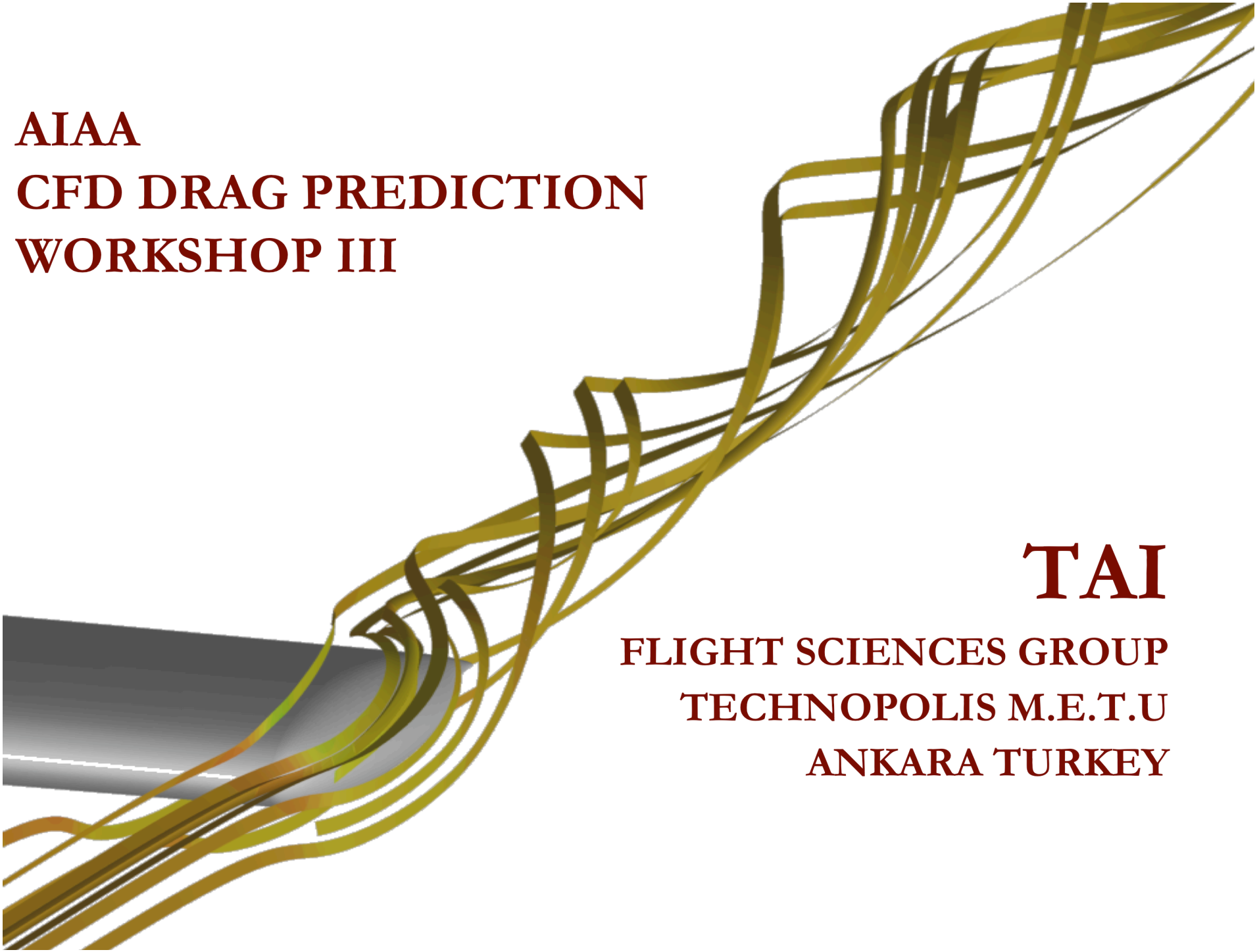
AIAA
CFD DRAG PREDICTION WORKSHOP III



TAI

FLIGHT SCIENCES GROUP

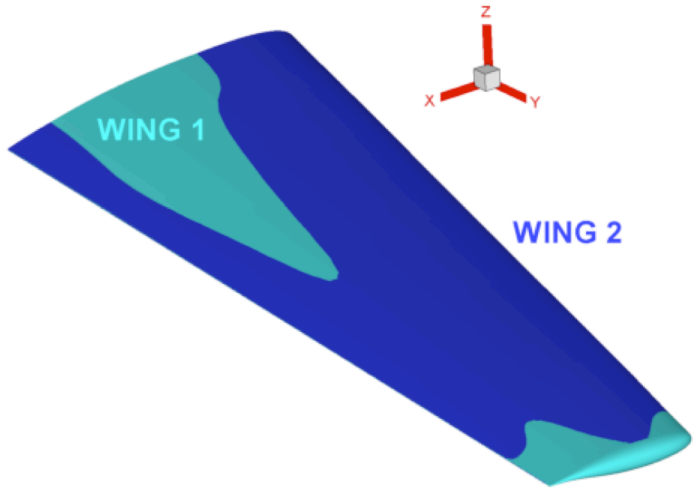
TECHNOPOLIS M.E.T.U

ANKARA TURKEY

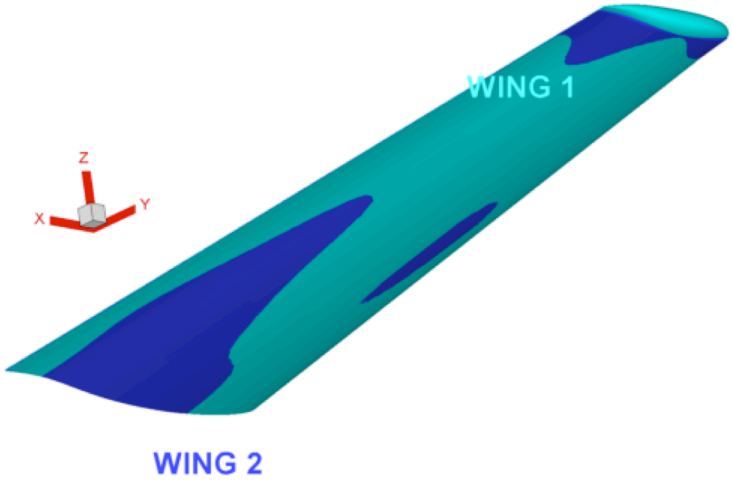
DPW-WING 1 AND WING 2 (TEST CASES)

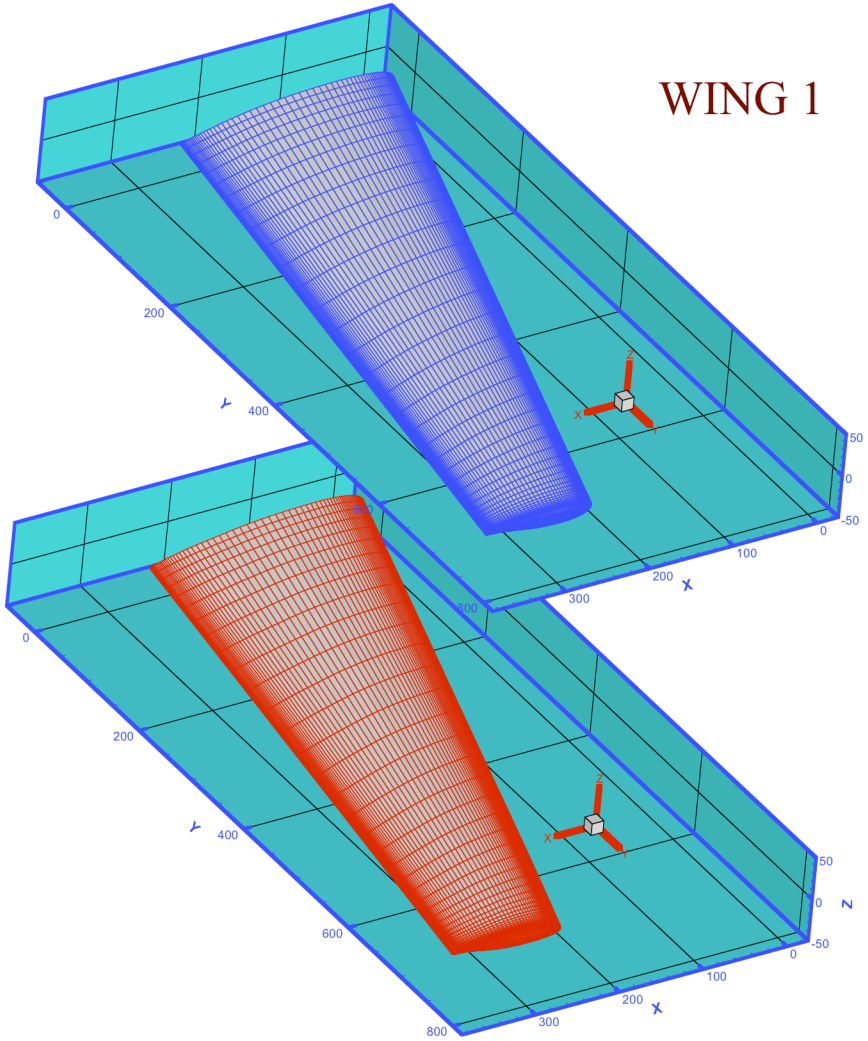
- Configuration : Wing alone comparisons
- DPW-Wing1 (baseline) and DPW-Wing2 (simple optimization)
- For all cases, Reynolds No. = 5x106 (Based on cref = 197.556 mm), free-stream Temperature 580R (322.22 Kelvin)
- Drag polar at Mach=0.76, alpha=-1, 0, 0.5, 1, 1.5, 2, 2.5, 3 (medium grid)
- Reference Geometry:
  Sref = 290322 mm2 = 450 in2
  cref = 197.556 mm = 7.778 in b = 1524 mm = 60 in
  AR = 8.0
  Mom. Center = (154.245,0.0,0.0) Relative to wing root l.e.

DPW-WING 1 AND WING 2 (GEOMETRIES)

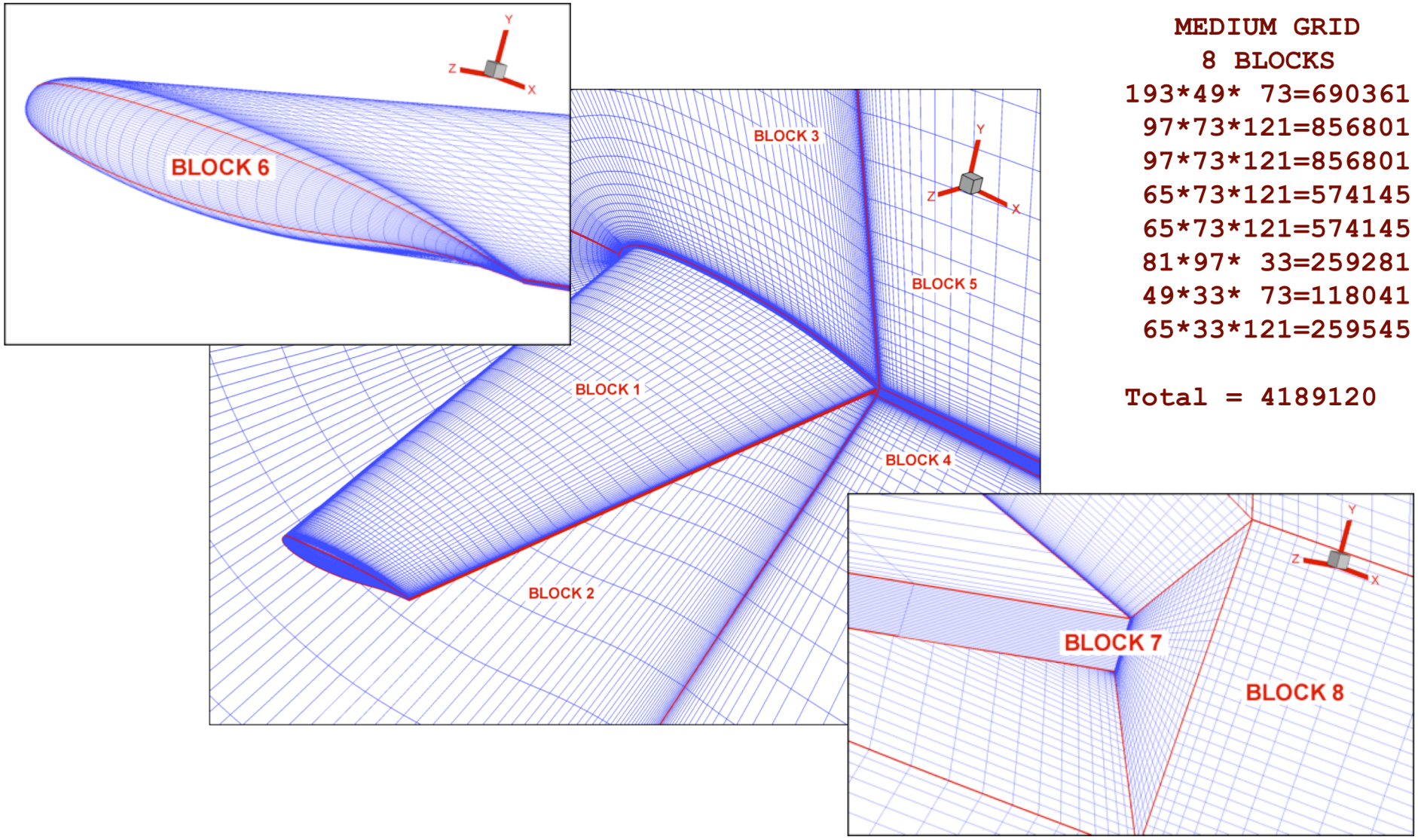


GEOMETRICAL COMPARISON OF WING 1 AND WING 2





BOEING W1&W2 MESH (8 BLOCKS)



MEDIUM GRID
8 BLOCKS
193*49* 73=690361
97*73*121=856801
97*73*121=856801
65*73*121=574145
65*73*121=574145
81*97* 33=259281
49*33* 73=118041
65*33*121=259545

Total = 4189120

THE FLOW SOLVER : XFLOW_SVPMB

- Structured Finite Volume, explicit formulation
- Euler/NS (Algebraic Turbulence model : Baldwin-Lomax)
- Jameson's Upwind-biased Symmetric Limited Positive Scheme
- Parallel-Multiblock (MPI with mpich-1.2.4)

COMPUTATIONS-SYSTEM REQUIREMENTS

FOR MEDIUM GRID SIZE

(8 BLOCKS AND TOTAL 4189120 NODES);

- CFL = 1.0; NUMBER OF ITERATIONS ~15,000 ; RAM ~240 MB (at each node); WALL CLOCK TIME ~30 HOURS

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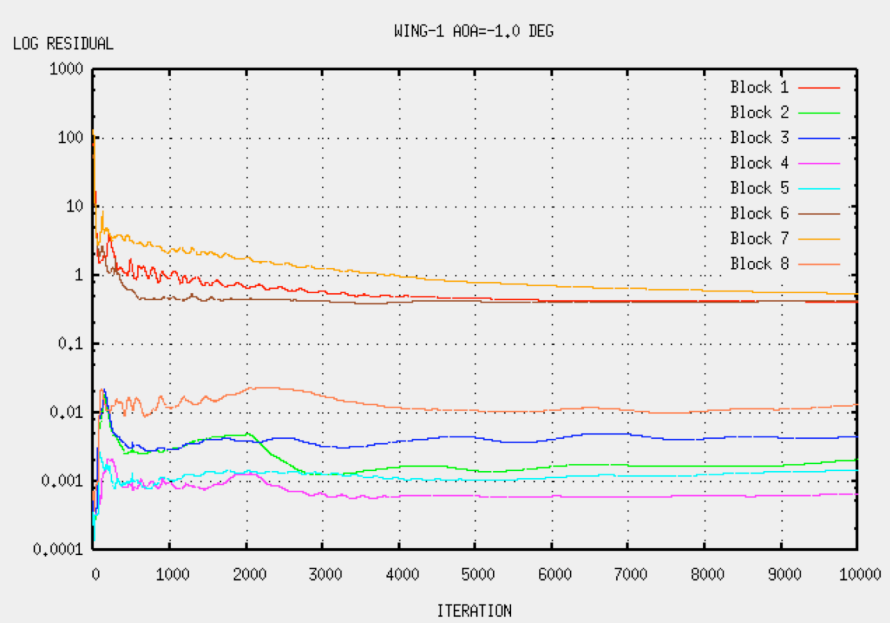

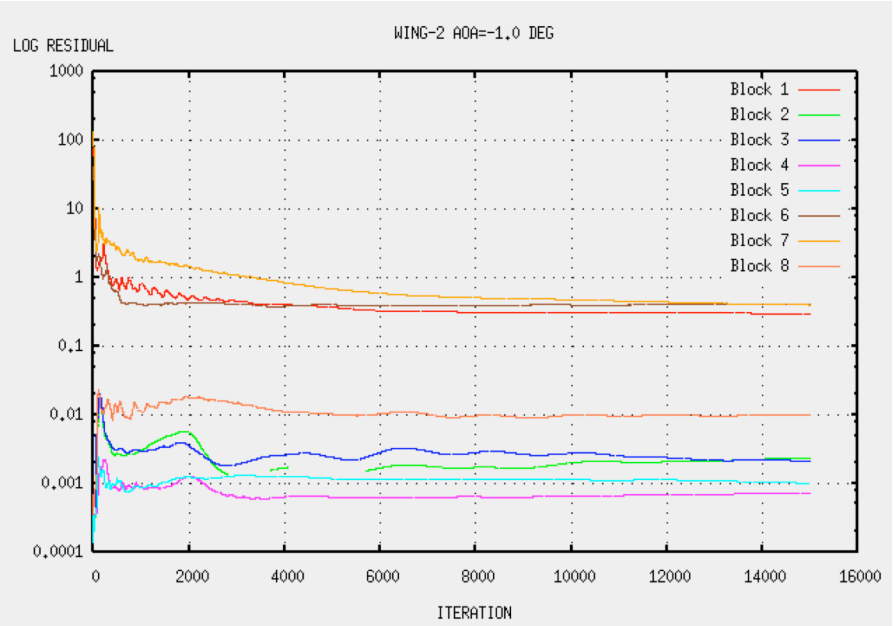

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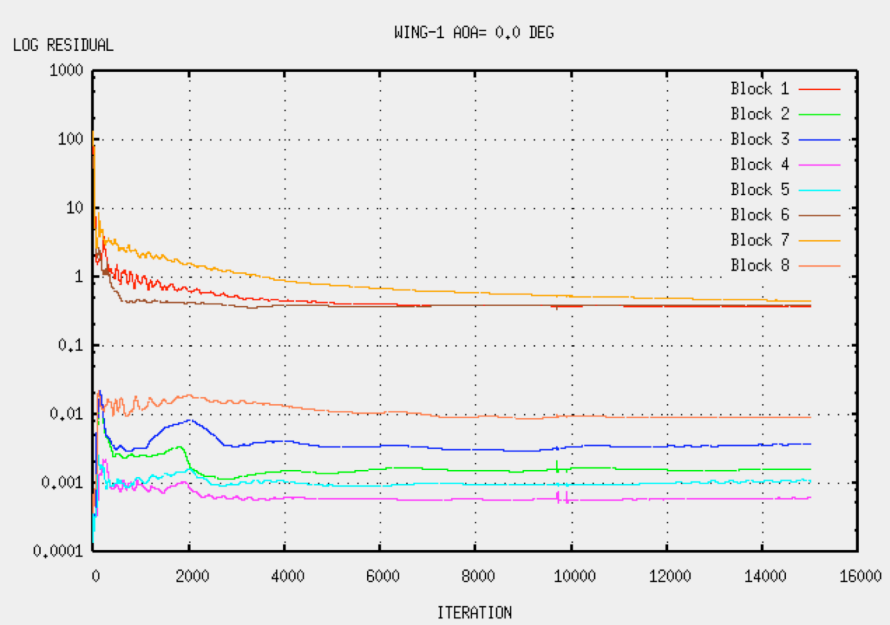

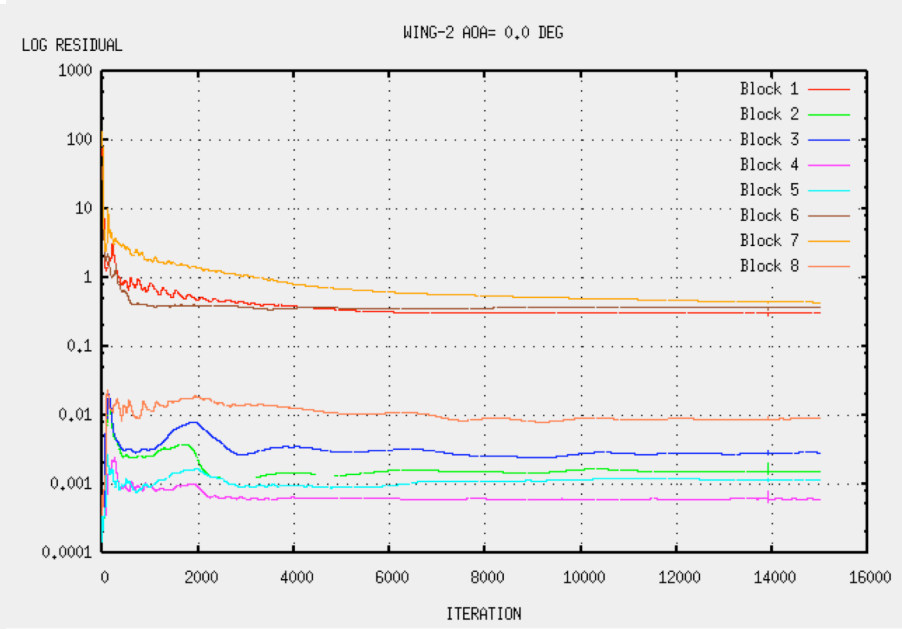

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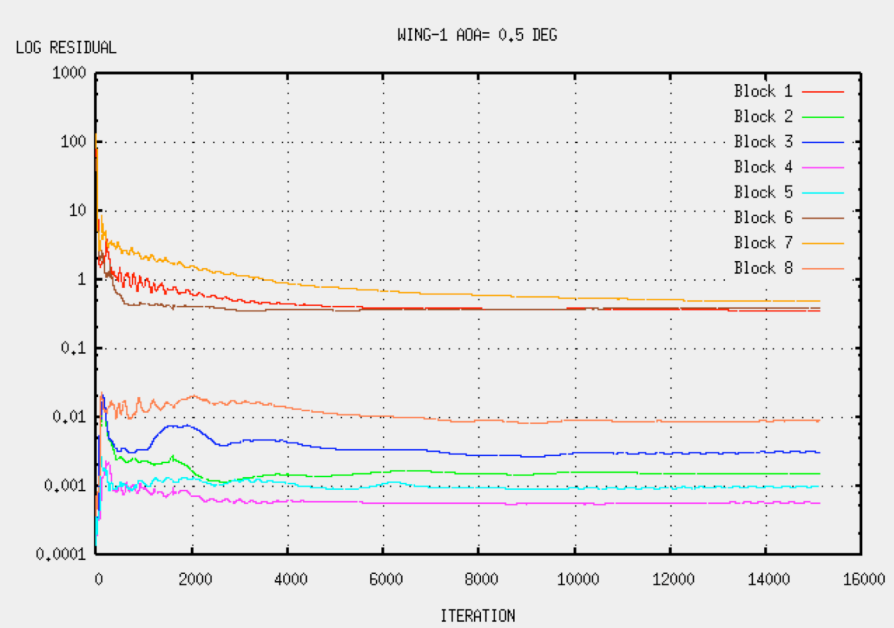

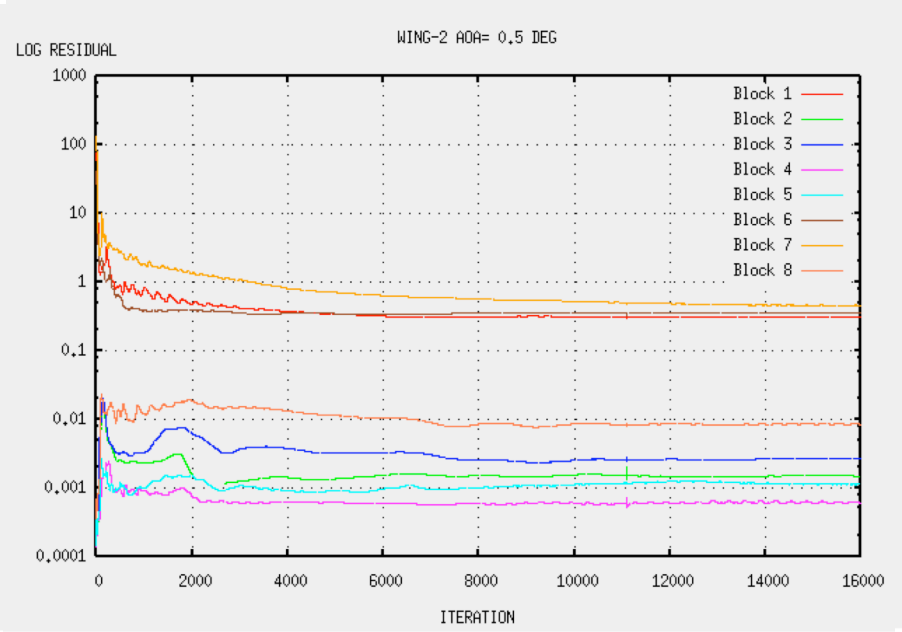

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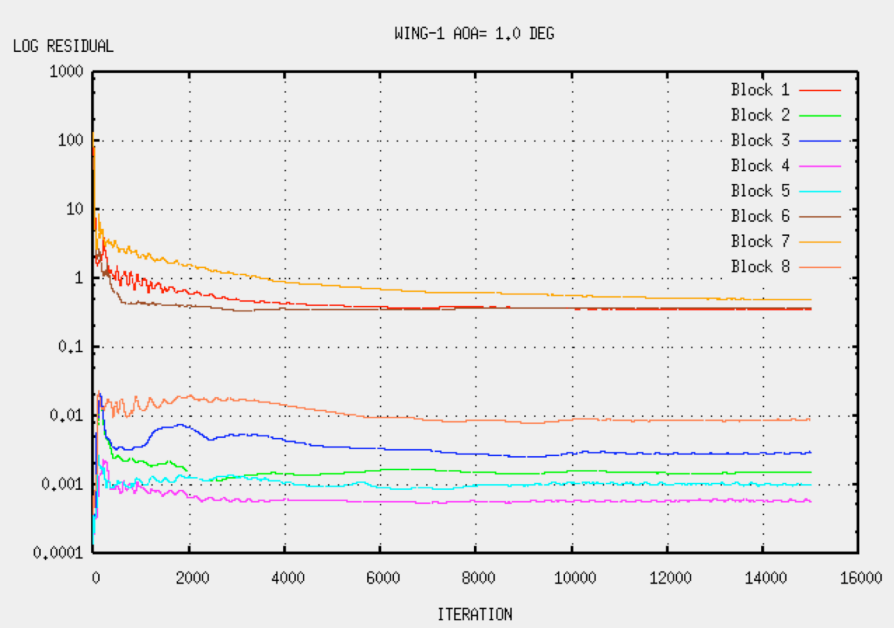

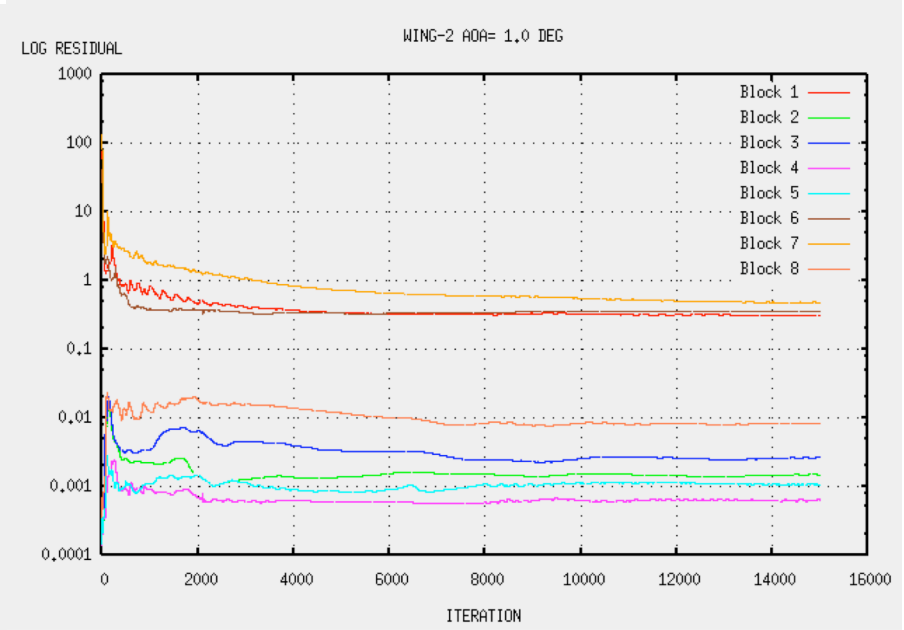

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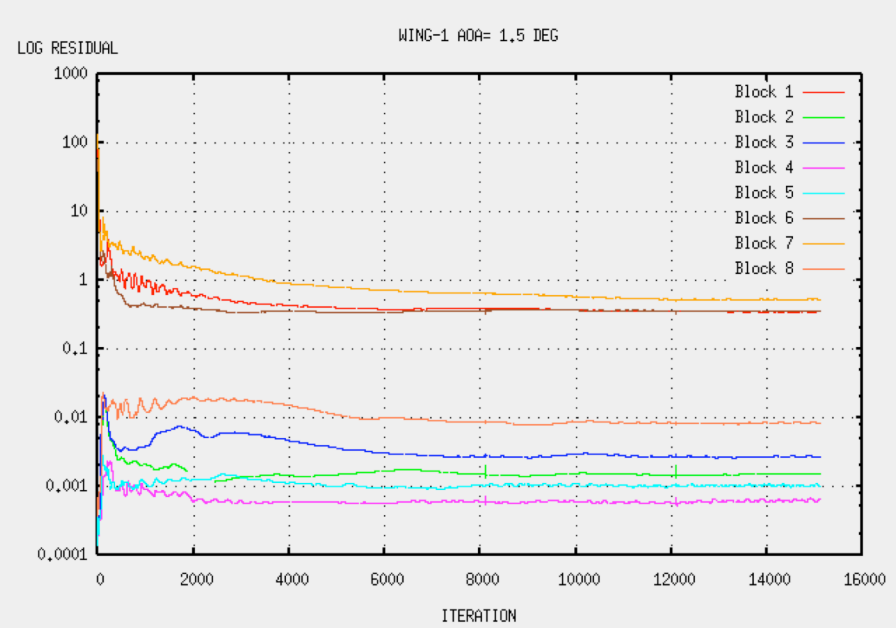

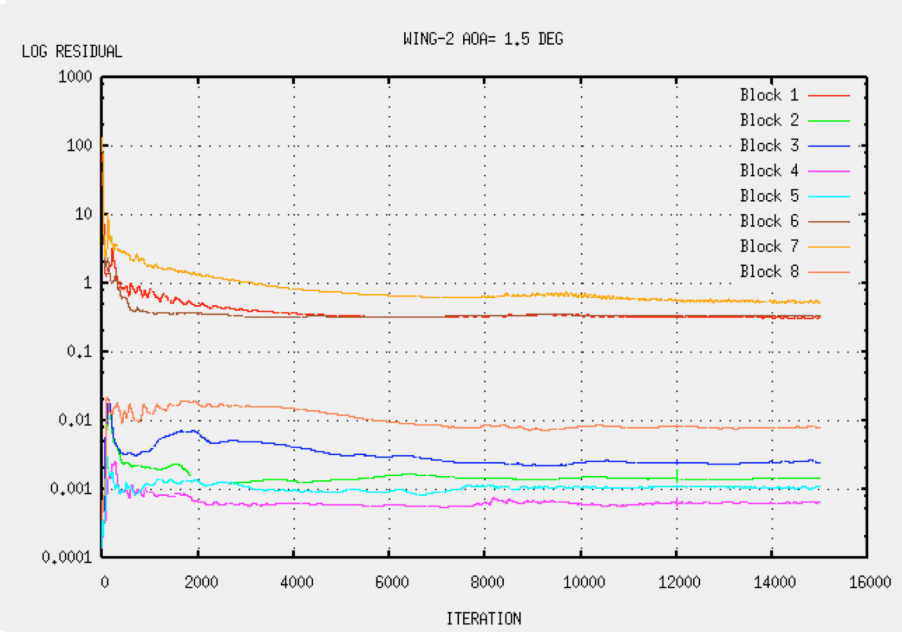

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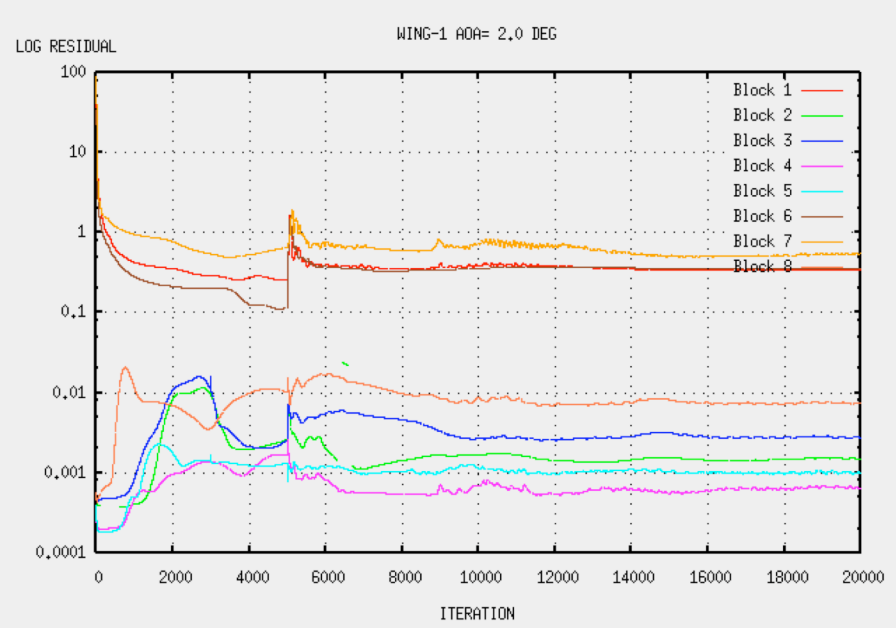

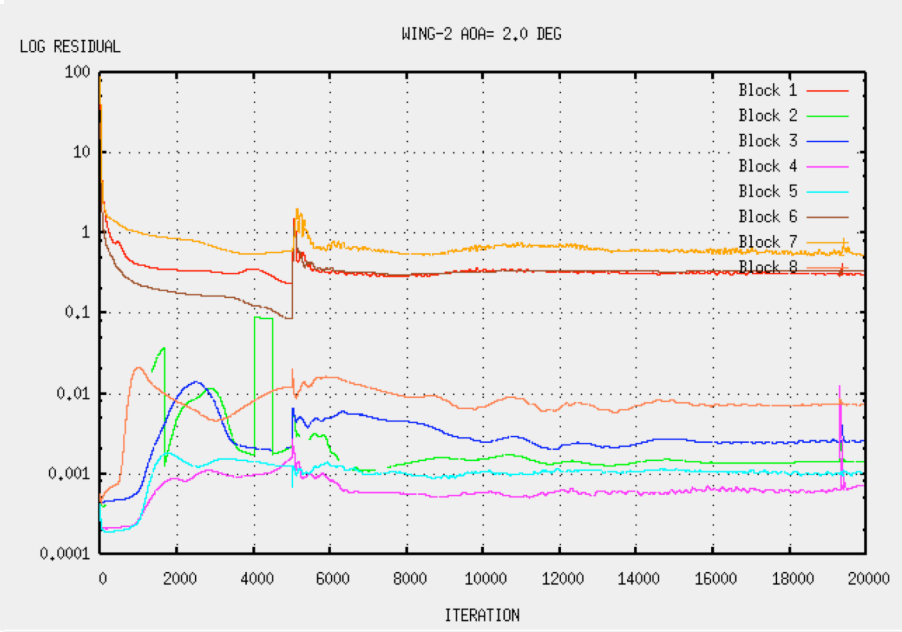

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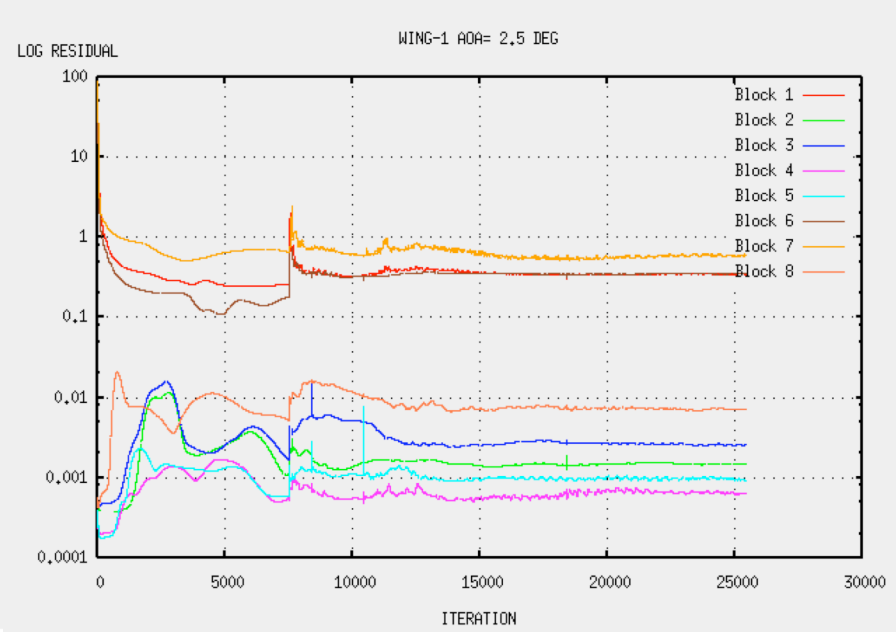

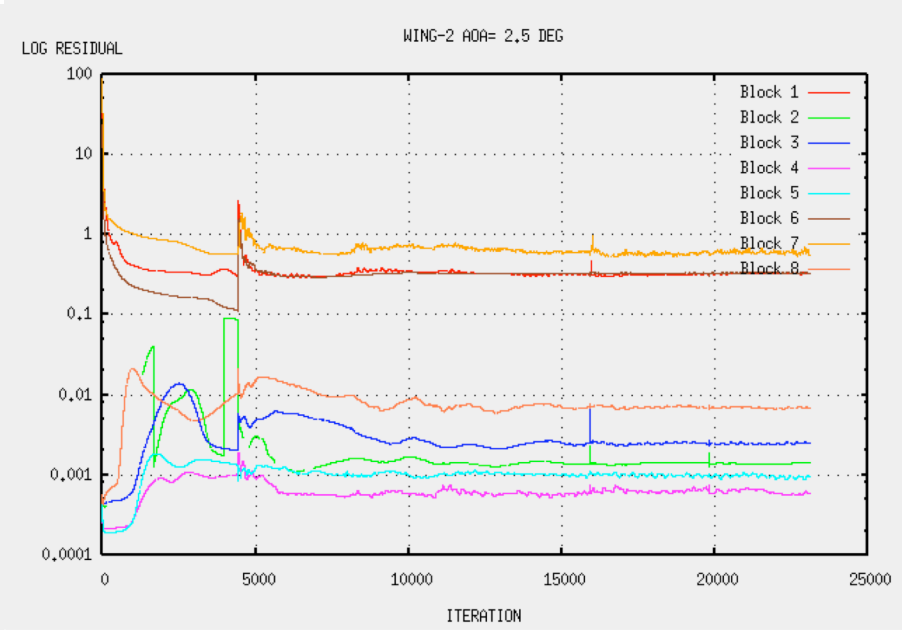

RESULTS (WING 1 & 2 SKIN FRICTION)

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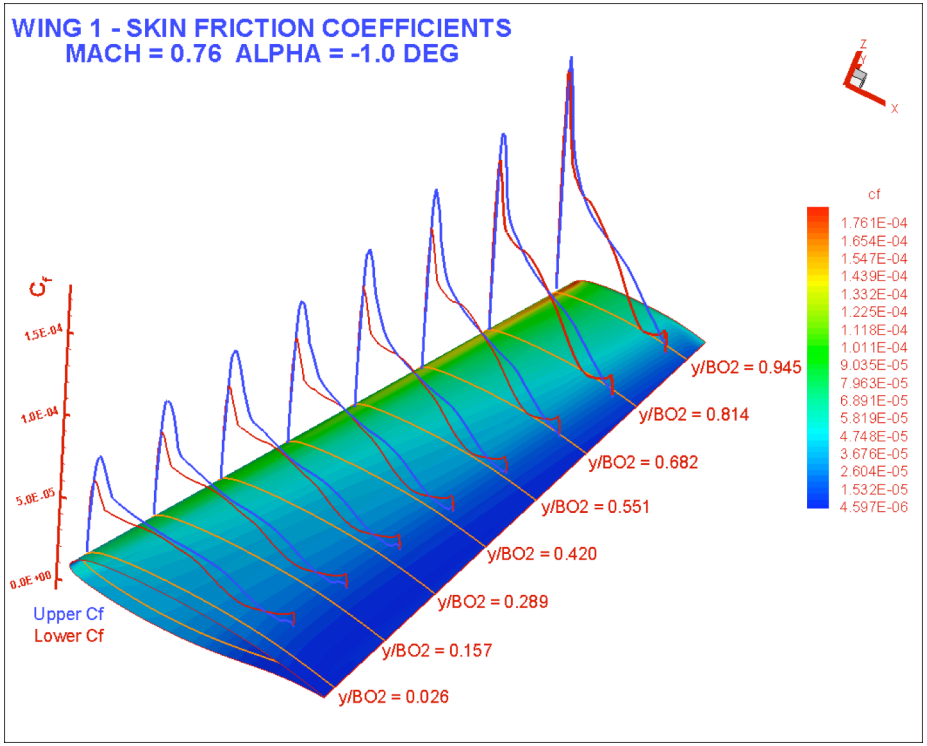

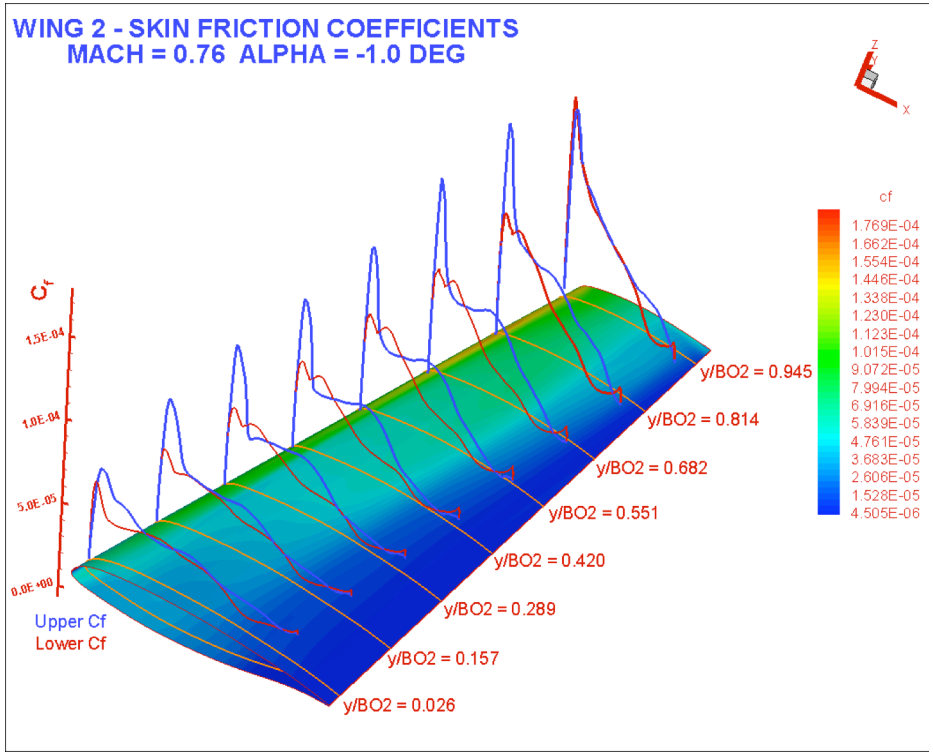

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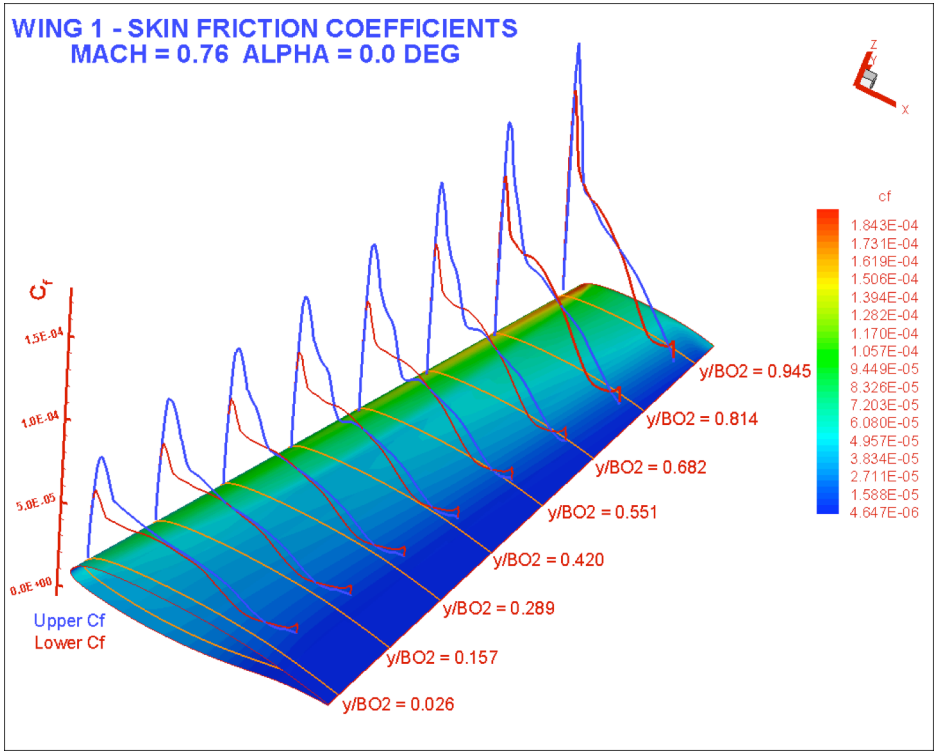

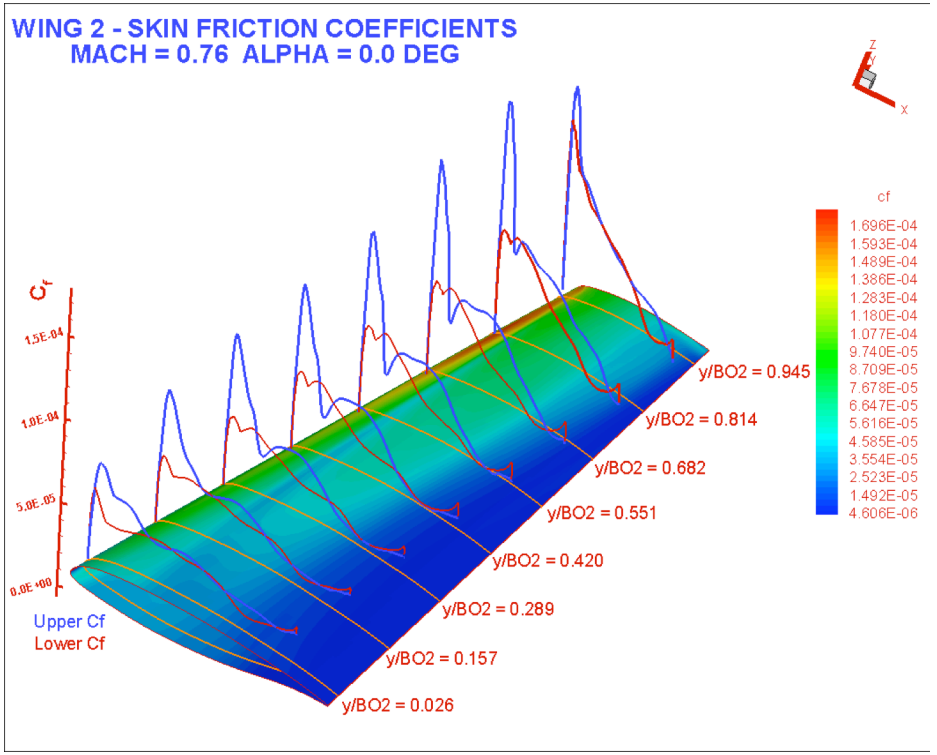

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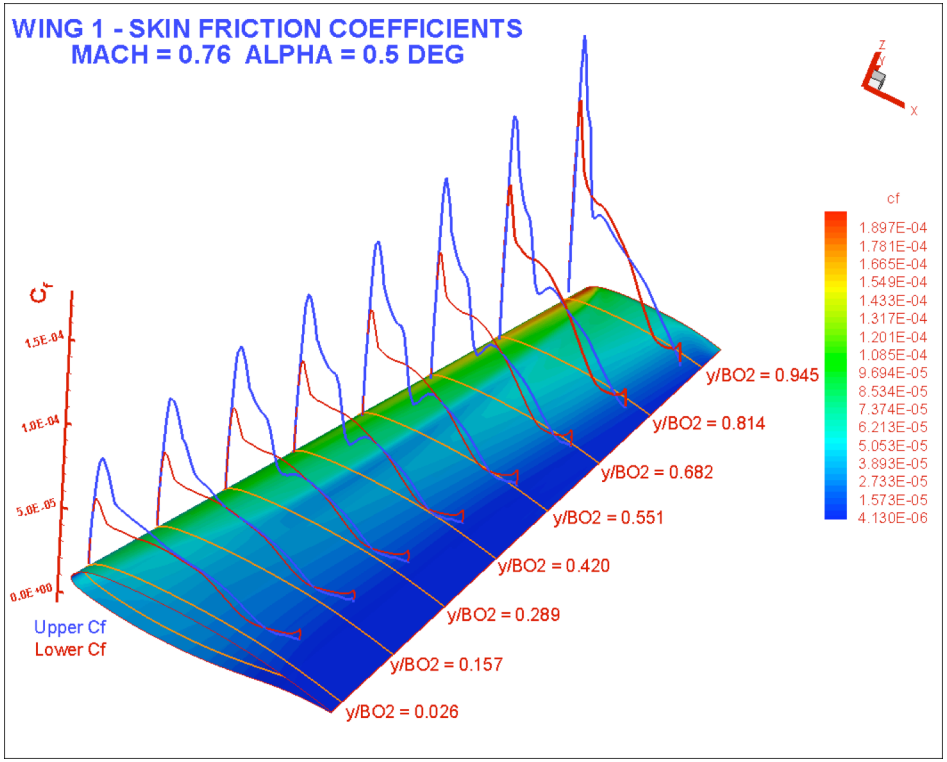

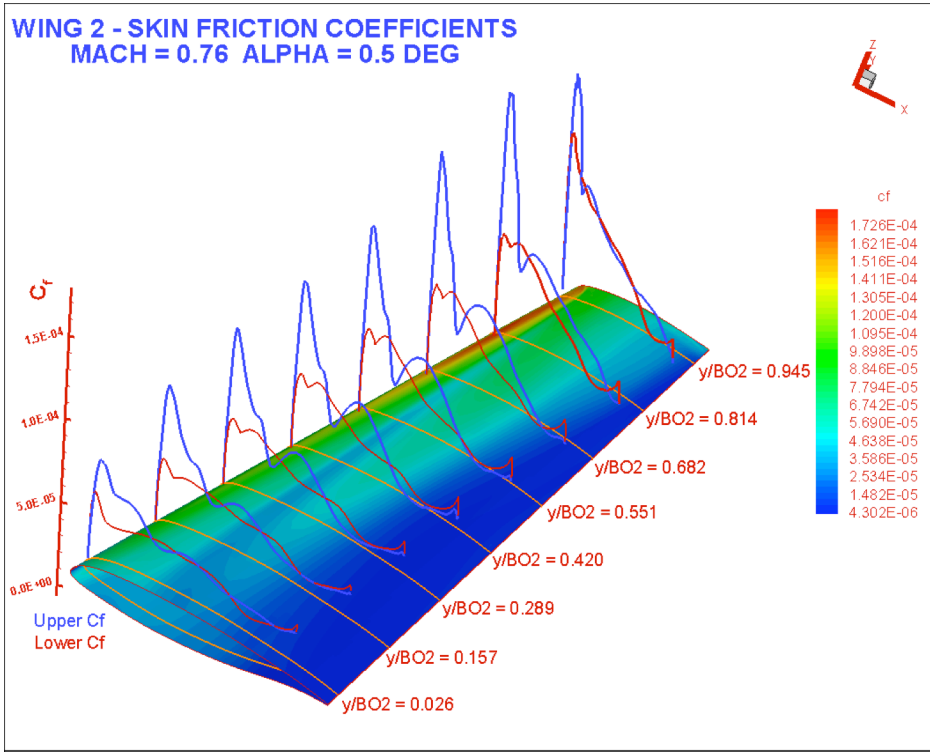

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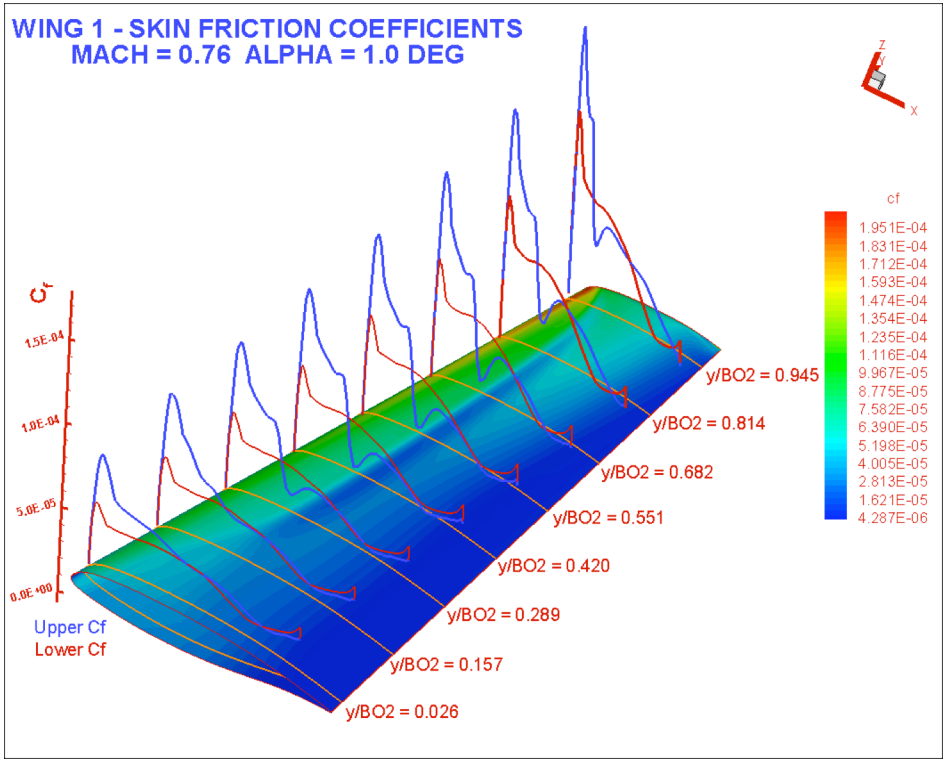

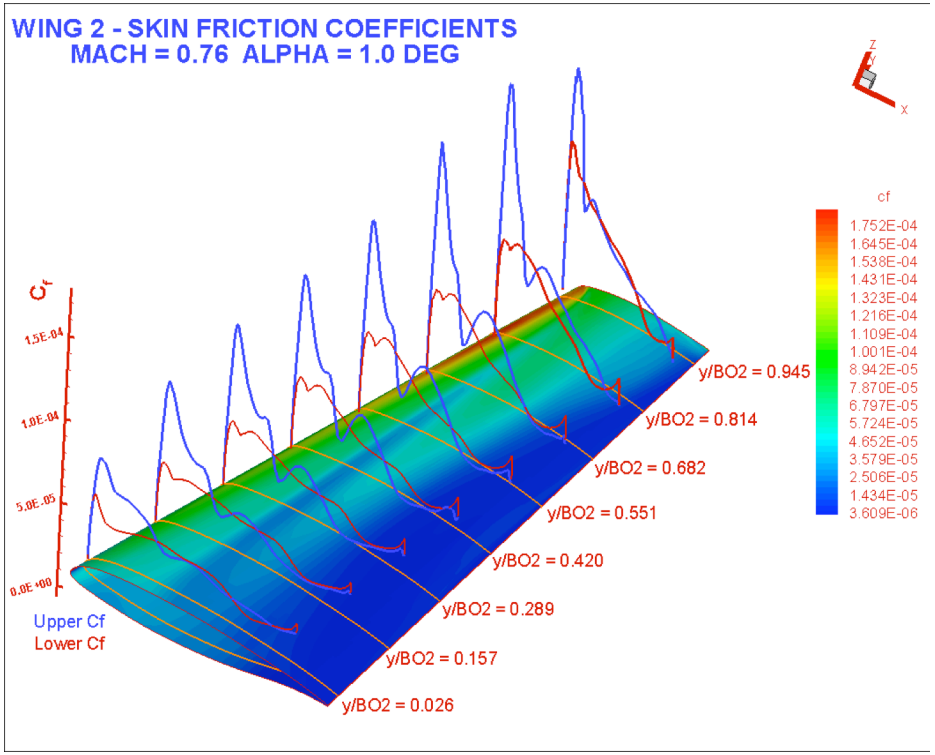

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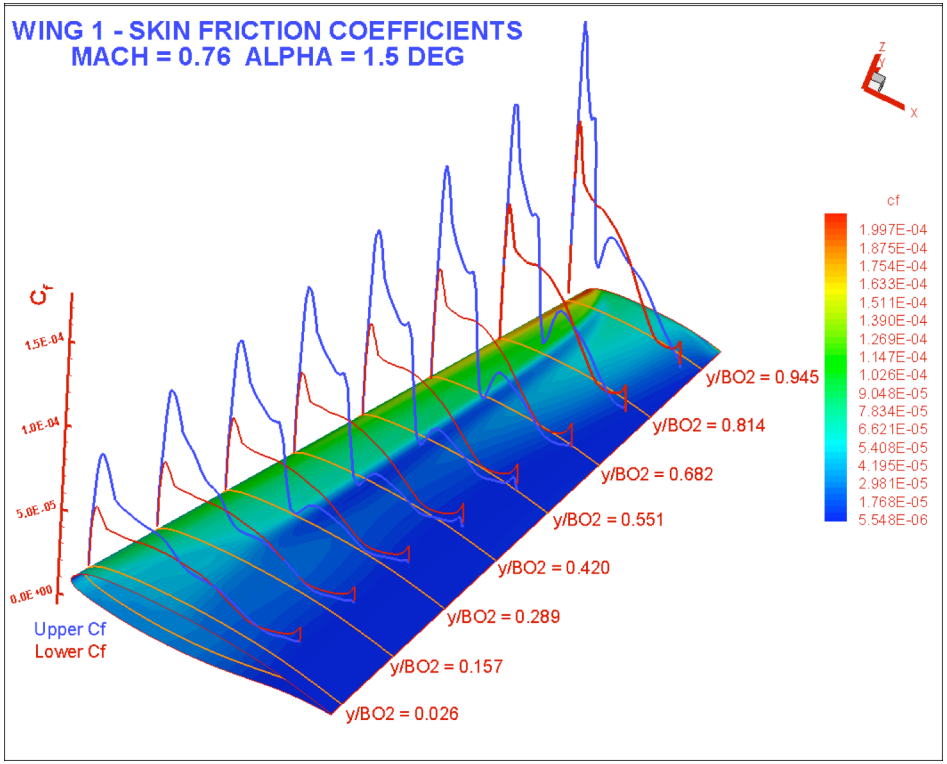

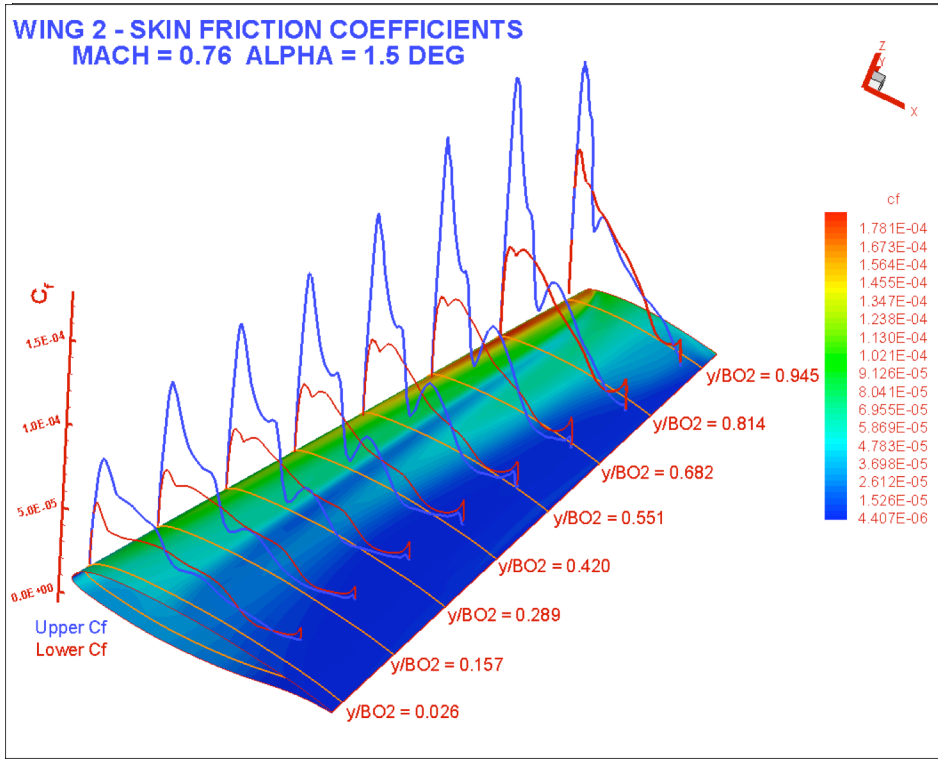

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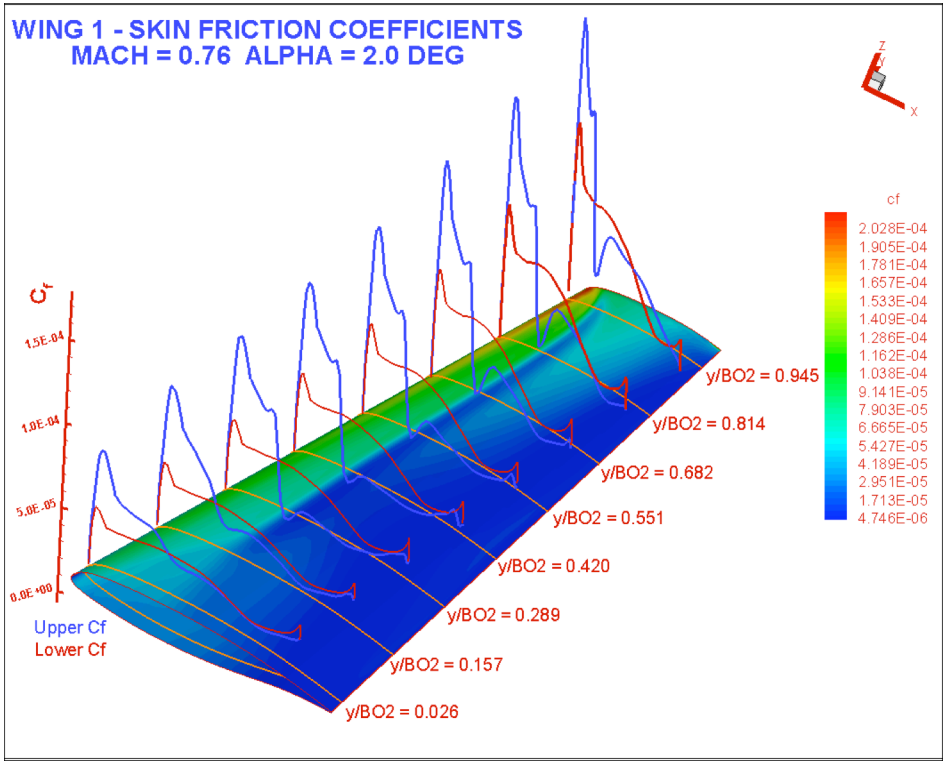

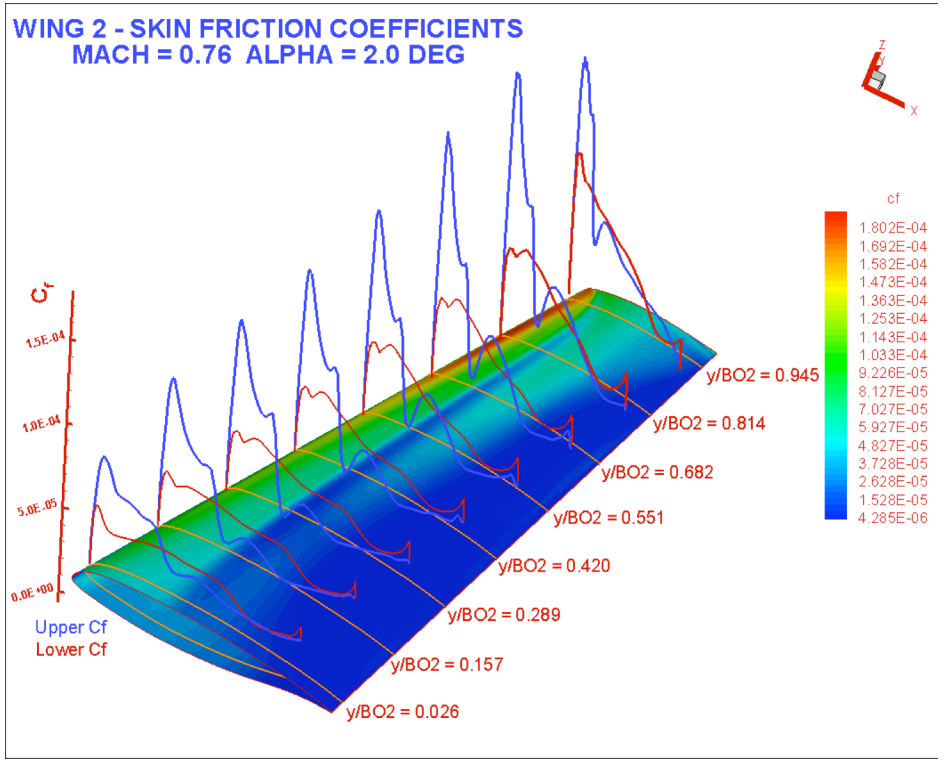

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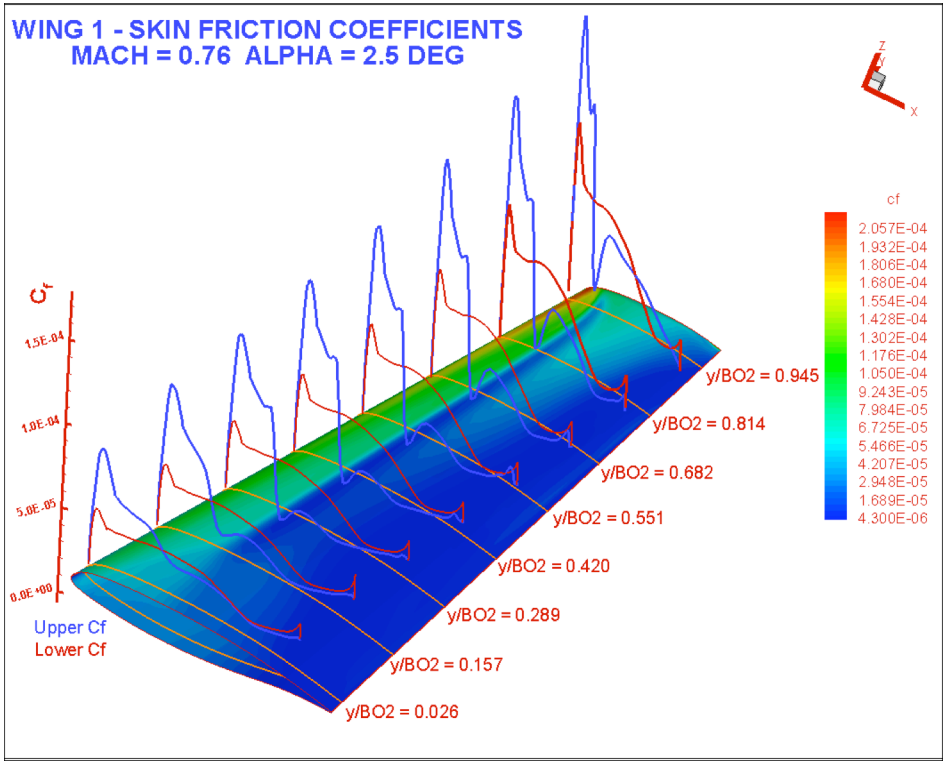

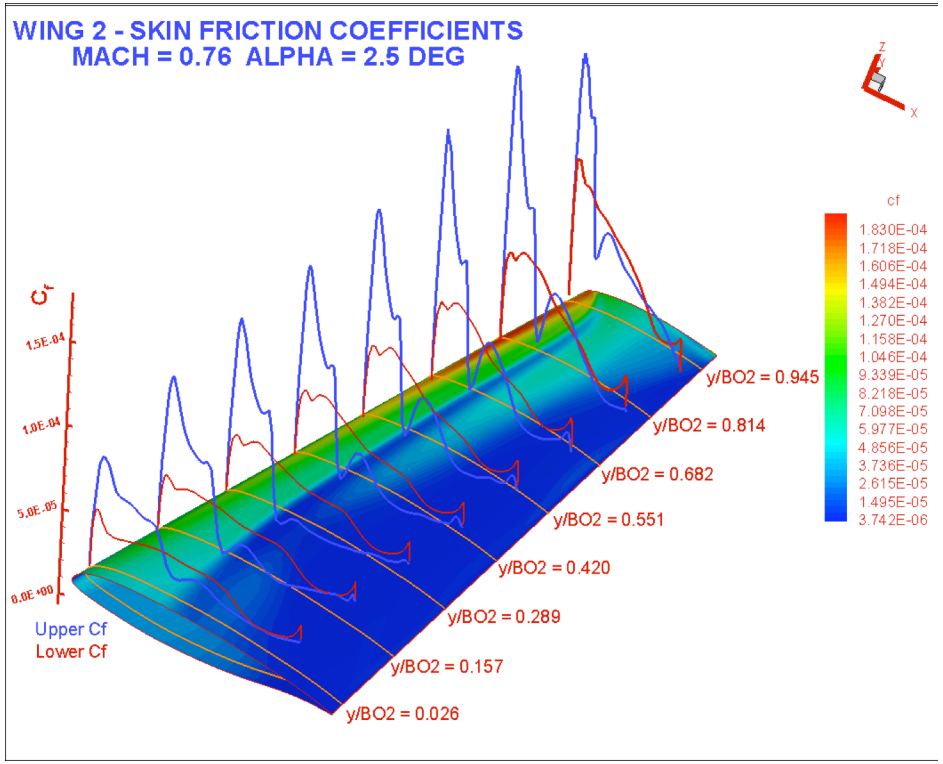

RESULTS (WING 1 & 2 SURFACE PRESSURE)

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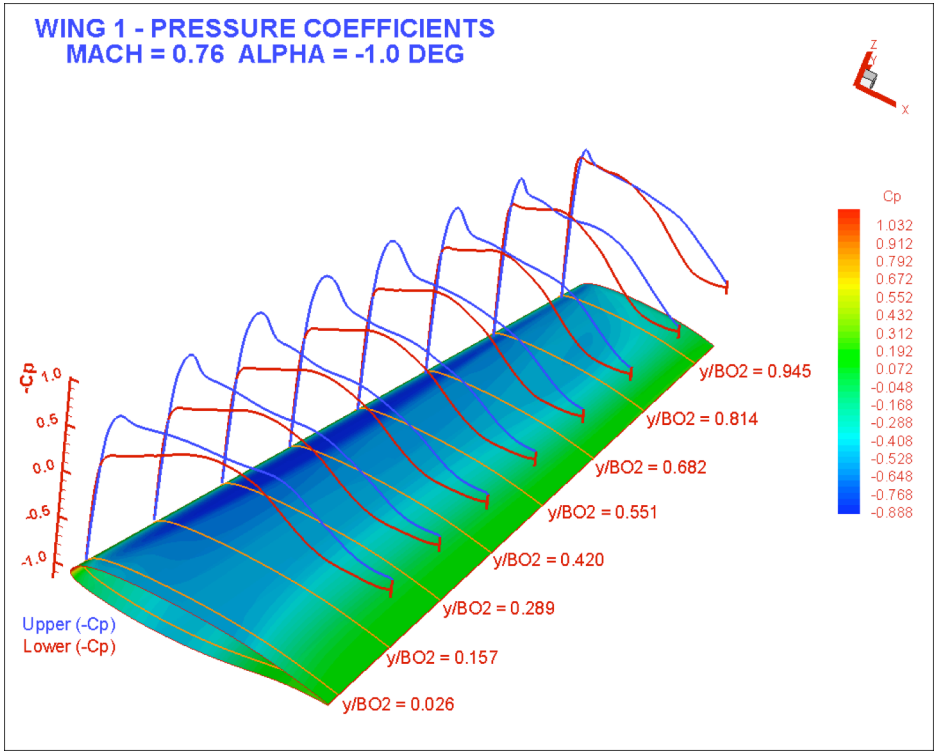

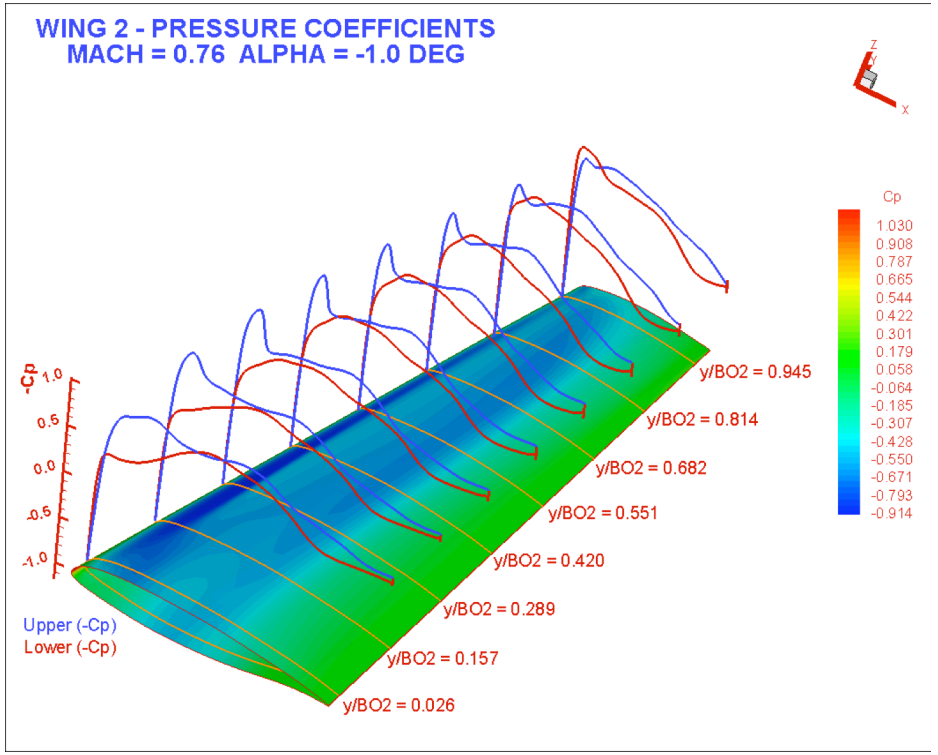

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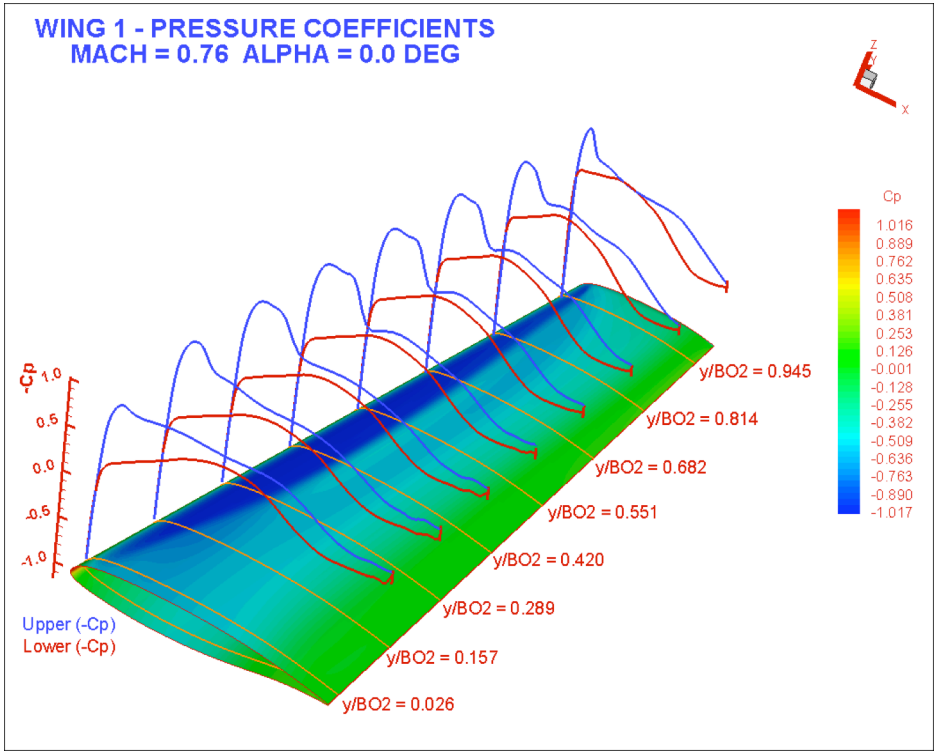

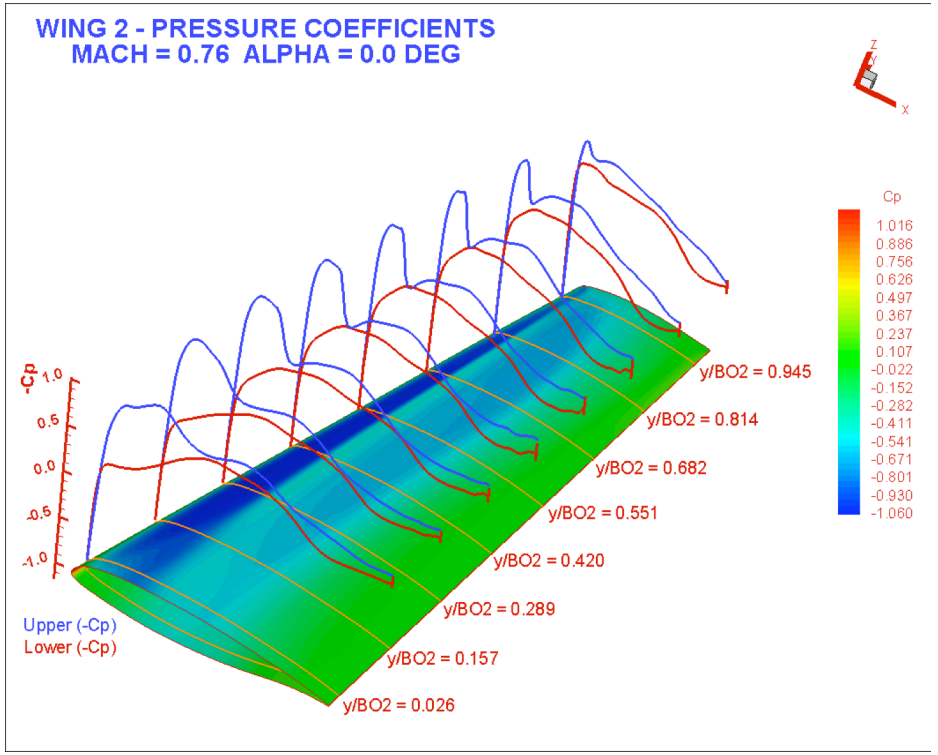

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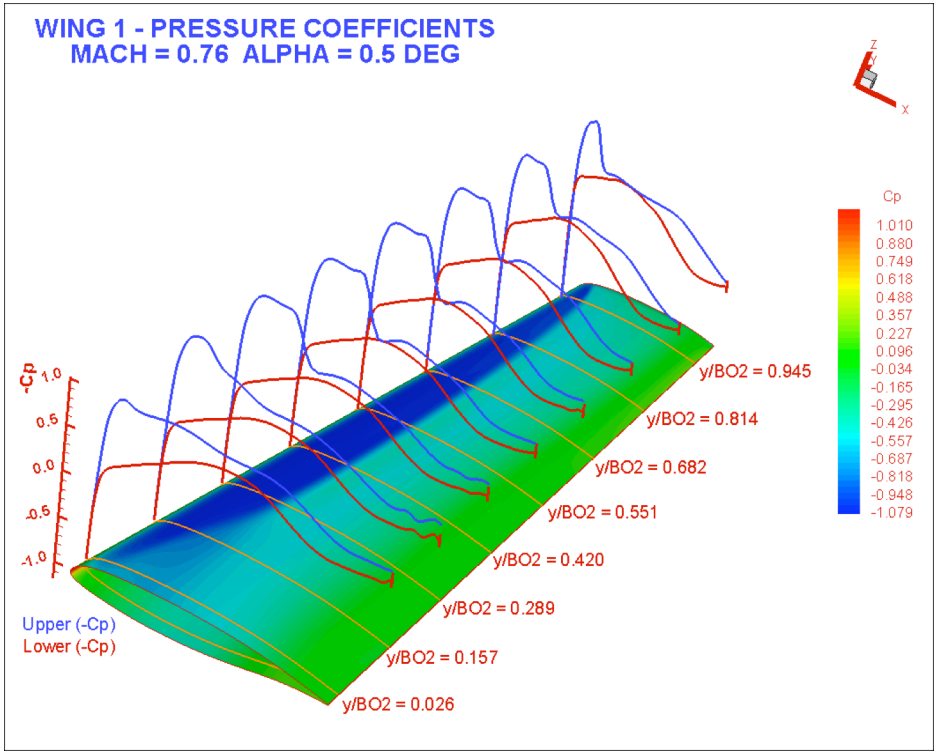

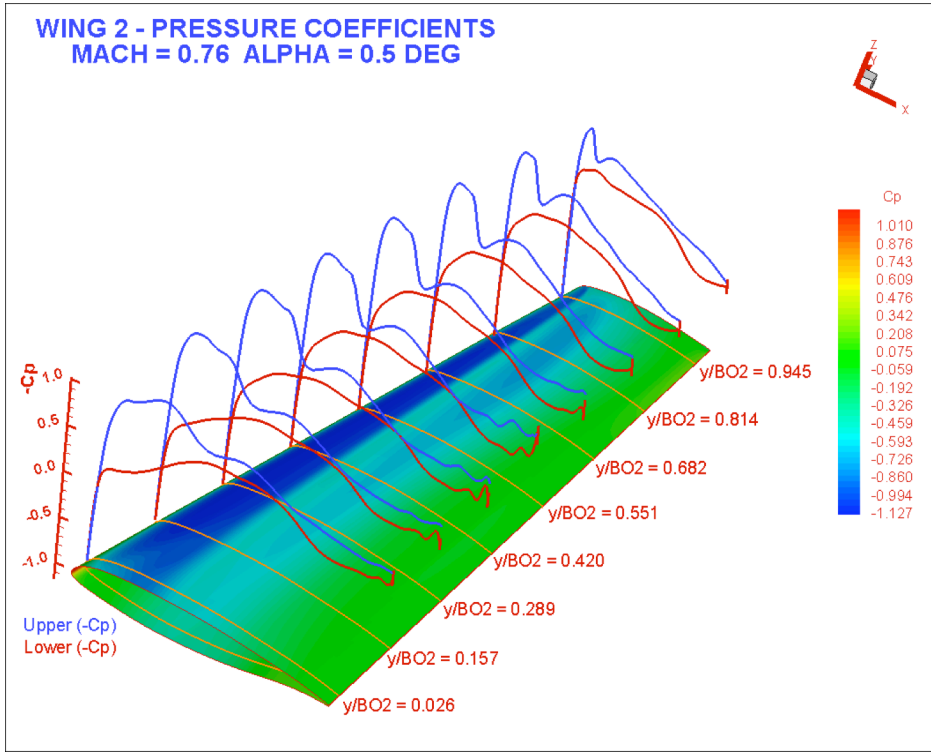

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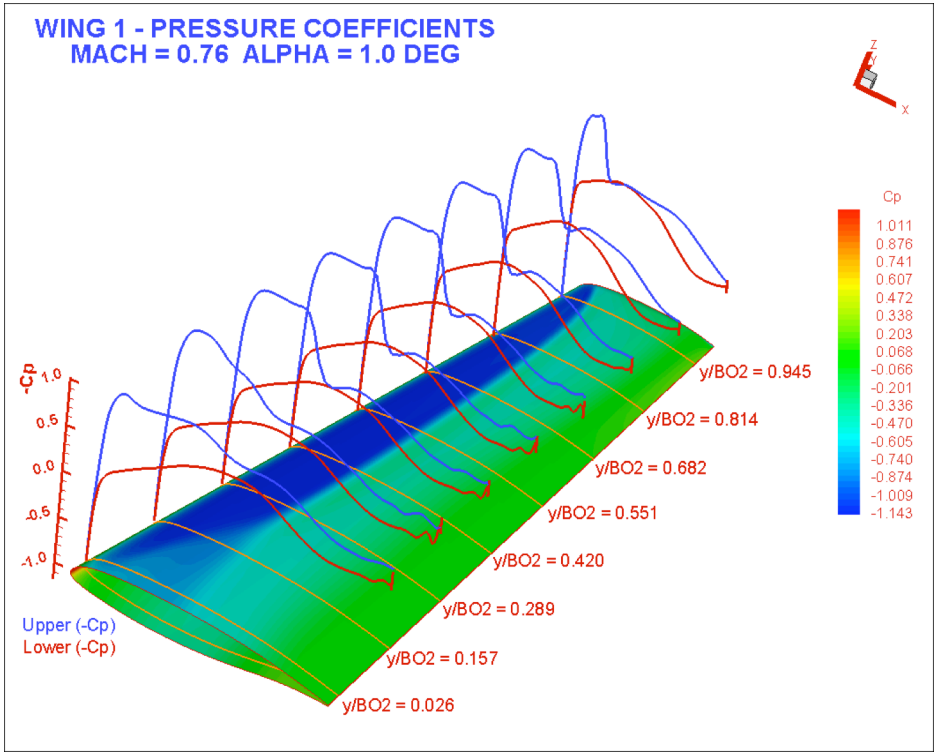

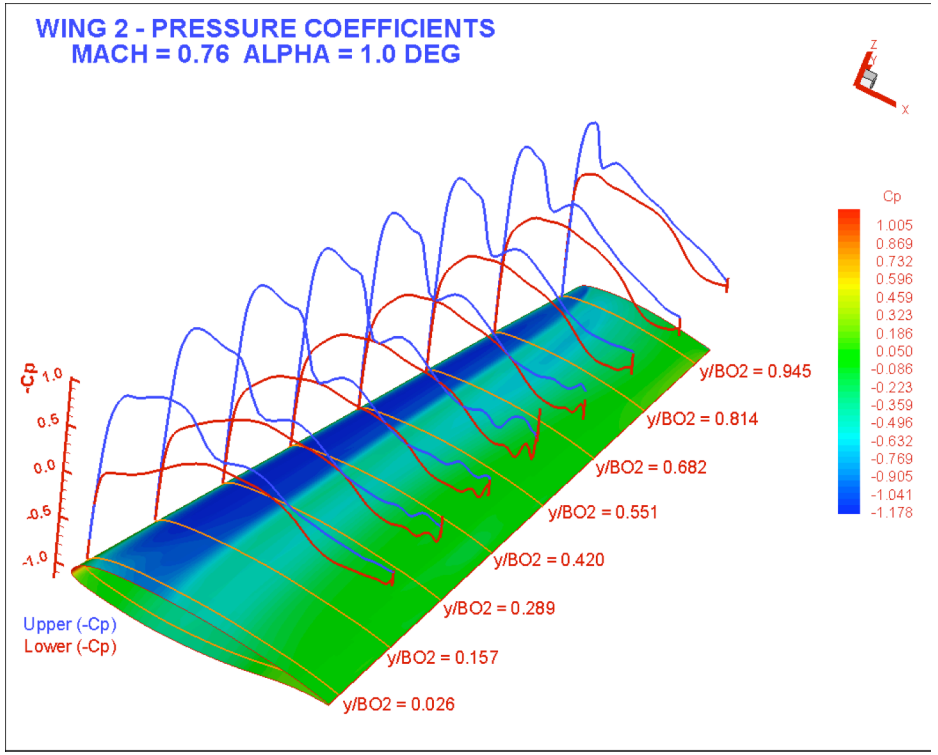

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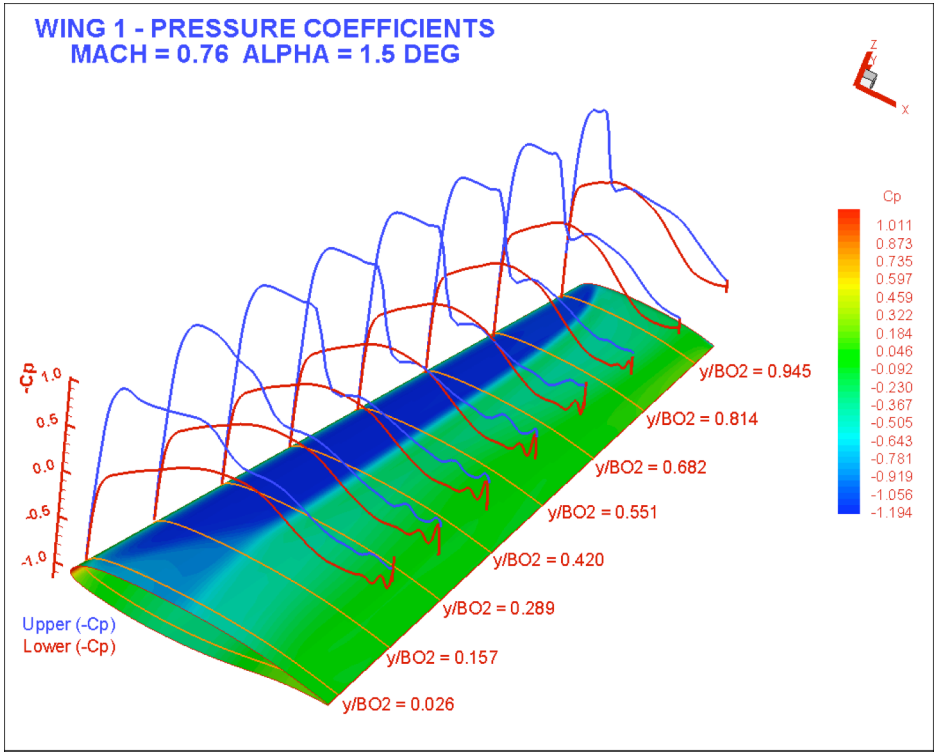

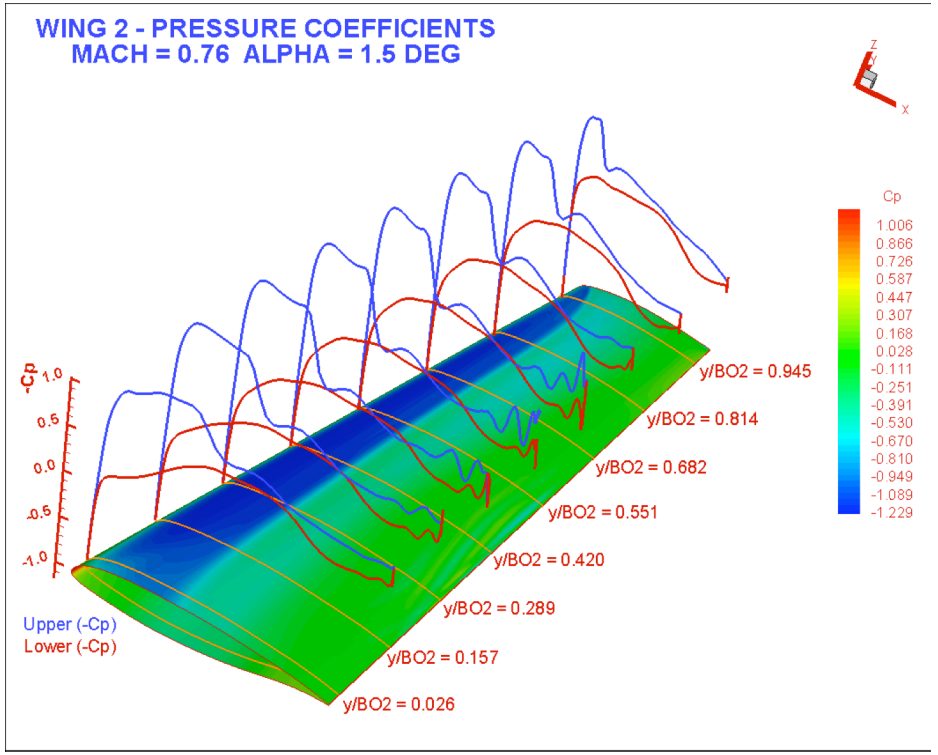

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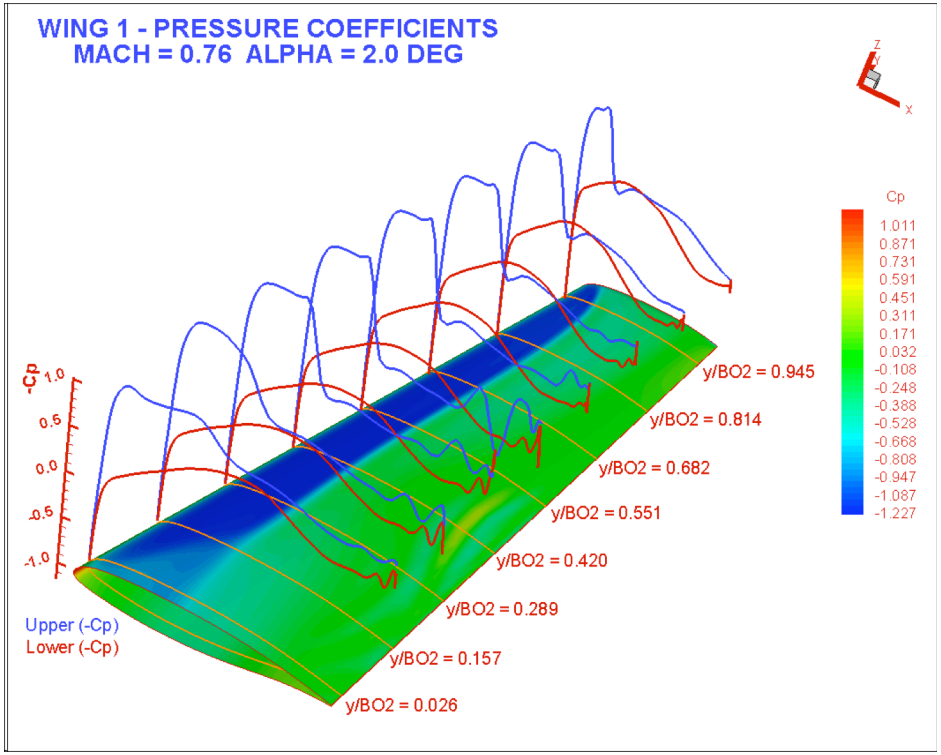

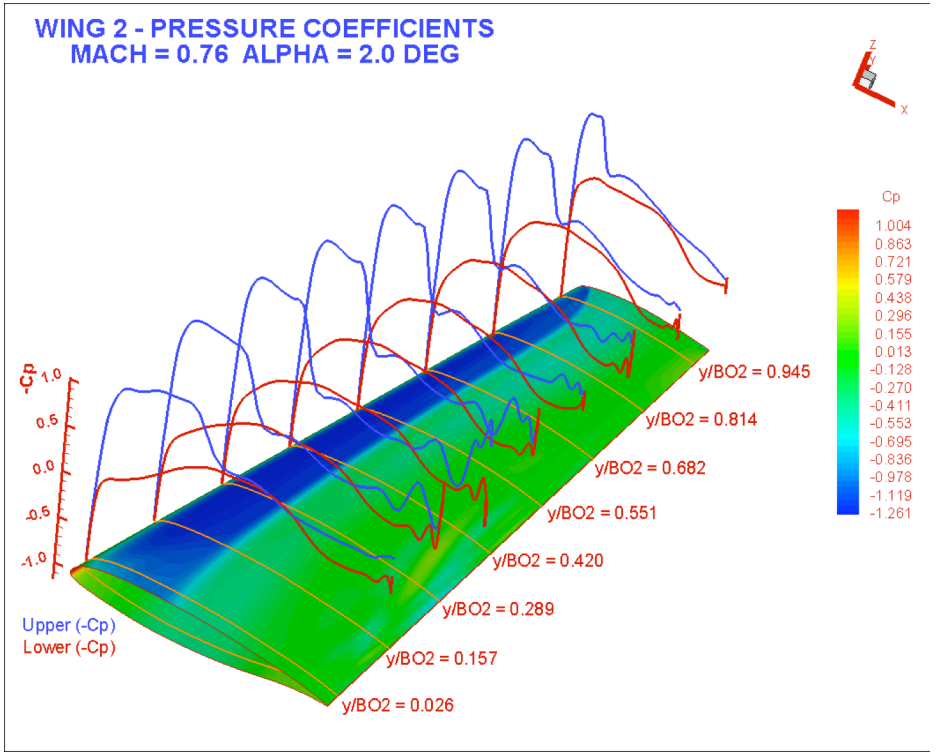

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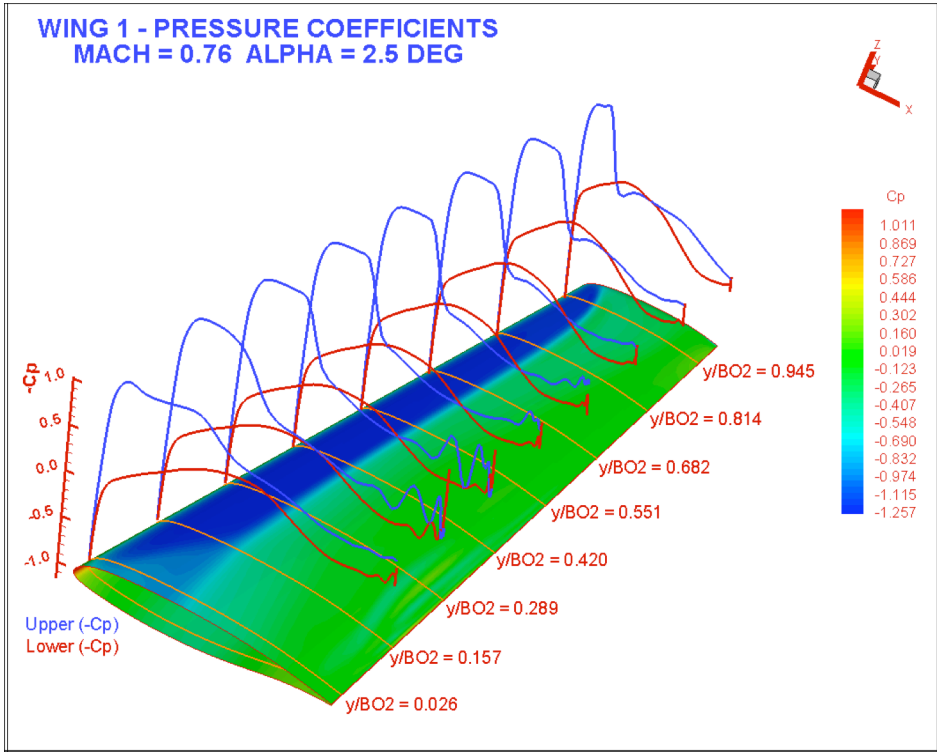

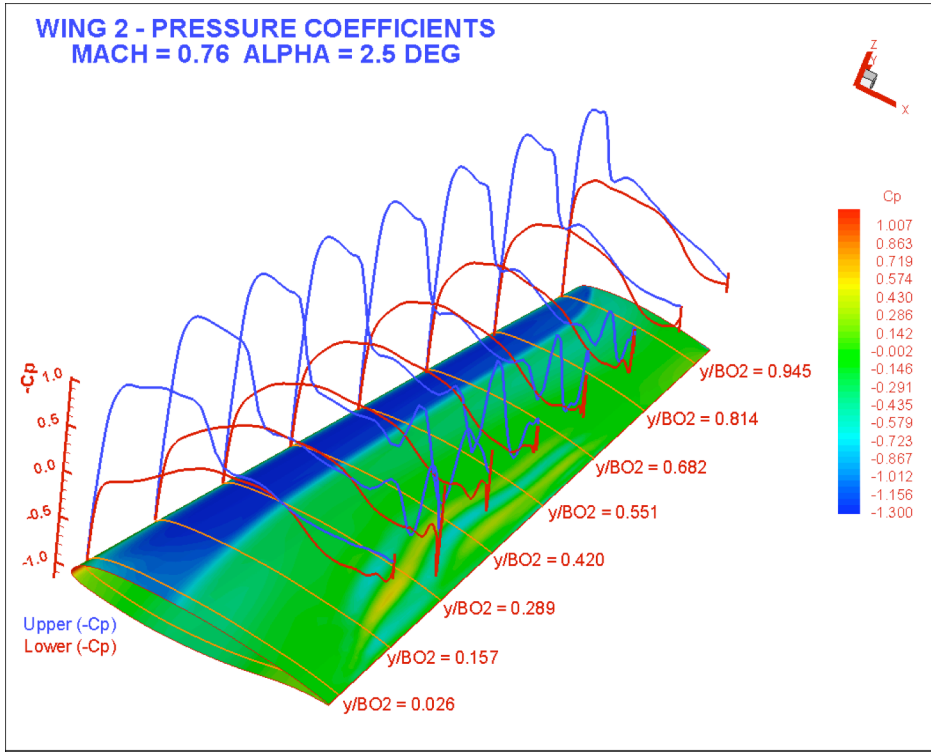

DETAILED FLOW ANALYSIS

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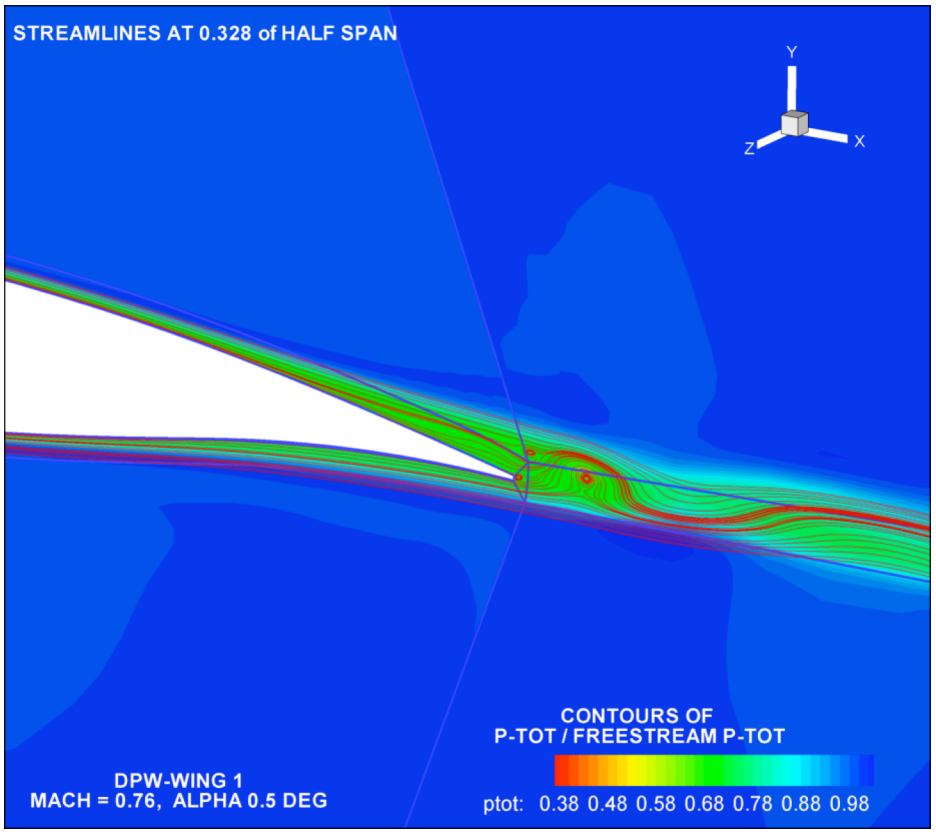
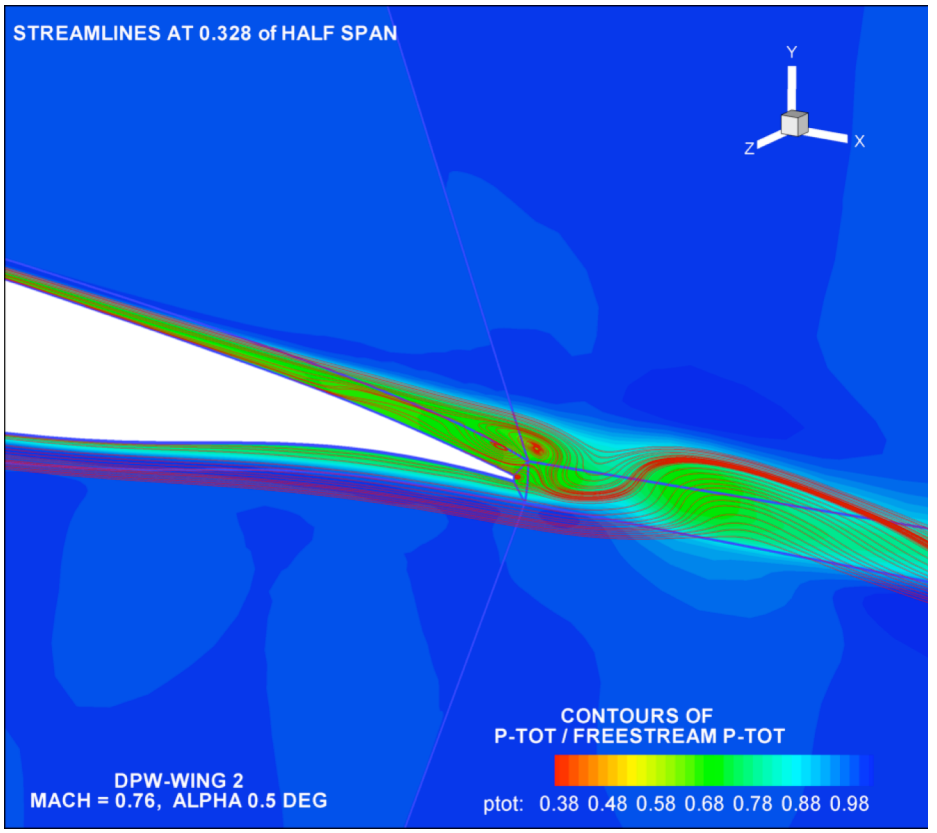
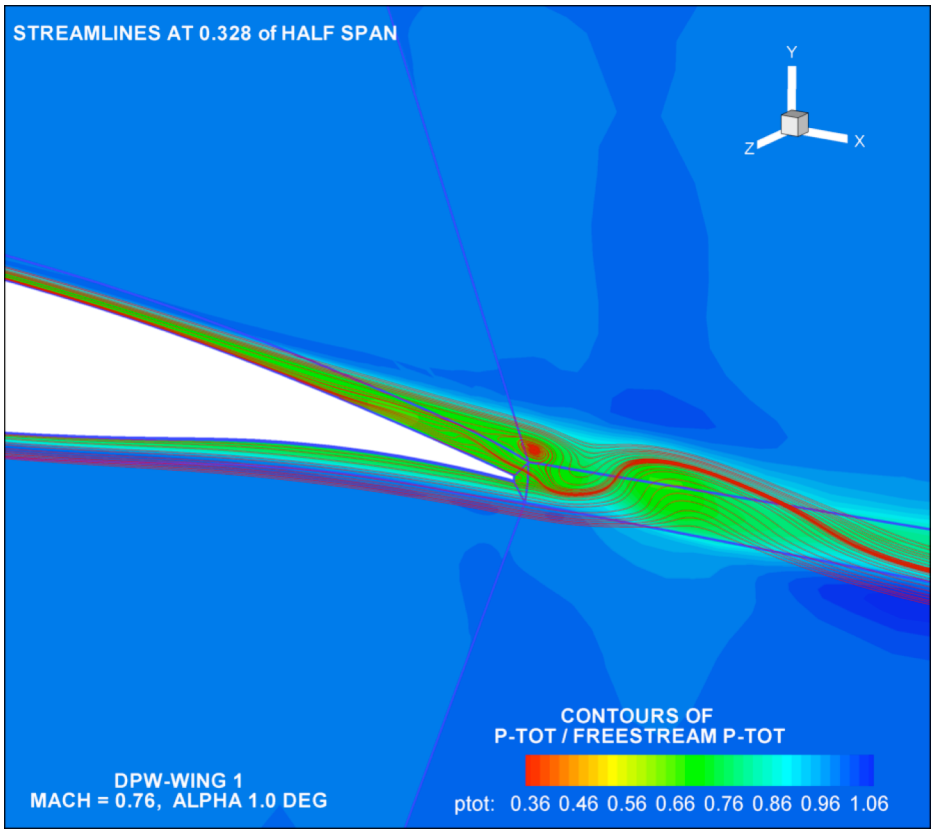
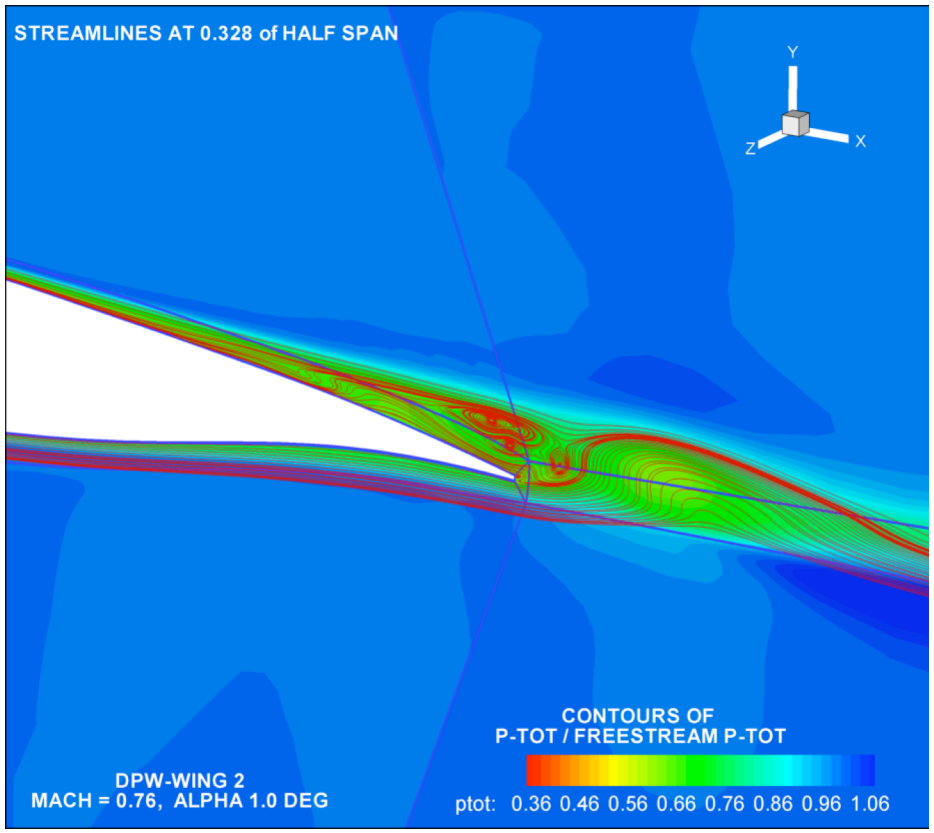




Streamlines and Total Pressure Contours

DETAILED FLOW ANALYSIS





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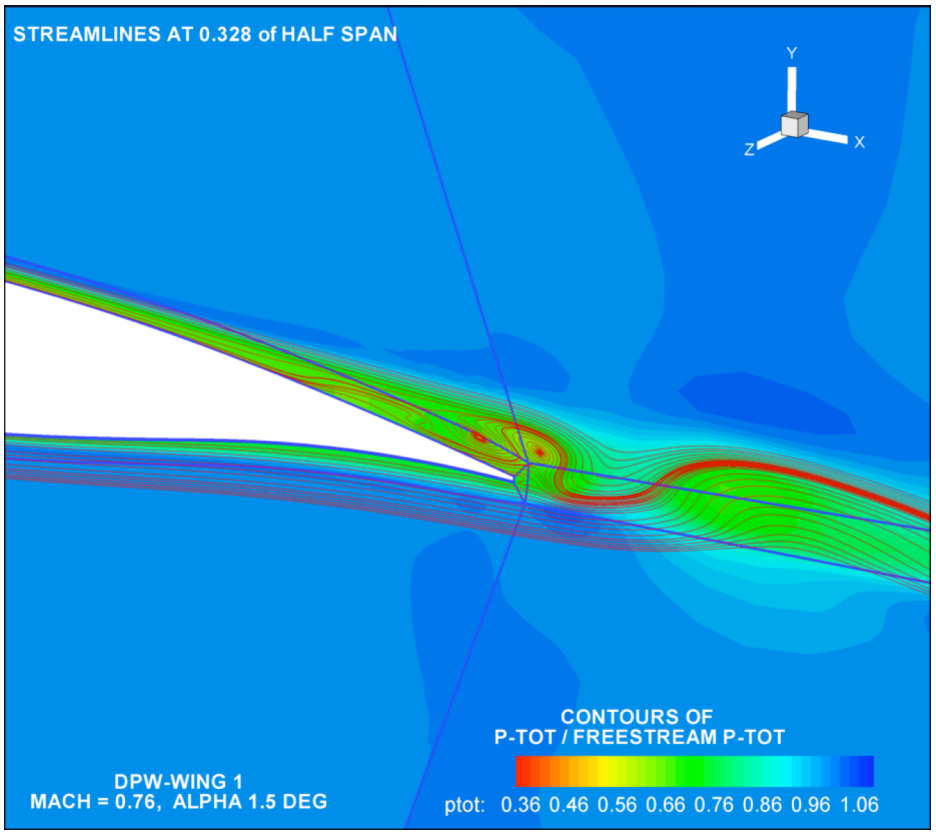
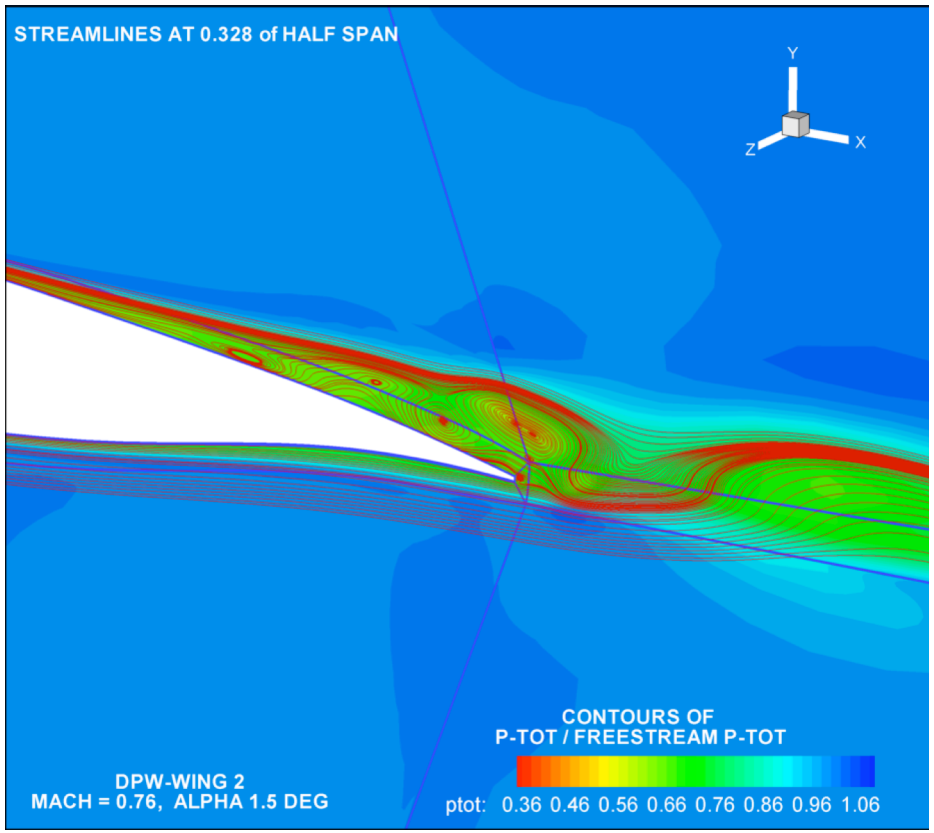
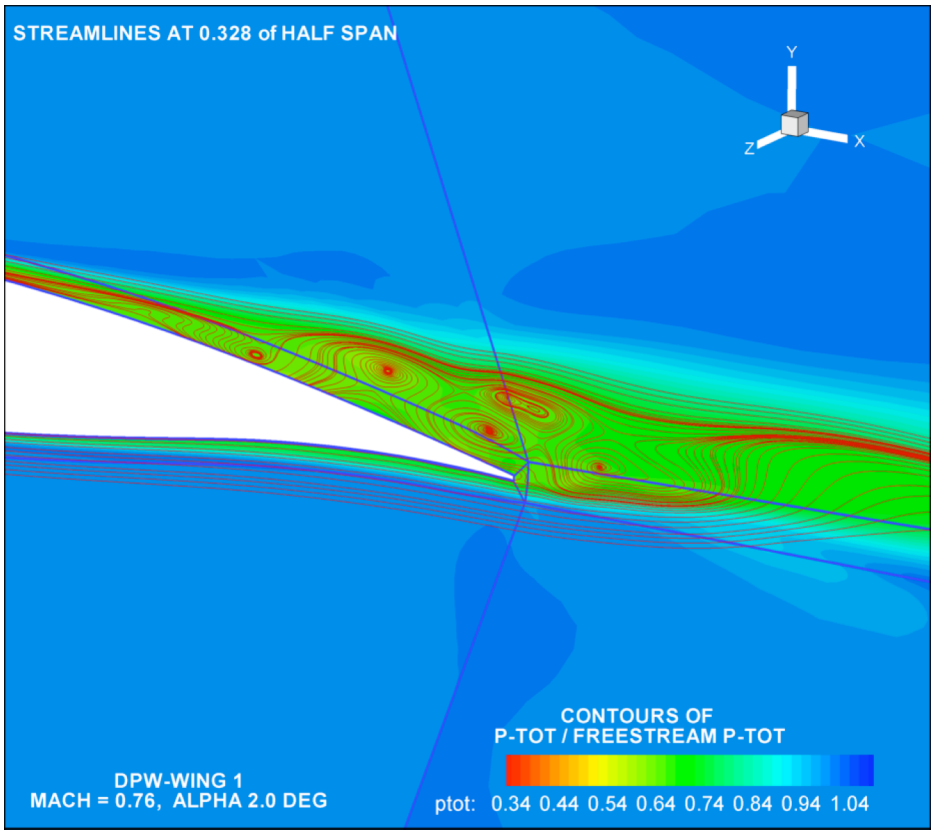
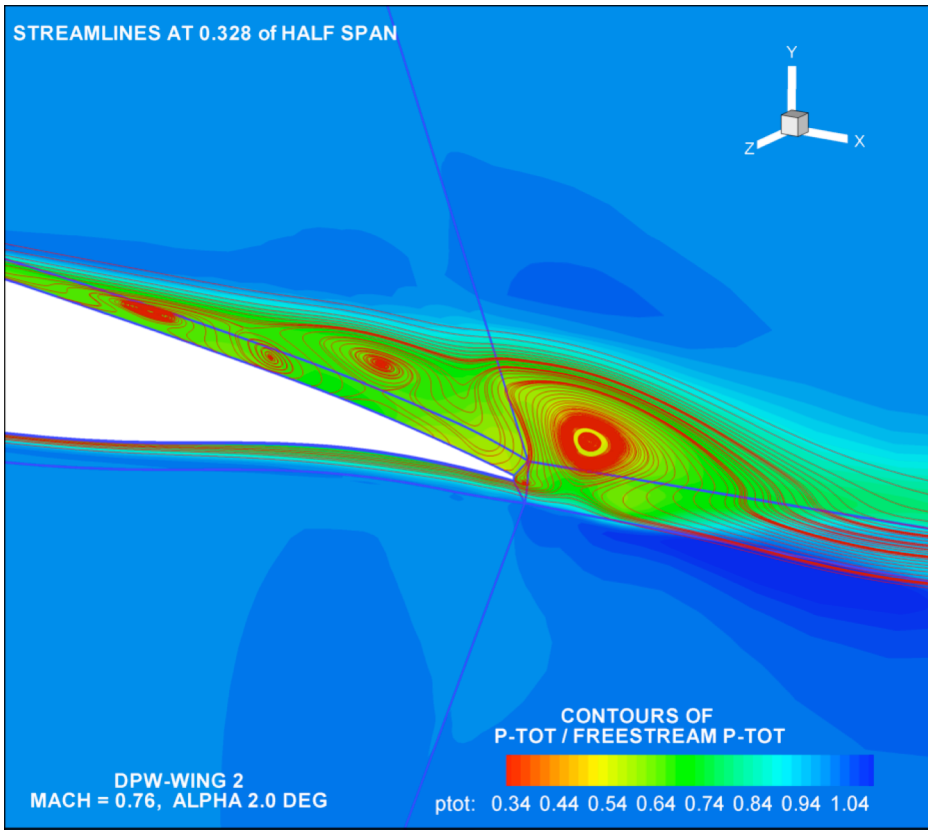




Streamlines and Total Pressure Contours

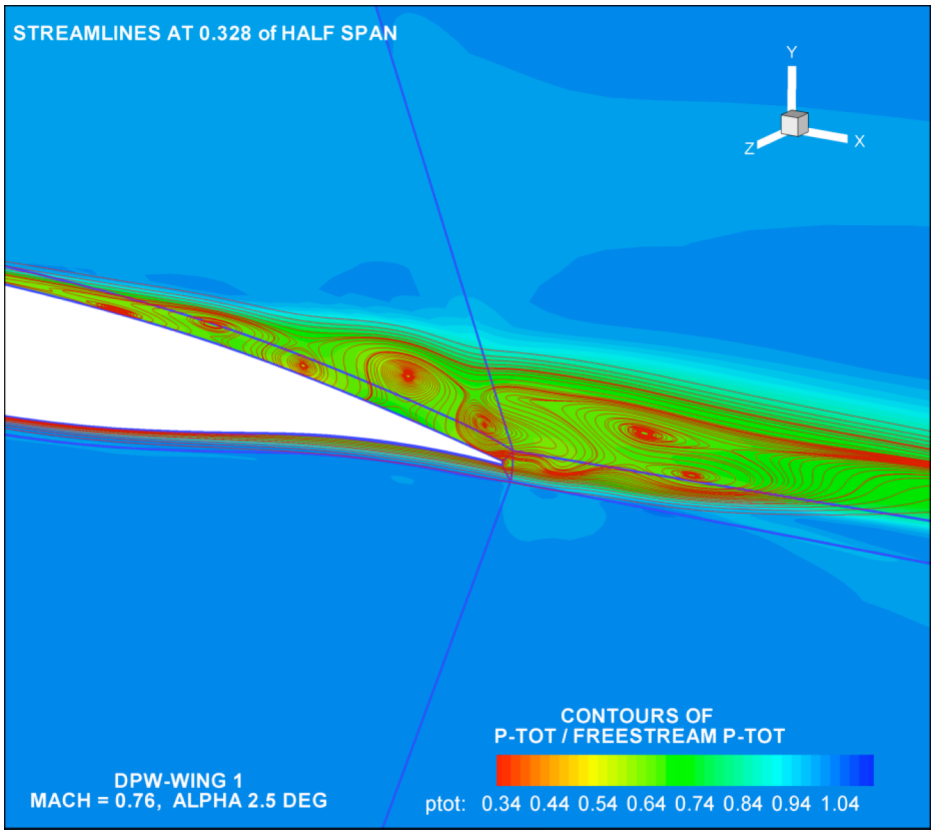
DETAILED FLOW ANALYSIS

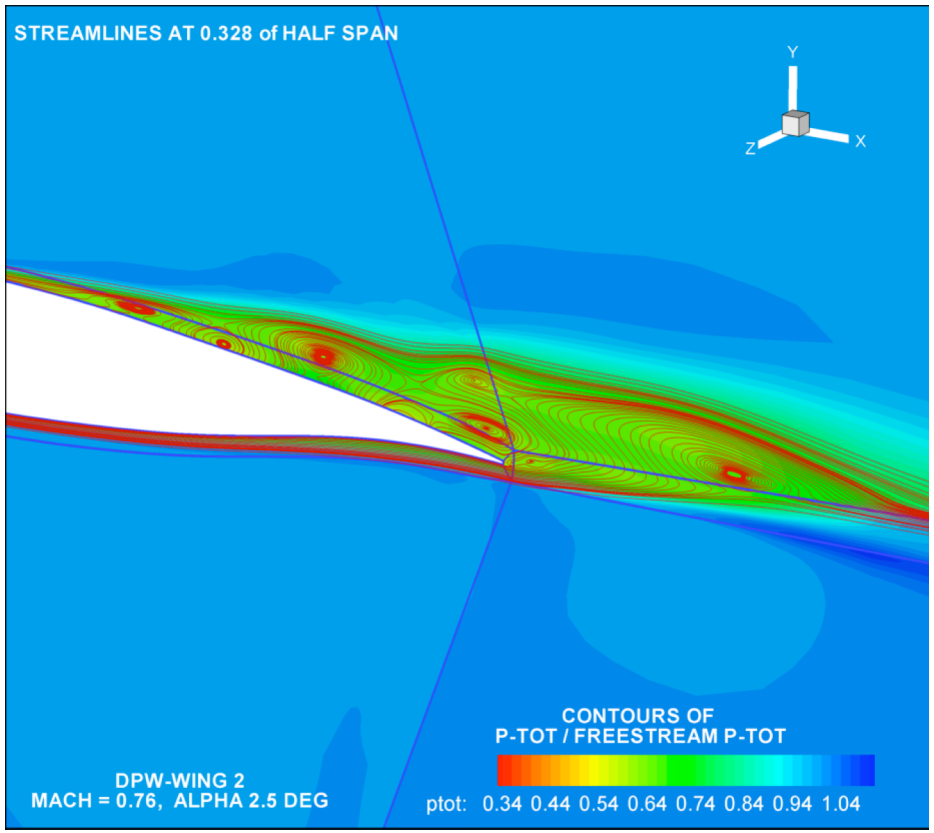




Streamlines and Total Pressure Contours

DETAILED FLOW ANALYSIS

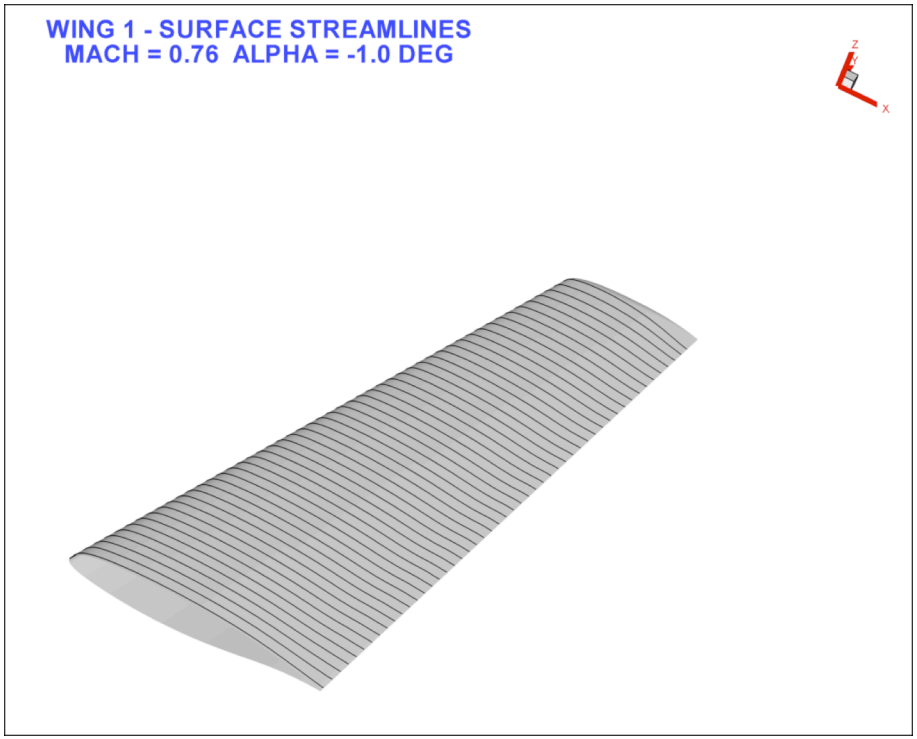


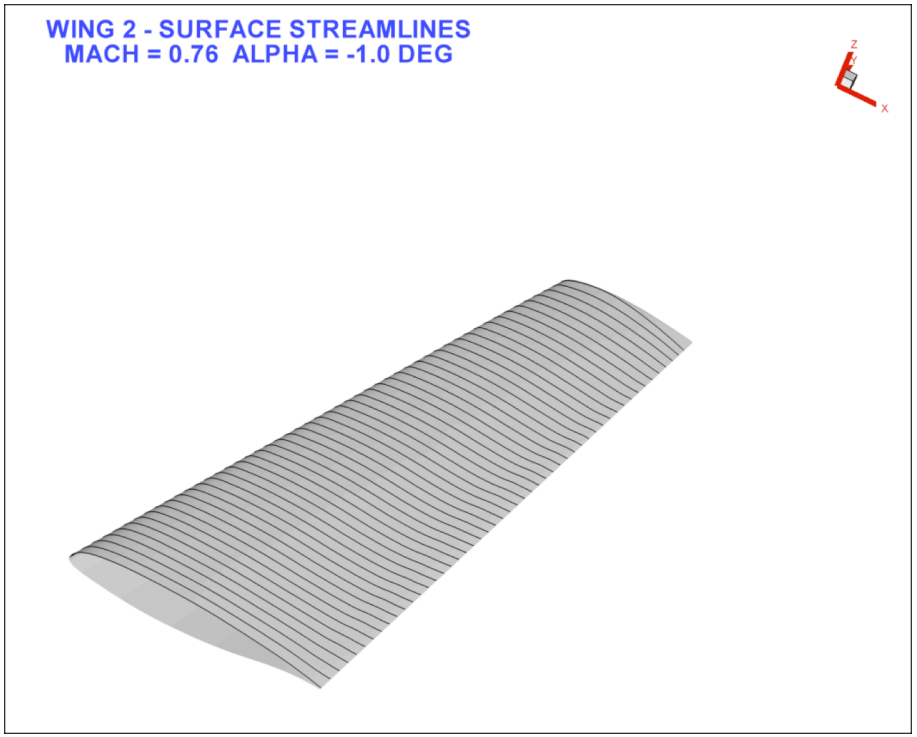


Streamlines and Total Pressure Contours

SURFACE STREAMLINES

SURFACE STREAMLINES





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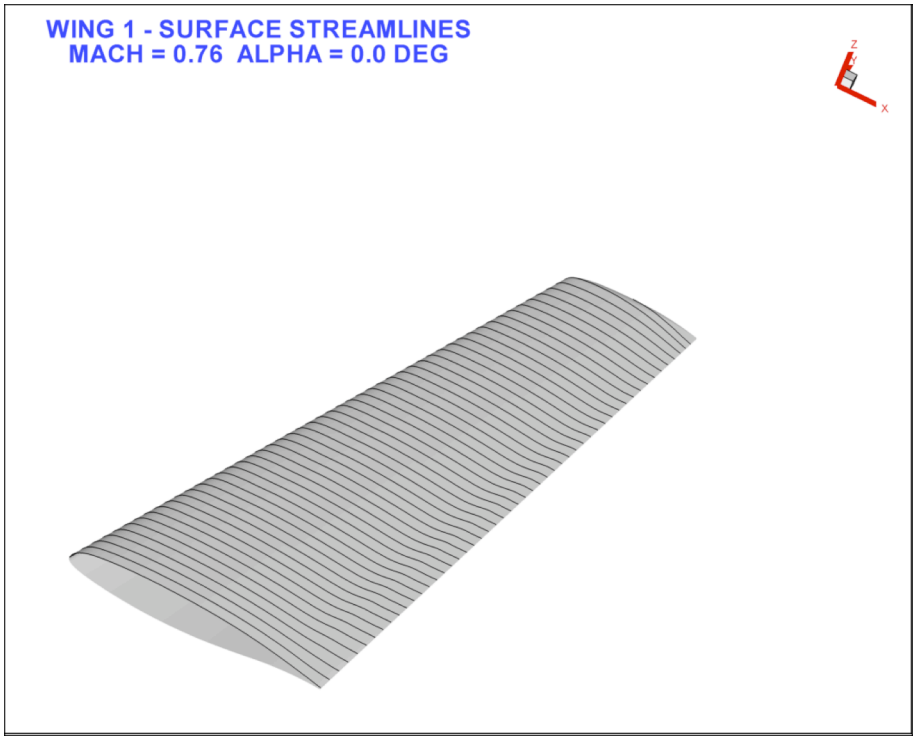

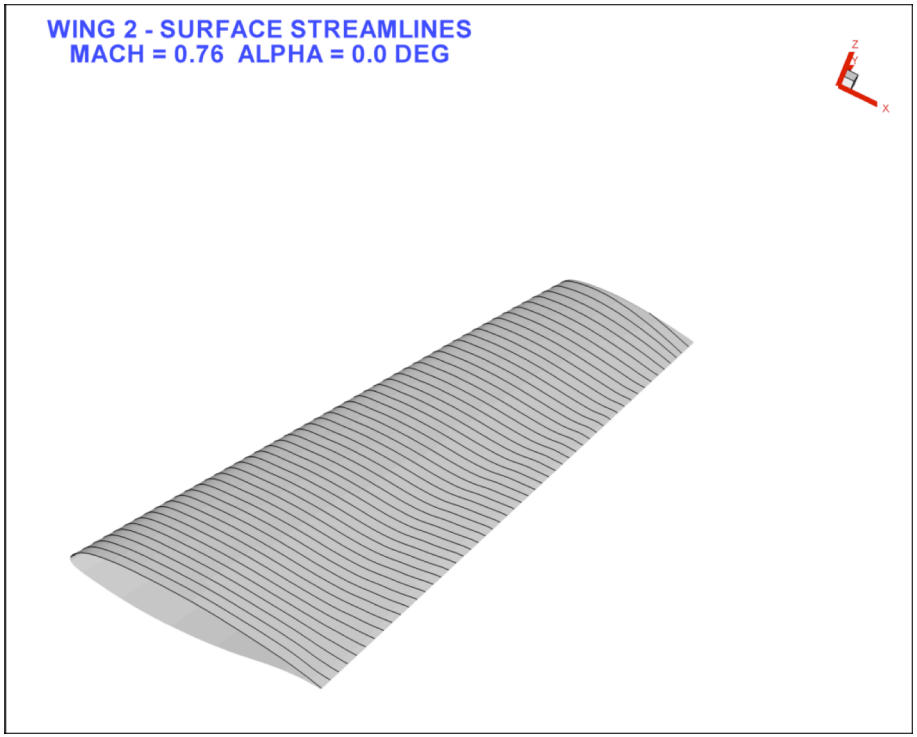

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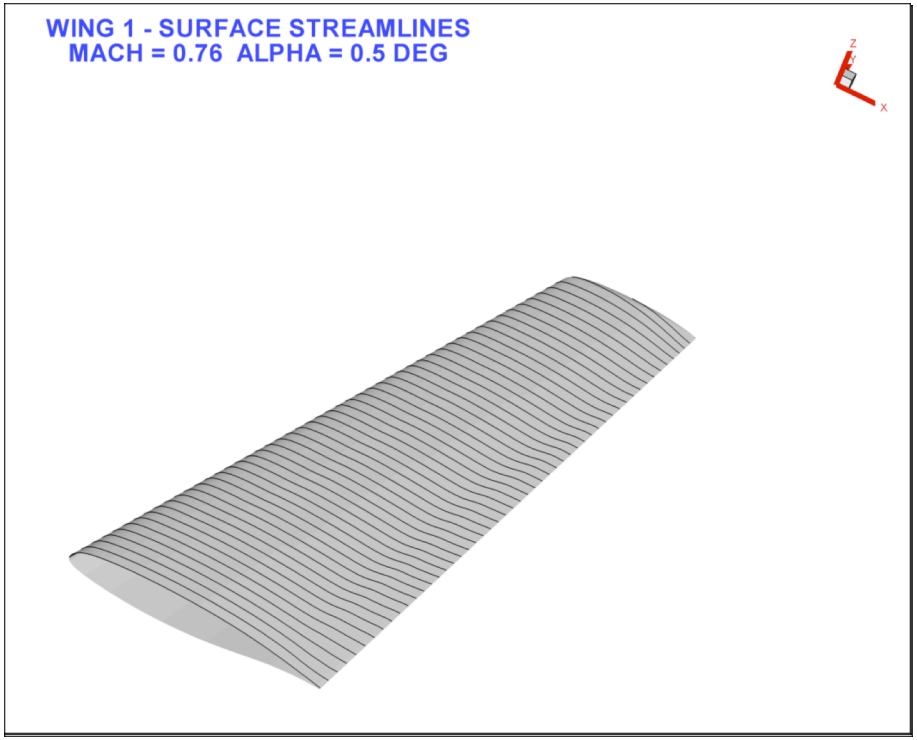

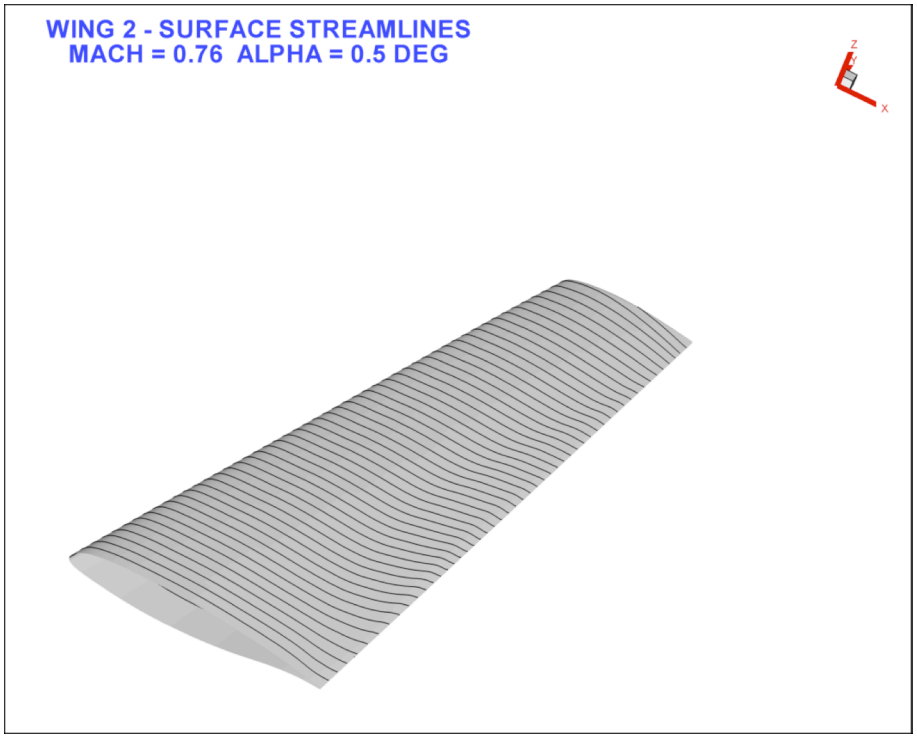

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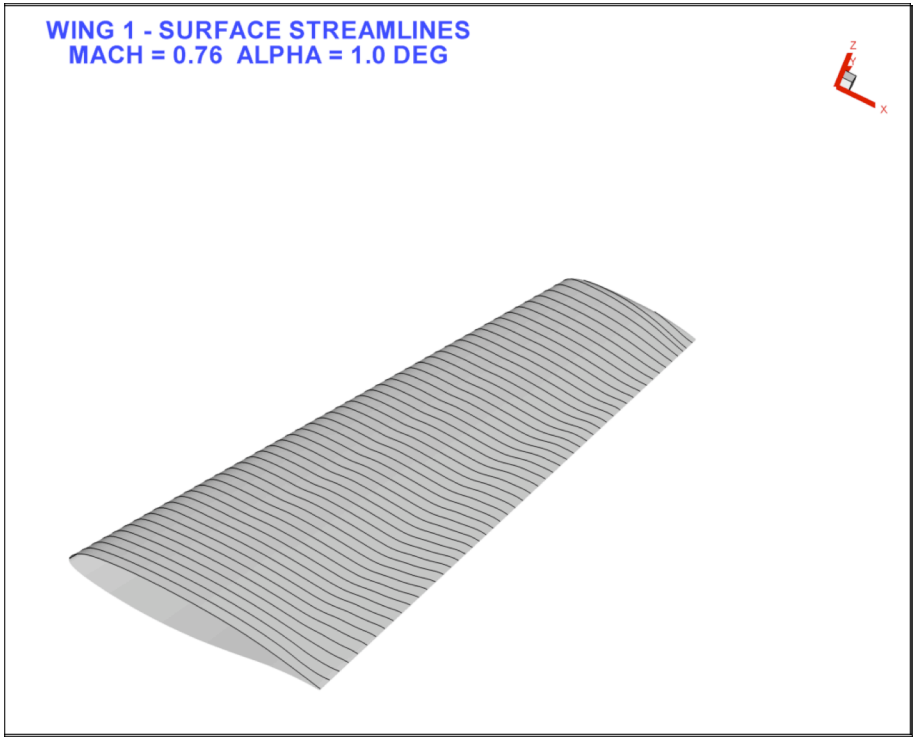

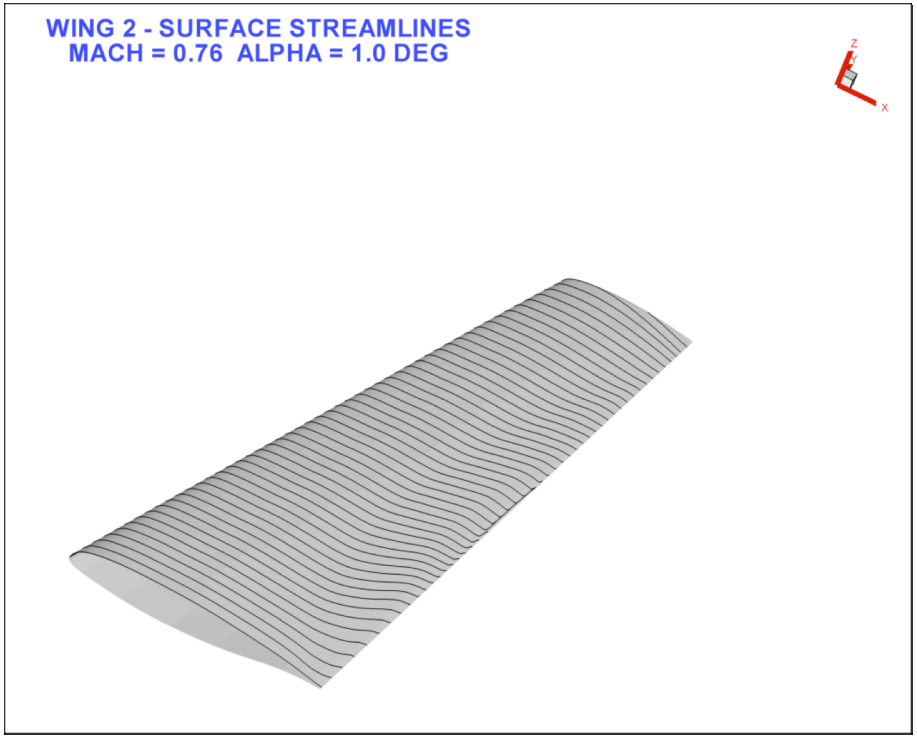

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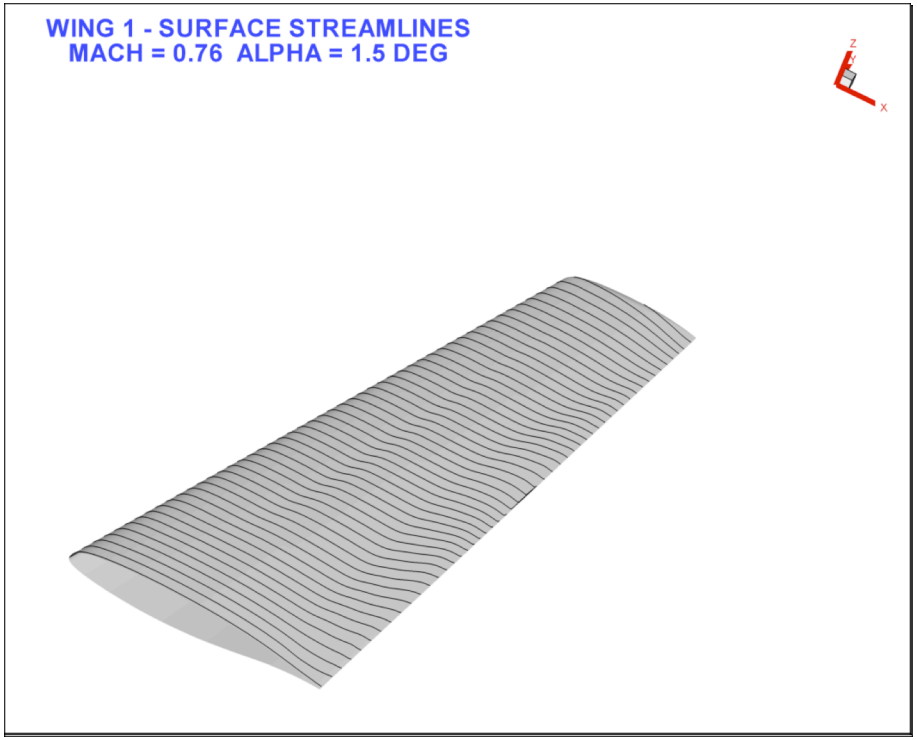

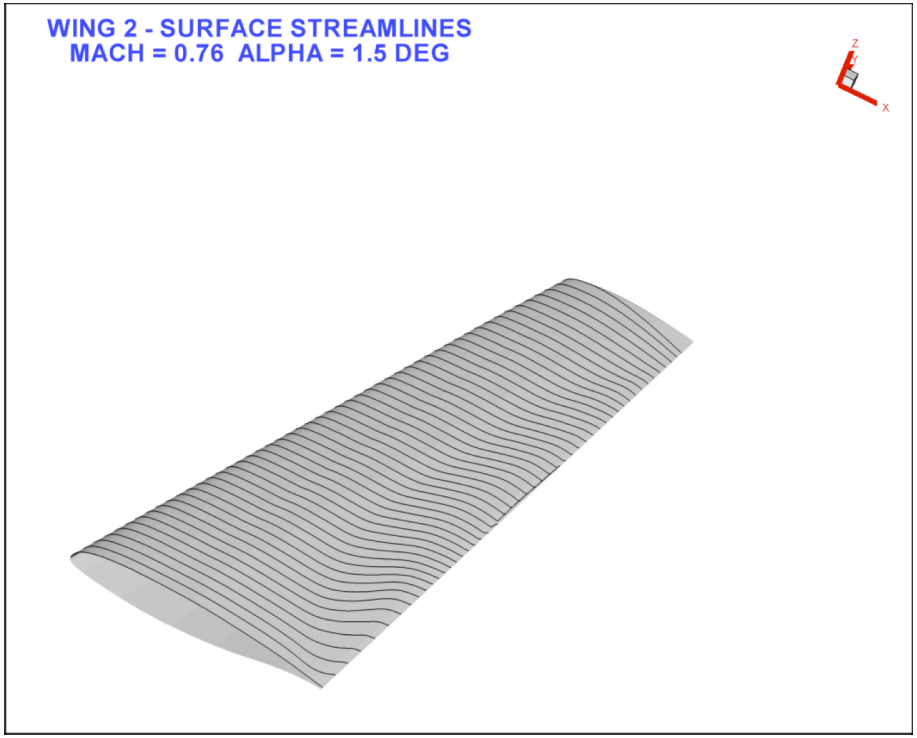

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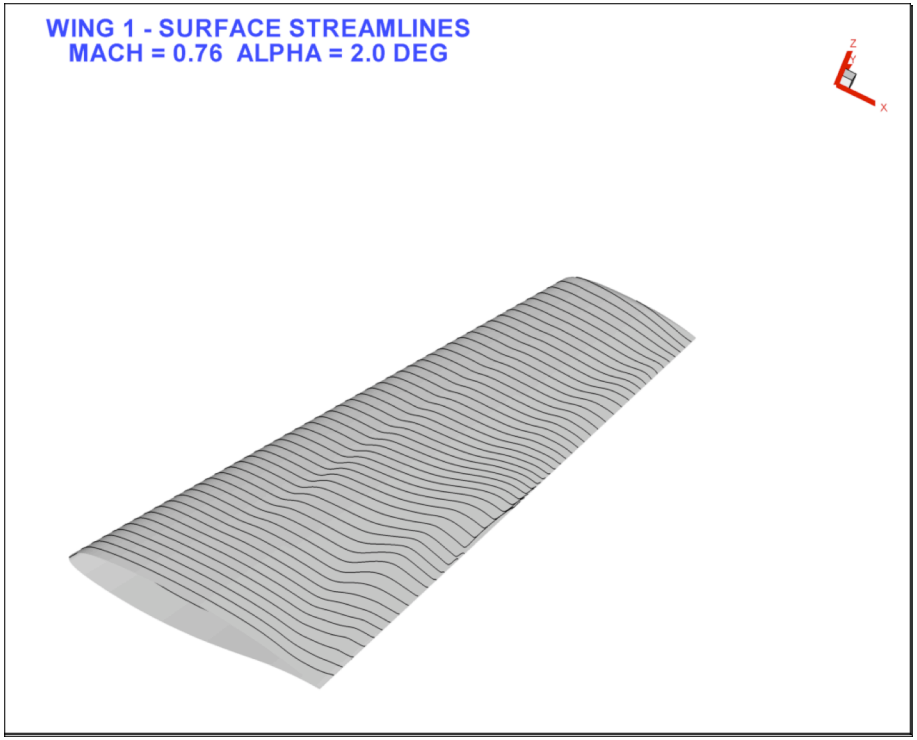

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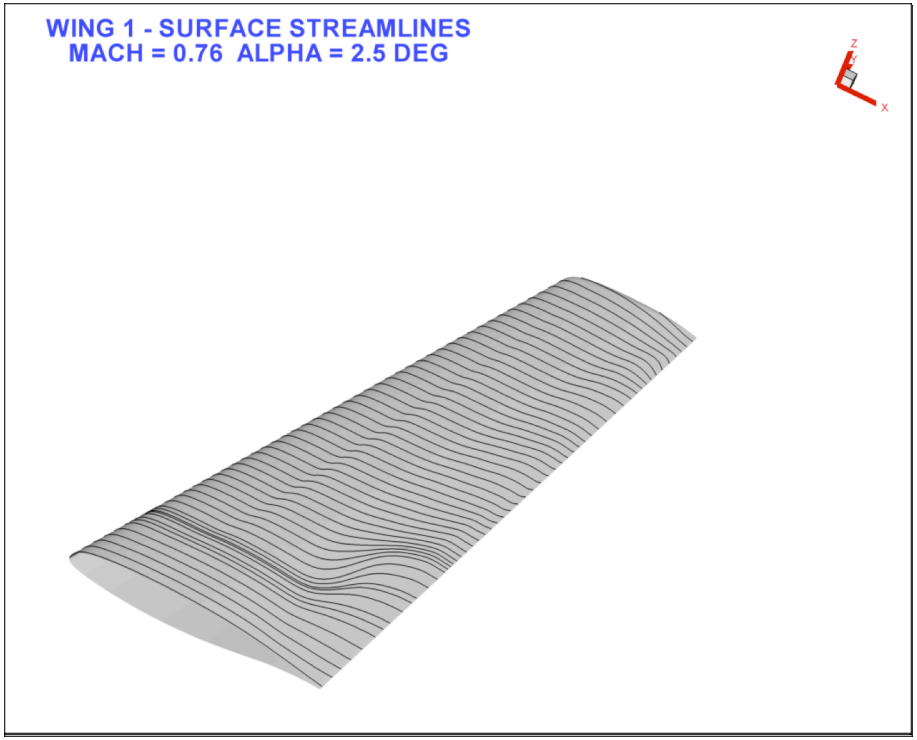

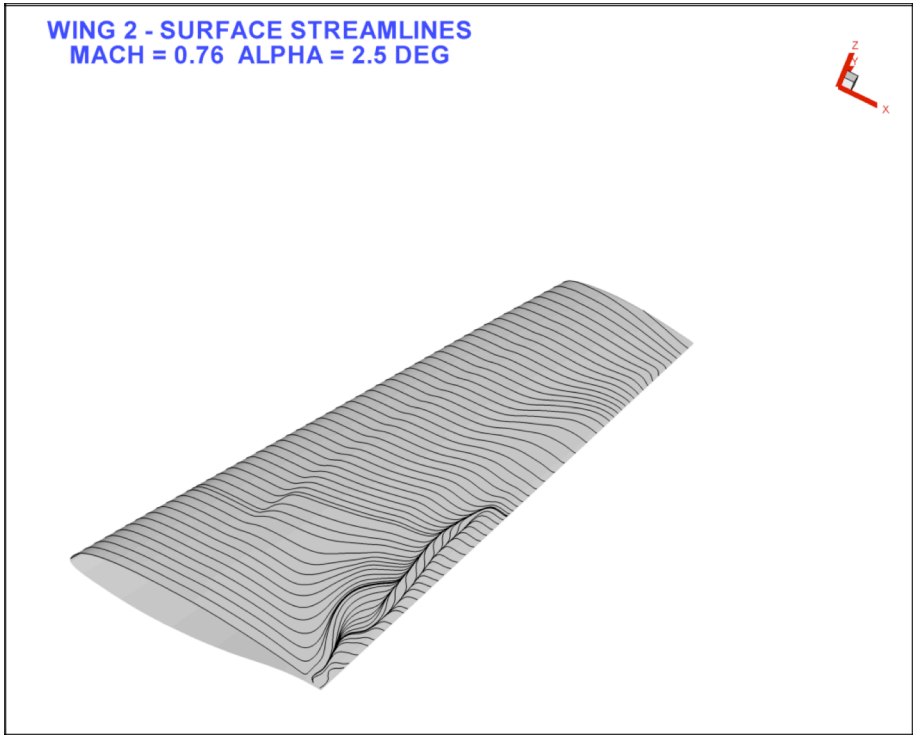

FORCE COEFFICIENTS

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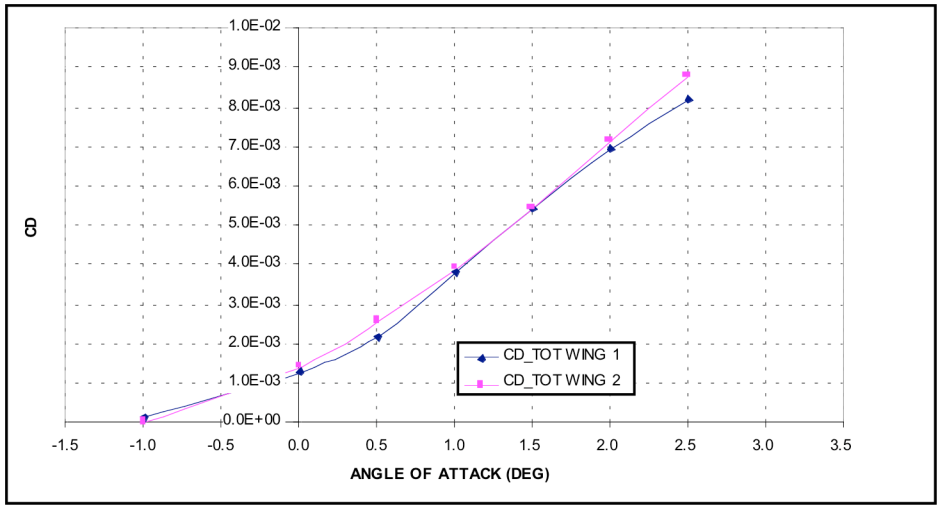

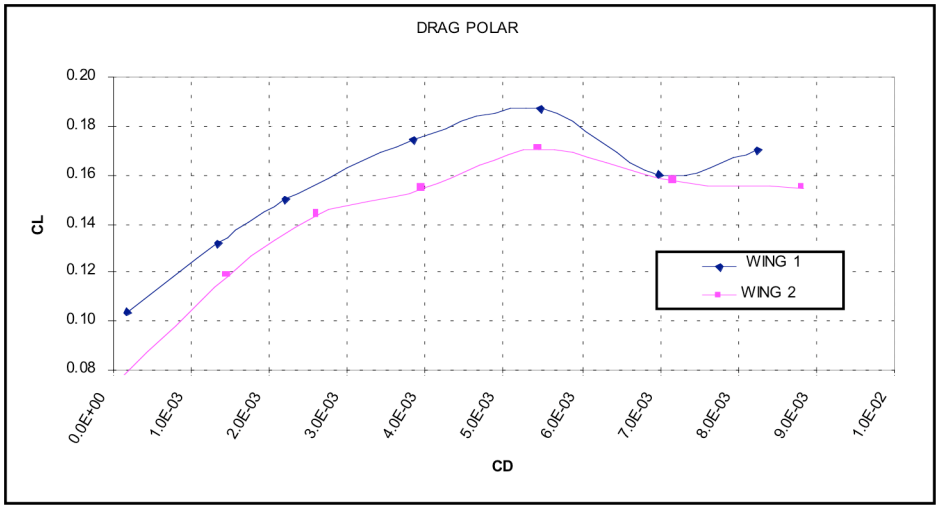

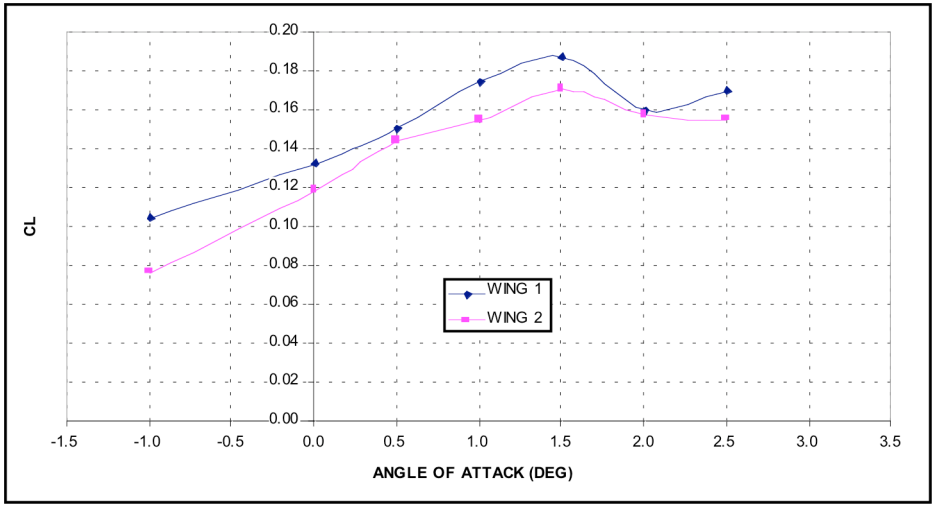

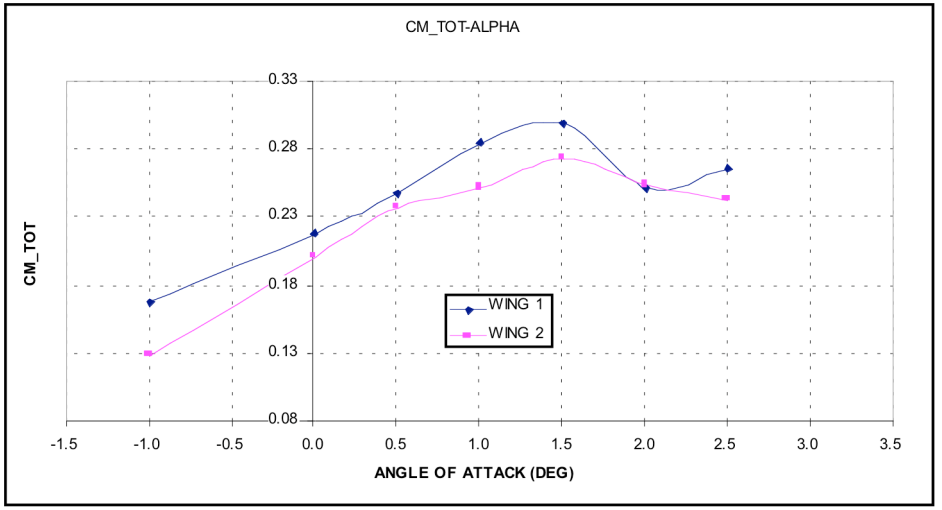

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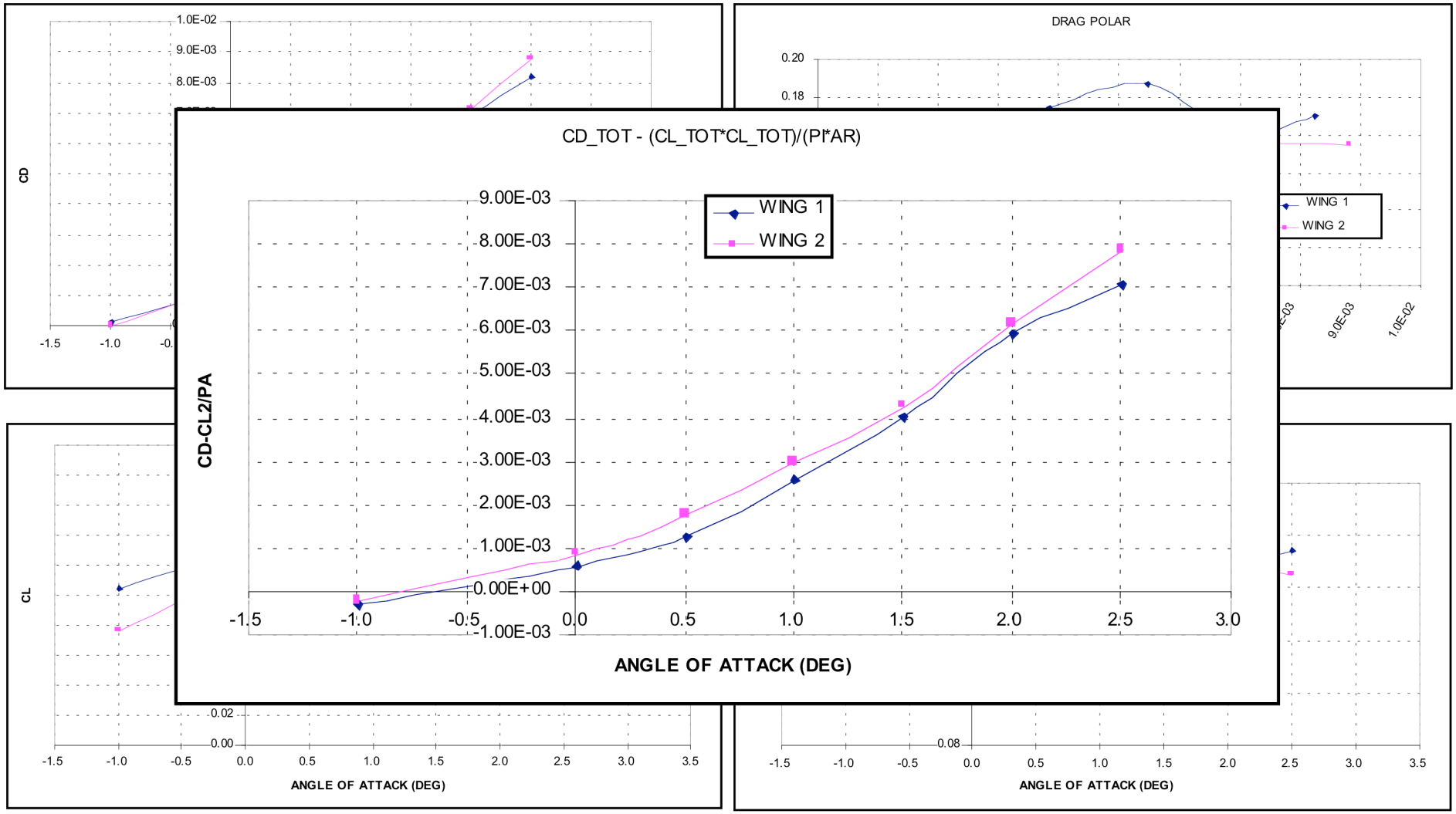

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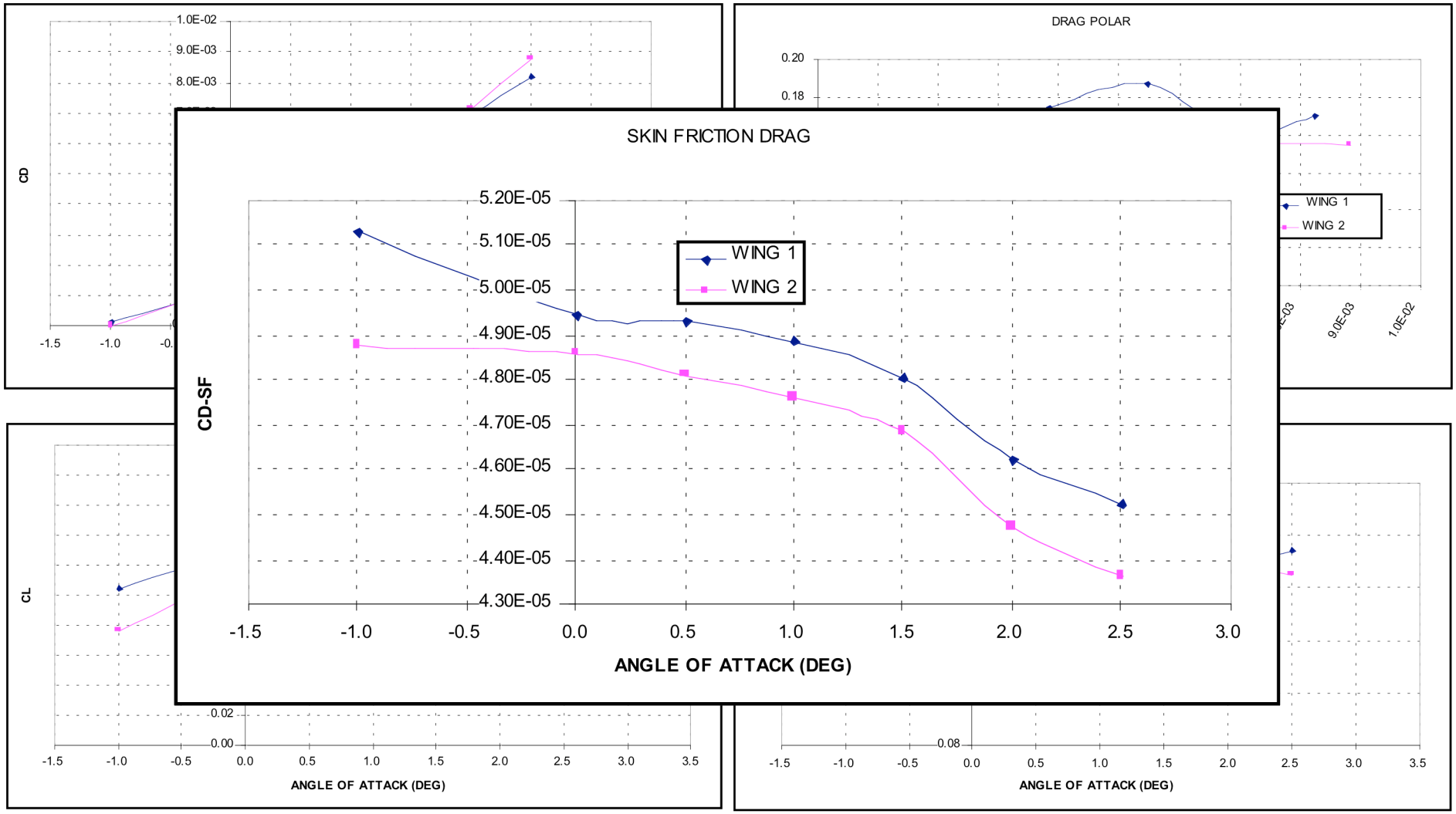

SKIN FRICTION METHODOLOGY

- Coordinate transformation
  (x,y,z)→ (ξ,η,ζ) orthogonal
- Calculation of Stress Tensor
  (Surface mesh cell center)
- Calculation of Traction Force **T**
- Surface shear force **S**

$$\tau_{i,j} = \mu\left(\frac{\partial u_i}{\partial x_j} + \frac{\partial u_j}{\partial x_i}\right) + \delta_{i,j}\lambda\frac{\partial u_k}{\partial x_k}, \lambda = -\frac{2}{3}\mu$$

$$T_i = \tau_{i,j} n_j$$

$$S_j = T_j - \left(T_j n_j\right) n_j$$

$$S_j = S_x\vec{i} + S_y\vec{j} + S_z\vec{k}$$

END OF THE PRESENTATION