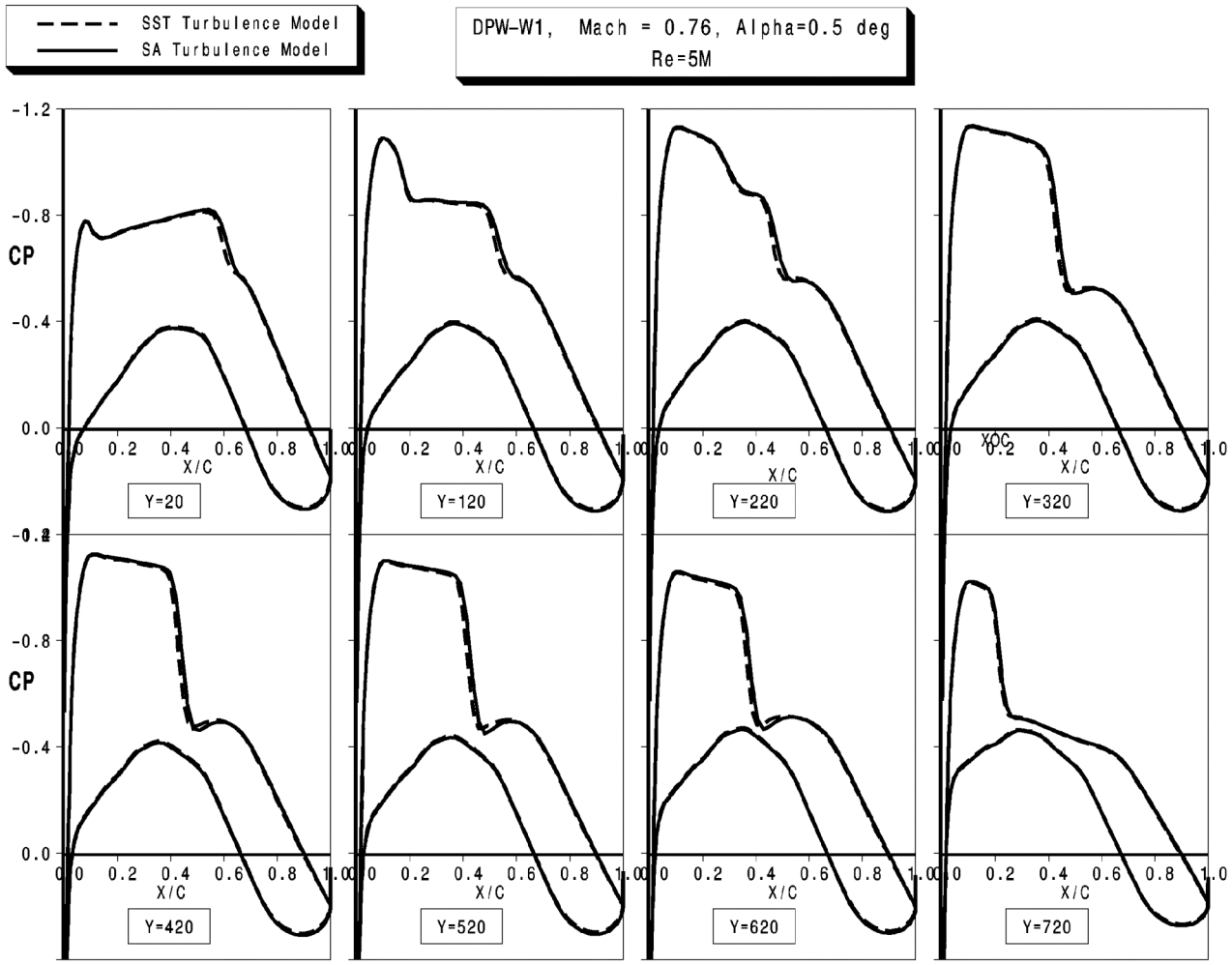
DPW-W1 – Wing Cp's – Turbulence Modeling Effects – CFL3D



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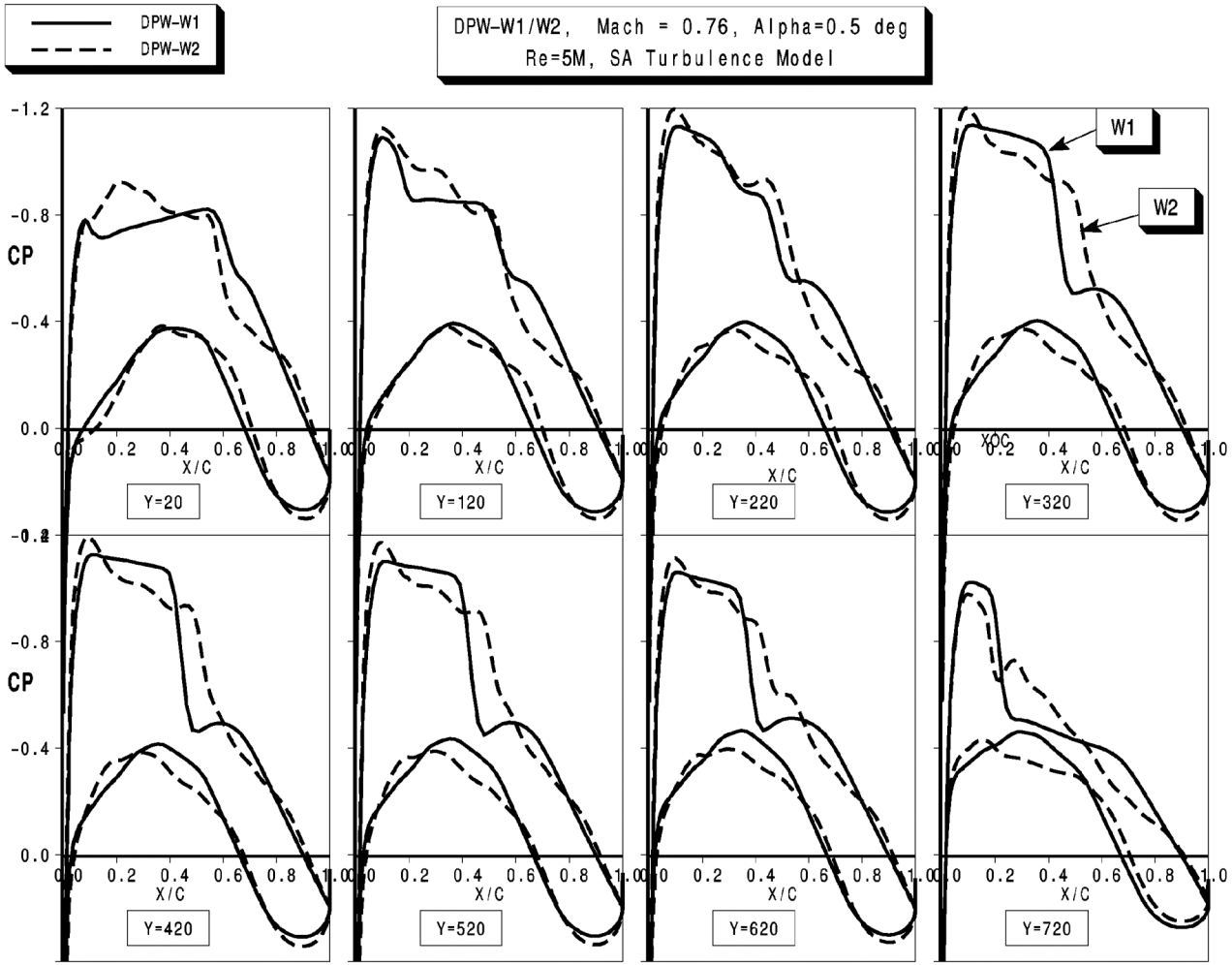
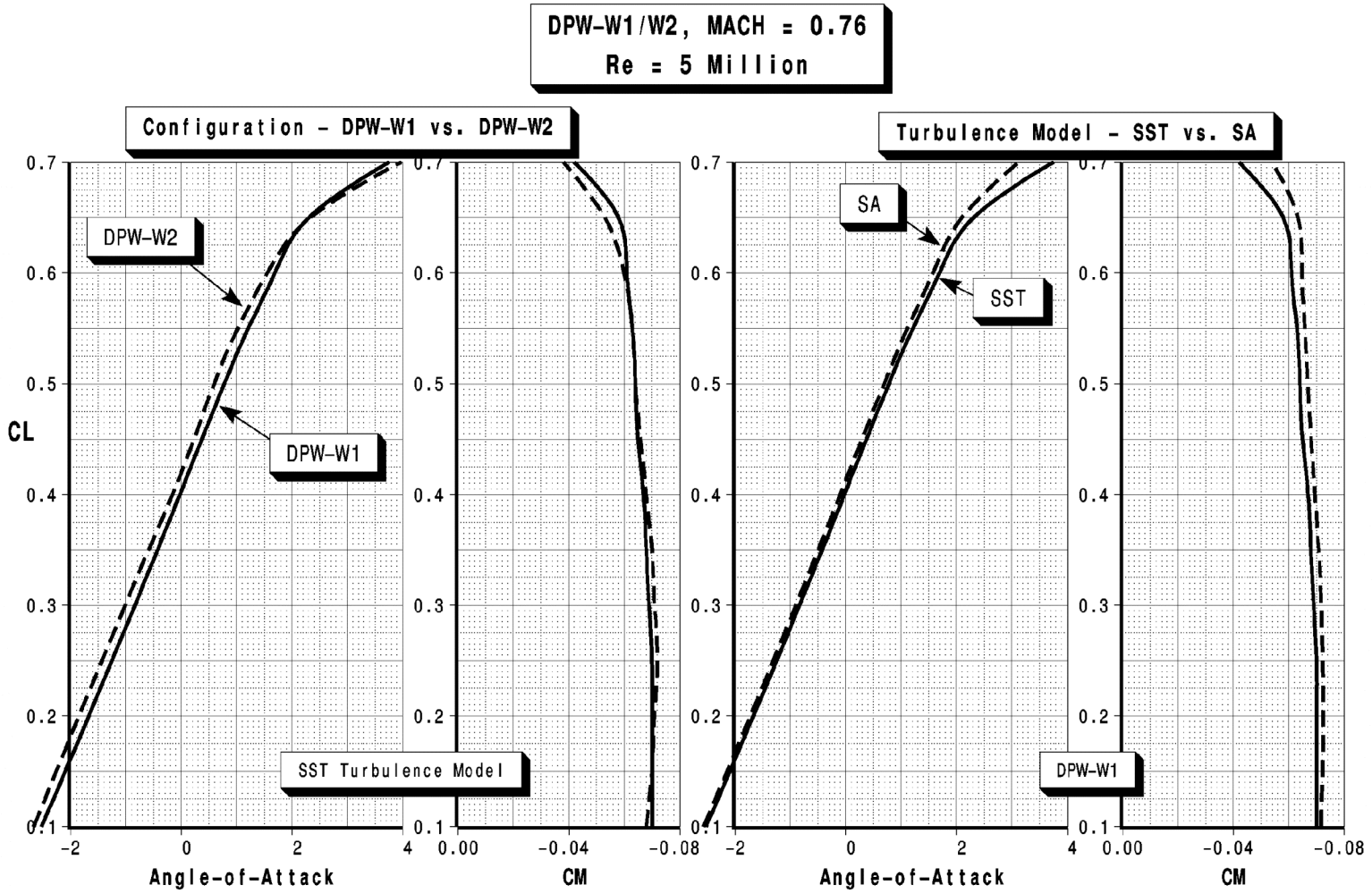
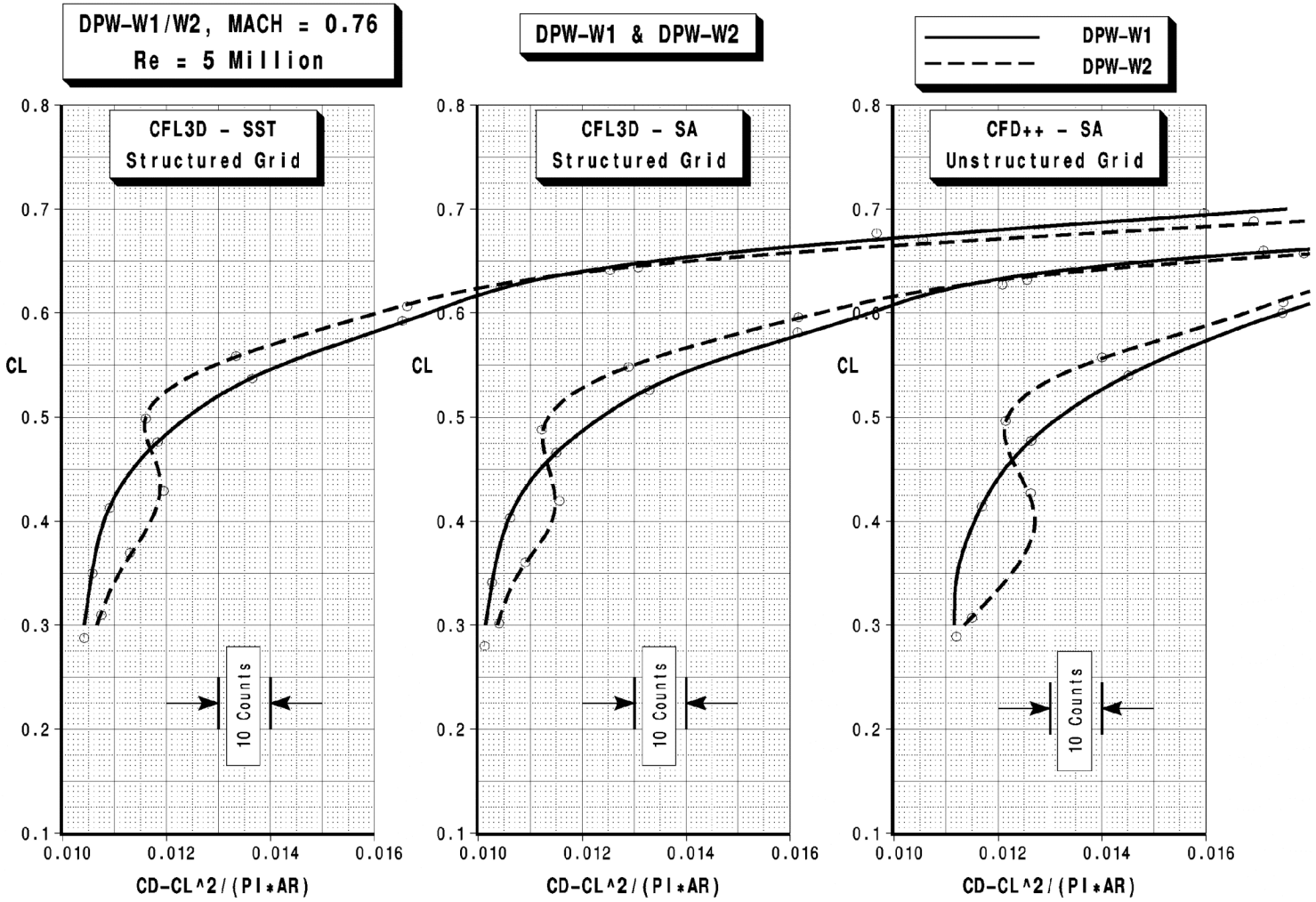
DPW-W1 vs W2 – Wing Cp's – CFL3D



DPW-W1 / W2 – Lift and Pitching Moment – CFL3D



DPW-W1 / W2 – Polar Shape - Code/Turbulence Modeling



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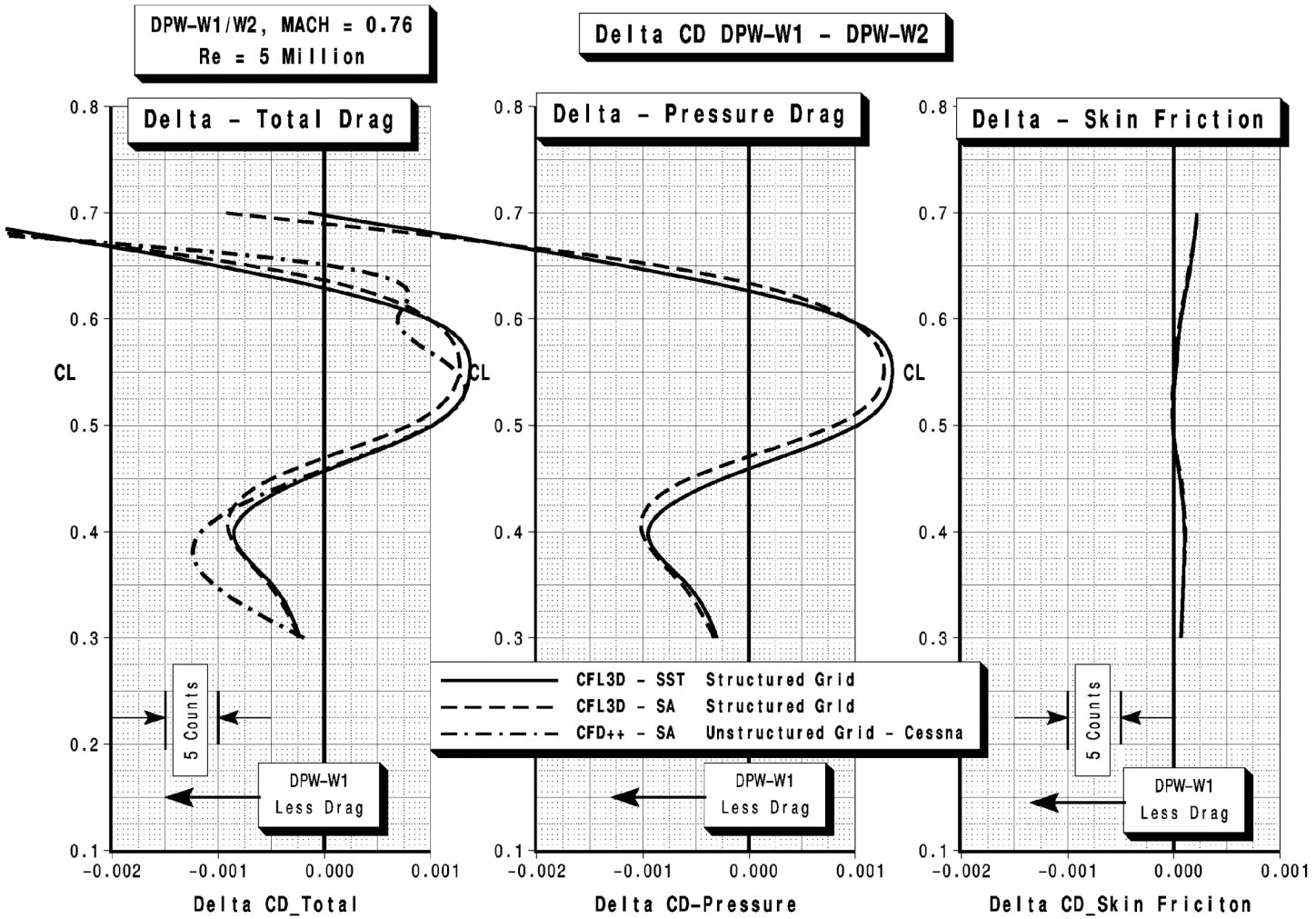
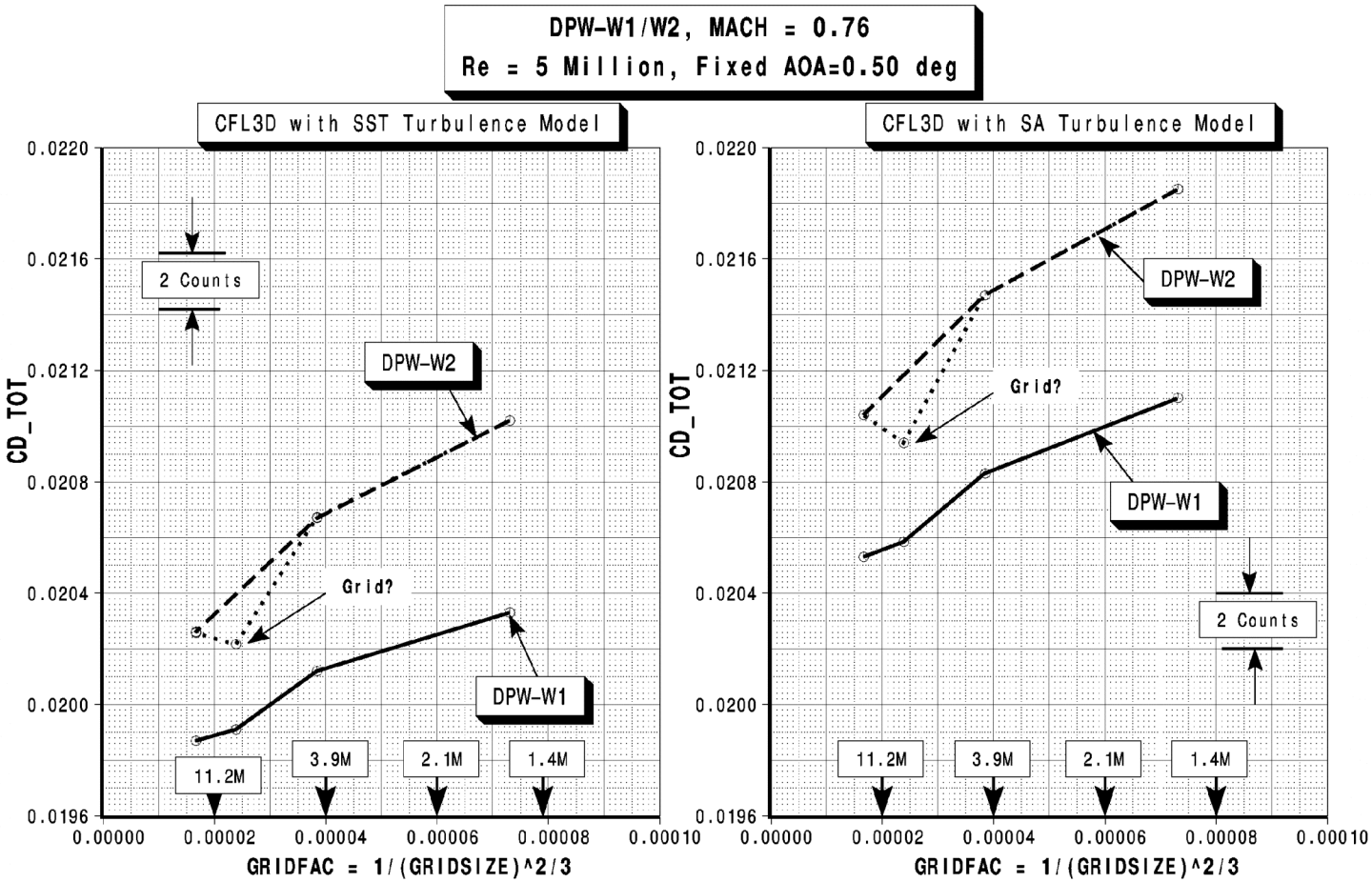
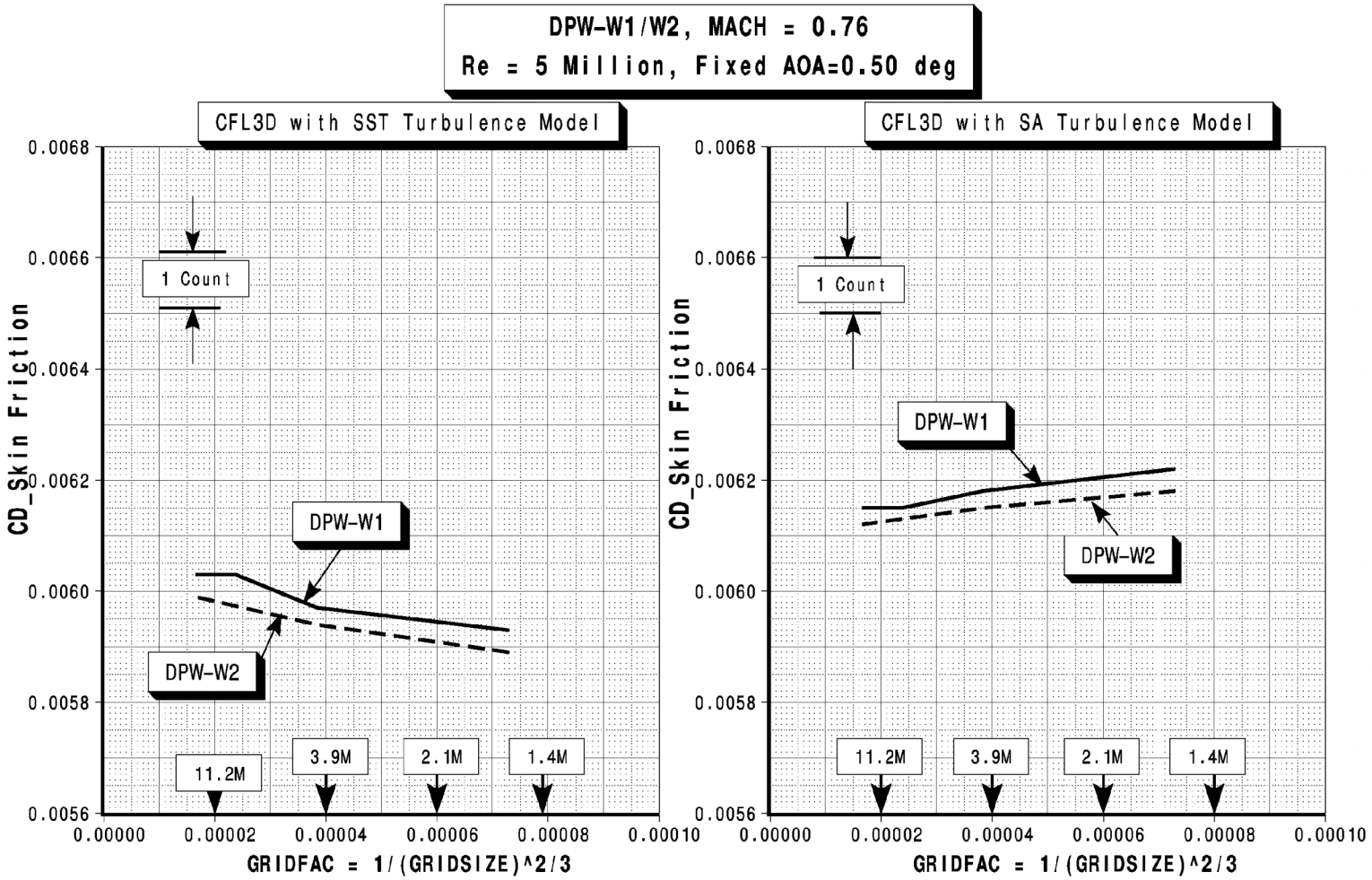
DPW-W1 / W2 – Drag Polar Increments



DPW-W1 / W2 – Total Drag Grid Convergence – CFL3D



DPW-W1 / W2 – Skin Friction Grid Convergence – CFL3D



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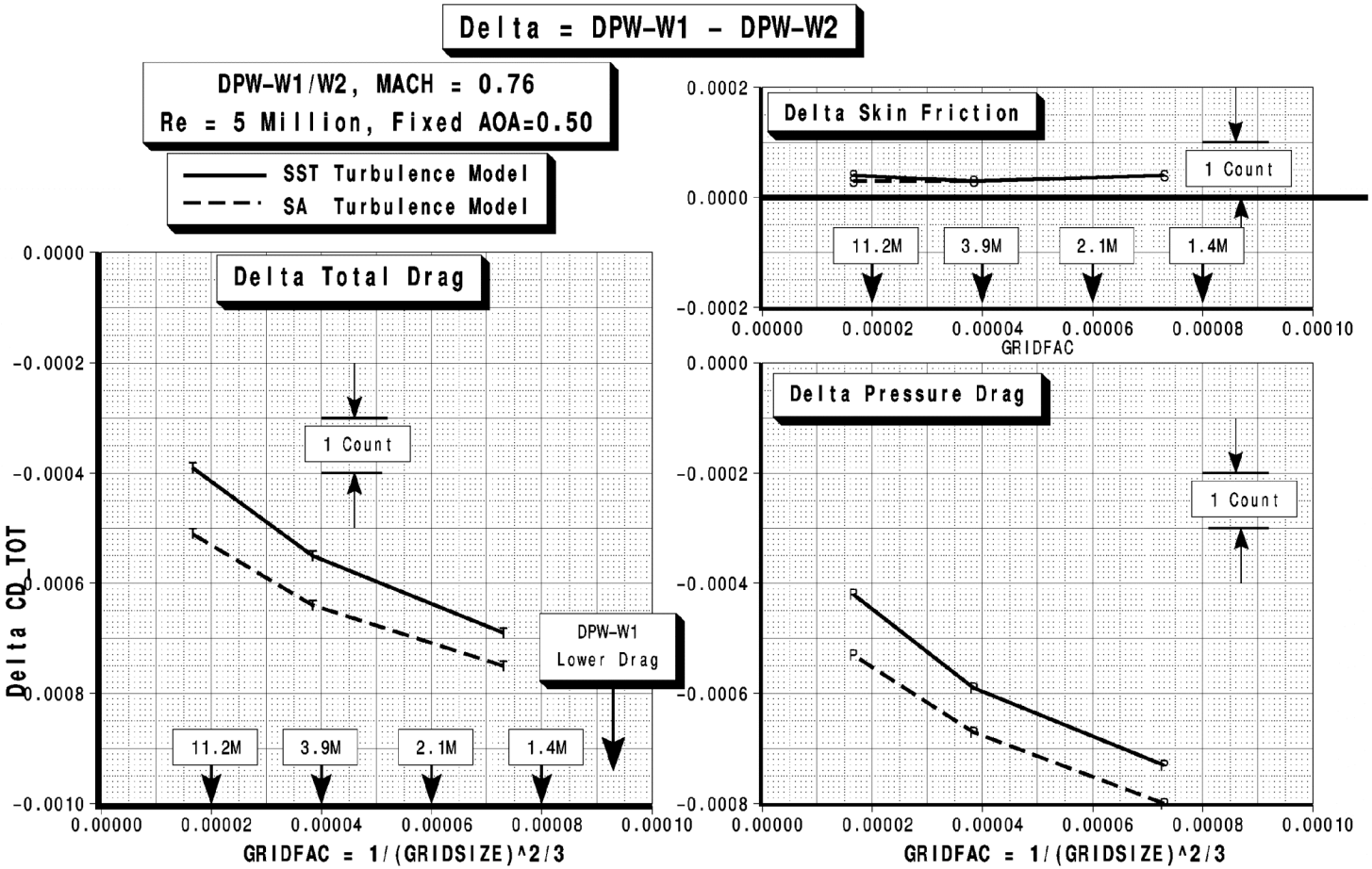
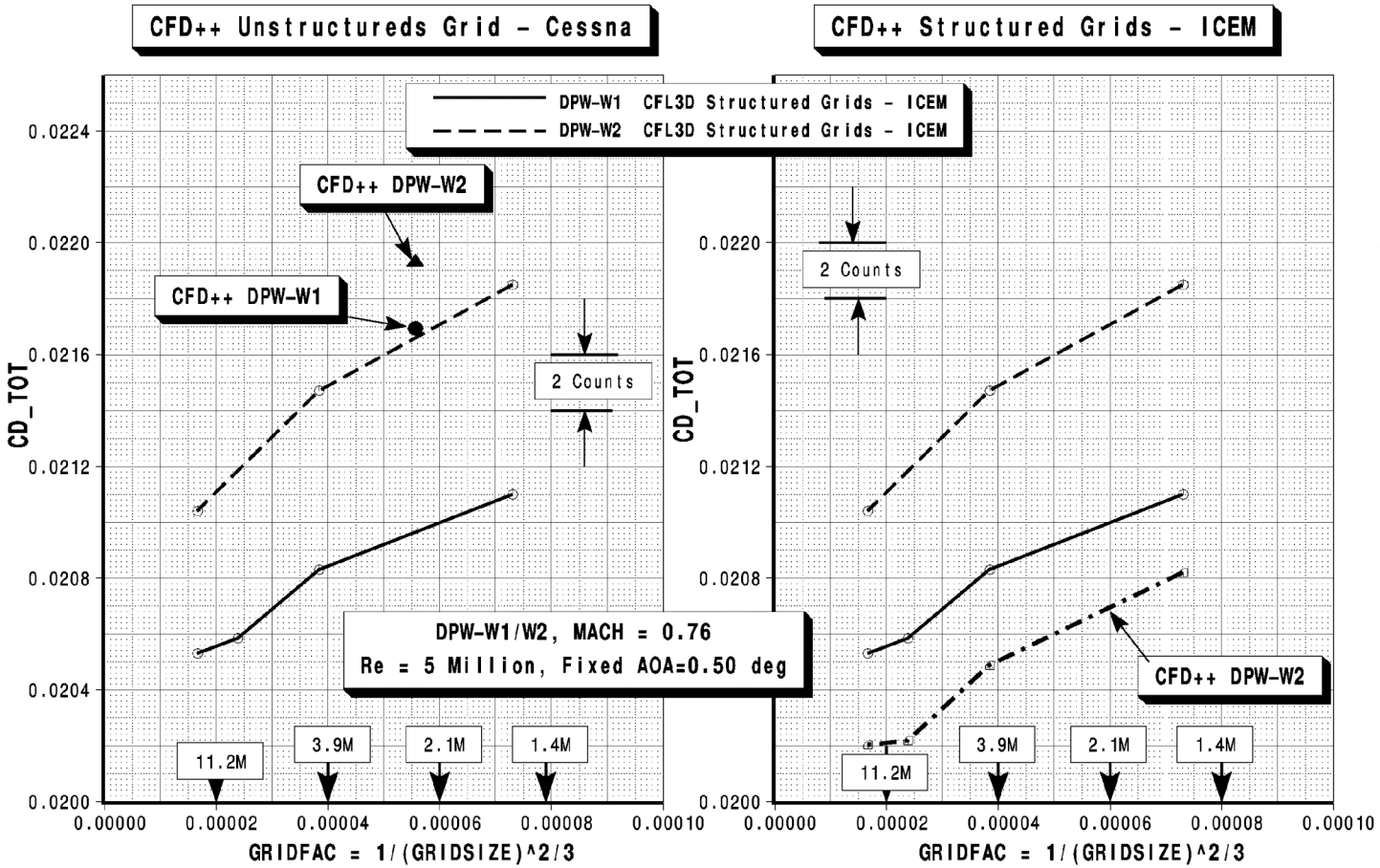
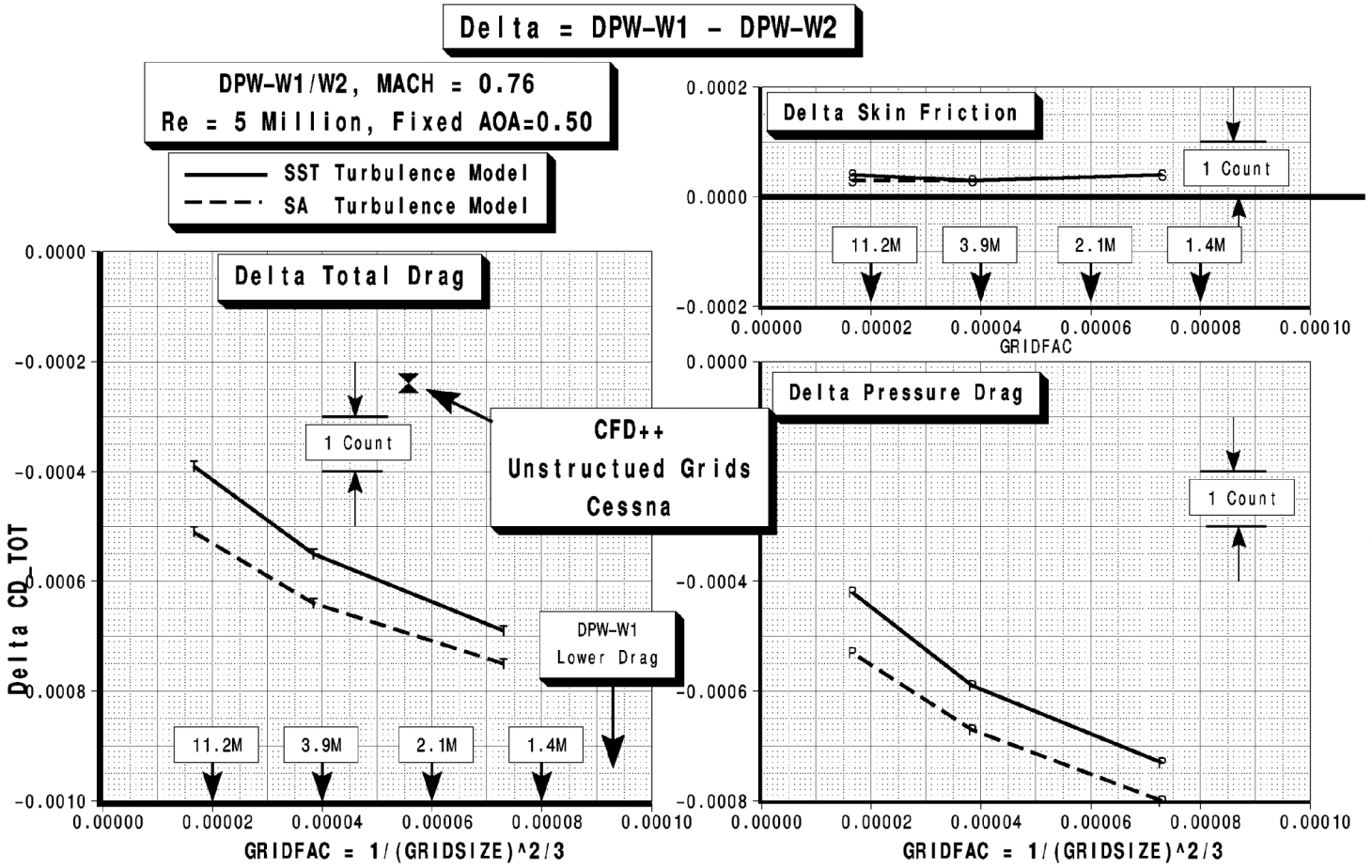
DPW-W1 / W2 – Drag Increment Grid Convergence – CFL3D



DPW-W1 / W2 – Total Drag Grid Convergence – CFD++



DPW-W1 / W2 – Drag Increment Grid Convergence – CFD++



Concluding Remarks

CFL3D – Structured ICEM Grids

- •Convergence characteristics not as good as seen for F6 cases
- •More variation in grids

CFD++ - Structured ICEM Grids

- • Good convergence characteristics

CFD++ - Unstructured Cessna Grids

- • No convergence problems on Cessna medium grid for W1.
- • Divergence observed on all cases for W2 except for a =2 deg. Solution for all other angles obtained using this as a restart solution.

We should rename to the Grid Convergence Workshop

Backup

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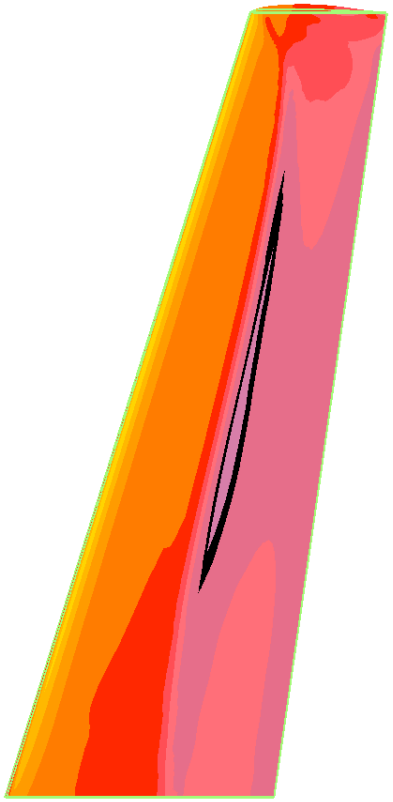
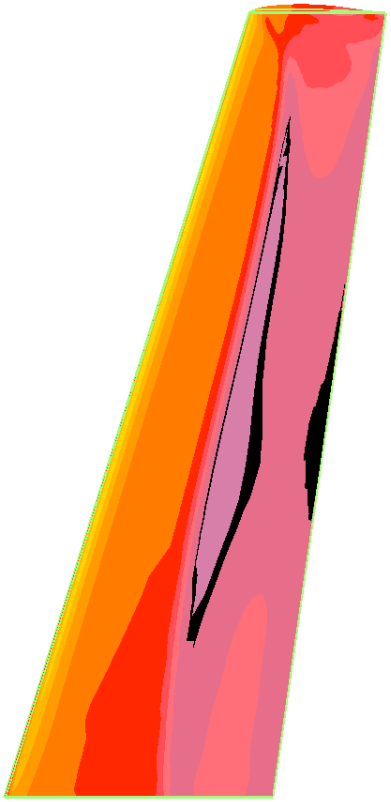
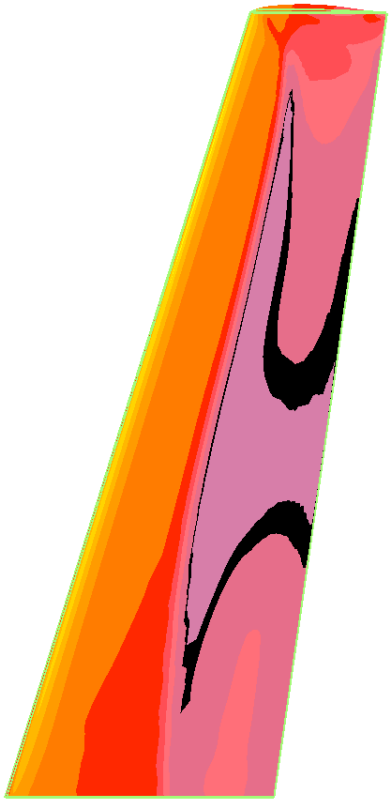
w2 – alpha=2.0



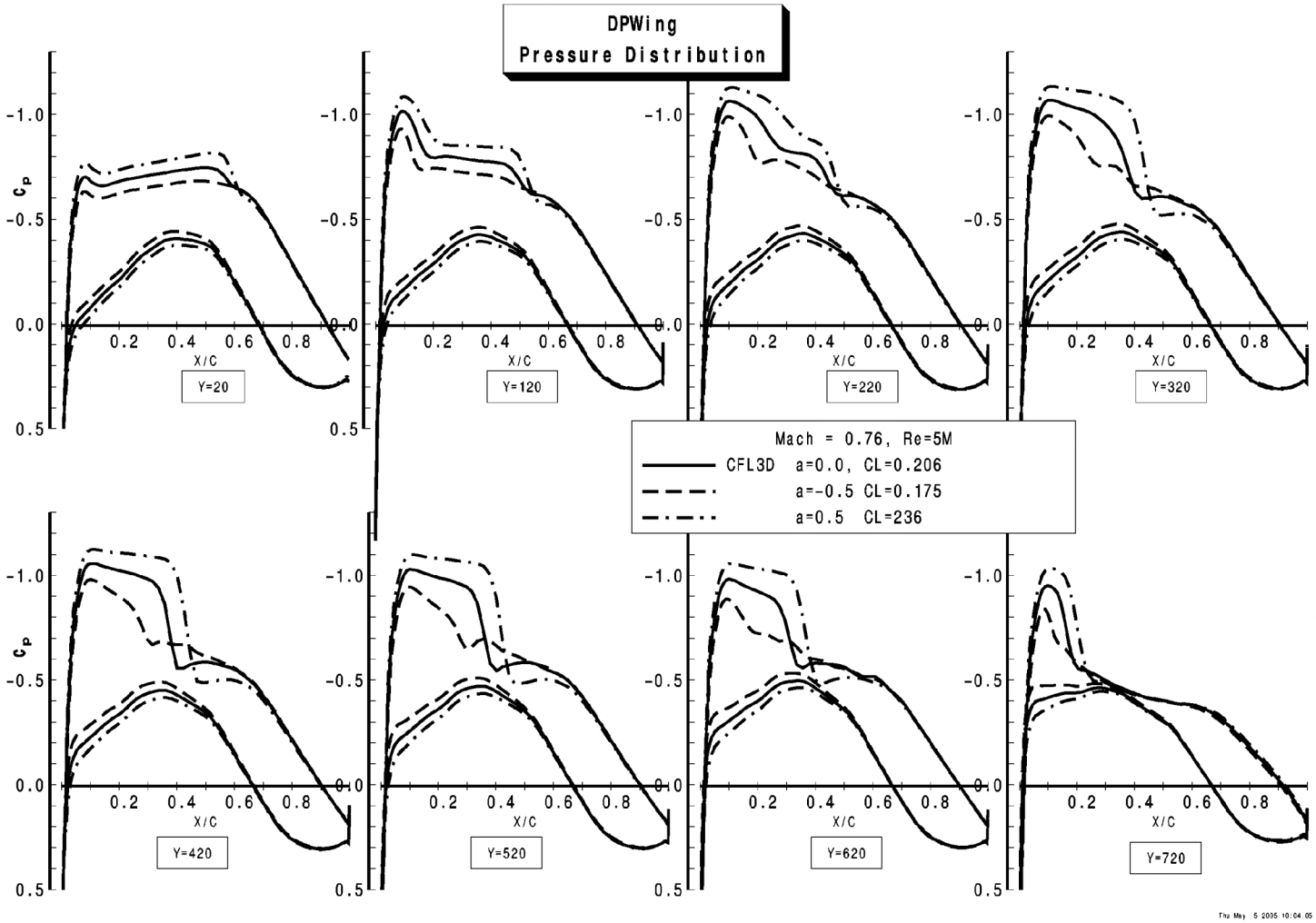
w2, alpha=2.5



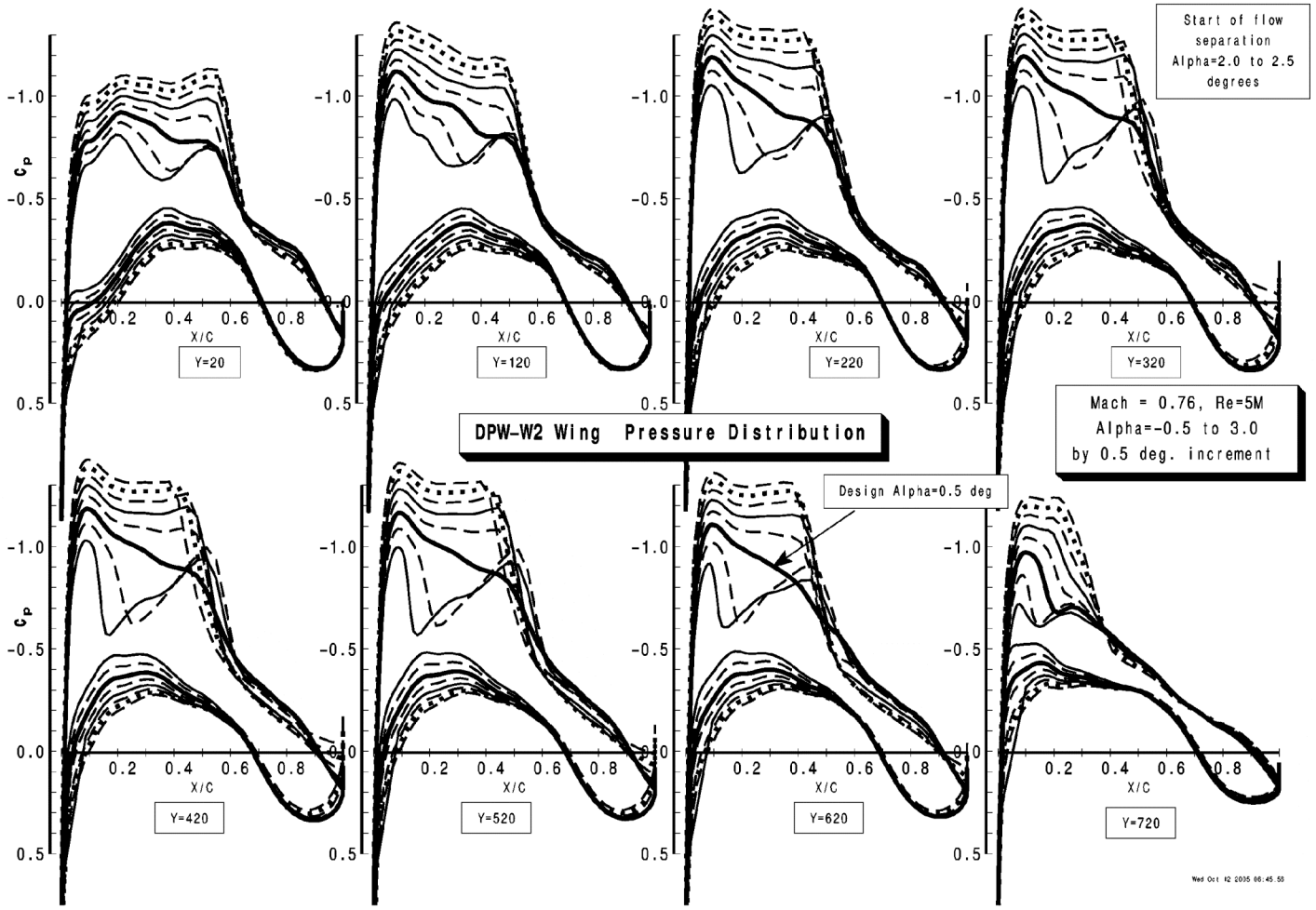
w2, alpha=3.0



DPW-W1 Pressure Distributions



DPW-W2 Pressure Distributions



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