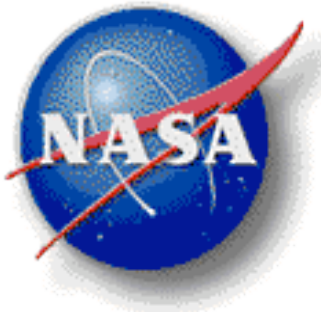

FUN3D Analysis of DPW-III Wing Alone Configurations

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3rd AIAA CFD Drag Prediction Workshop
Sponsored by the Applied Aerodynamics TC
San Francisco, California, June 3-4, 2006

FUN3D Unstructured Grid Code

- Parallel 3D compressible finite-volume RANS for tetrahedral meshes
- Implicit time-stepping using point Gauss-Seidel and line-relaxation for linear system
- Upwind Roe scheme for inviscid fluxes
- Galerkin-type approximation for viscous fluxes
- Full Navier-Stokes equations
- Spalart-Allmaras & SST turbulence models (loosely coupled)

FUN3D Unstructured Grid Code

- Parallel version
  - Pre-processor, flow solver and post-processor fully parallel
  - Domain decomposition using the MeTiS and ParMetis mesh partitioning software (weighted for the line solver)
  - Parallel code execution scheme utilizes MPI

Computational Grids – Wing Alone

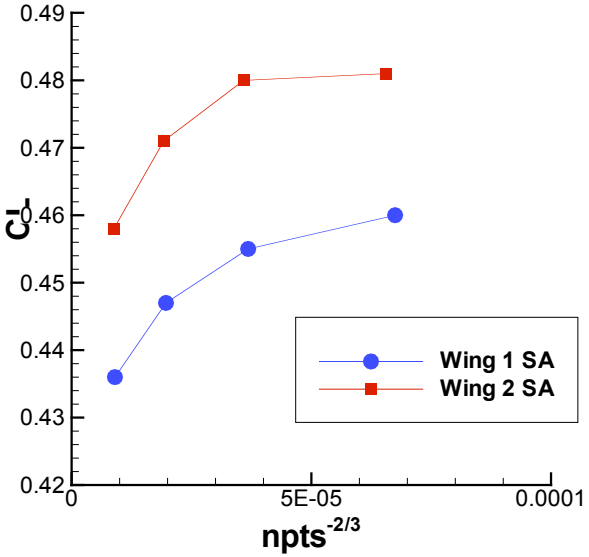
- Workshop VGRIDns node-based grids (with the octree based spacing of Kania)
- VGRIDns 64-bit batch on columbia (Pirzadeh)

	Wing 1 Total Nodes	Wing 2 Total Nodes
Coarse	1,806,422	1,882,672
Medium	4,476,969	4,658,853
Fine	11,459,041	11,903,329
Super Fine	36,900,028	38,462,630

Summary FUN3D Results

- Case 2A: Mach 0.76, α=0.5deg, Re_c=5x10^6(SA fully turbulent)
  - Wing 1 coarse, medium, fine and super fine grids
  - Wing 2 coarse, medium, fine and super fine grids
- Case 2B: Mach 0.76, α=0.5deg, Re_c=5x10^6 (SA fully turbulent)
  - Wing 1 medium grid polar
  - Wing 2 medium grid polar

Wing Alone Grid Refinement



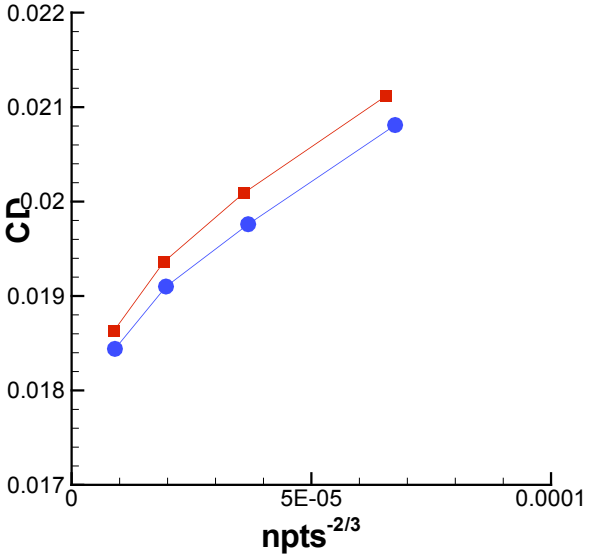
Mach = 0.76

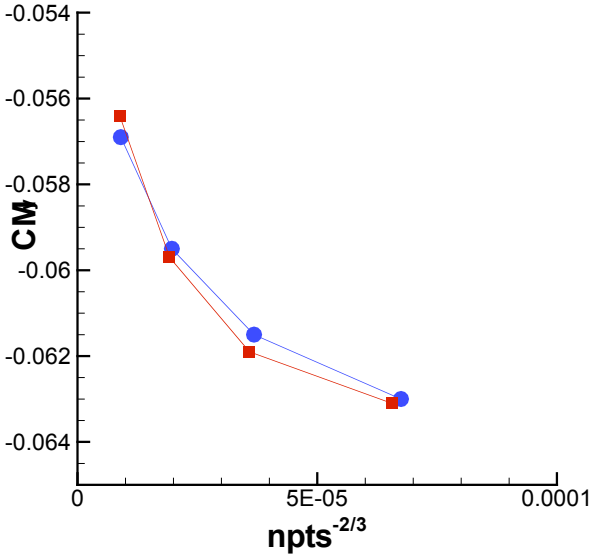
α = 0.5deg

$Re_c = 5x10^6$

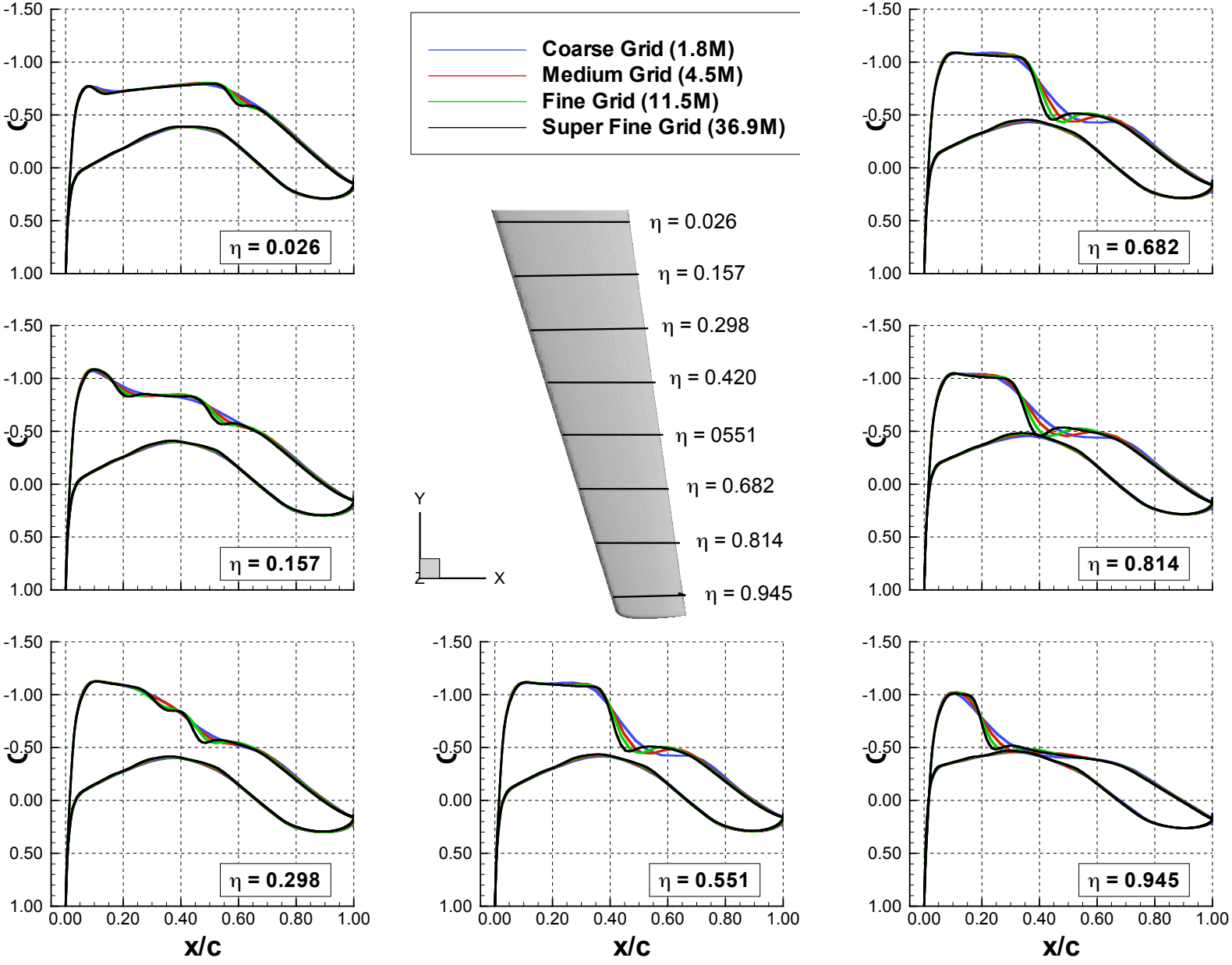
Spalart-Allmaras

Fully Turbulent

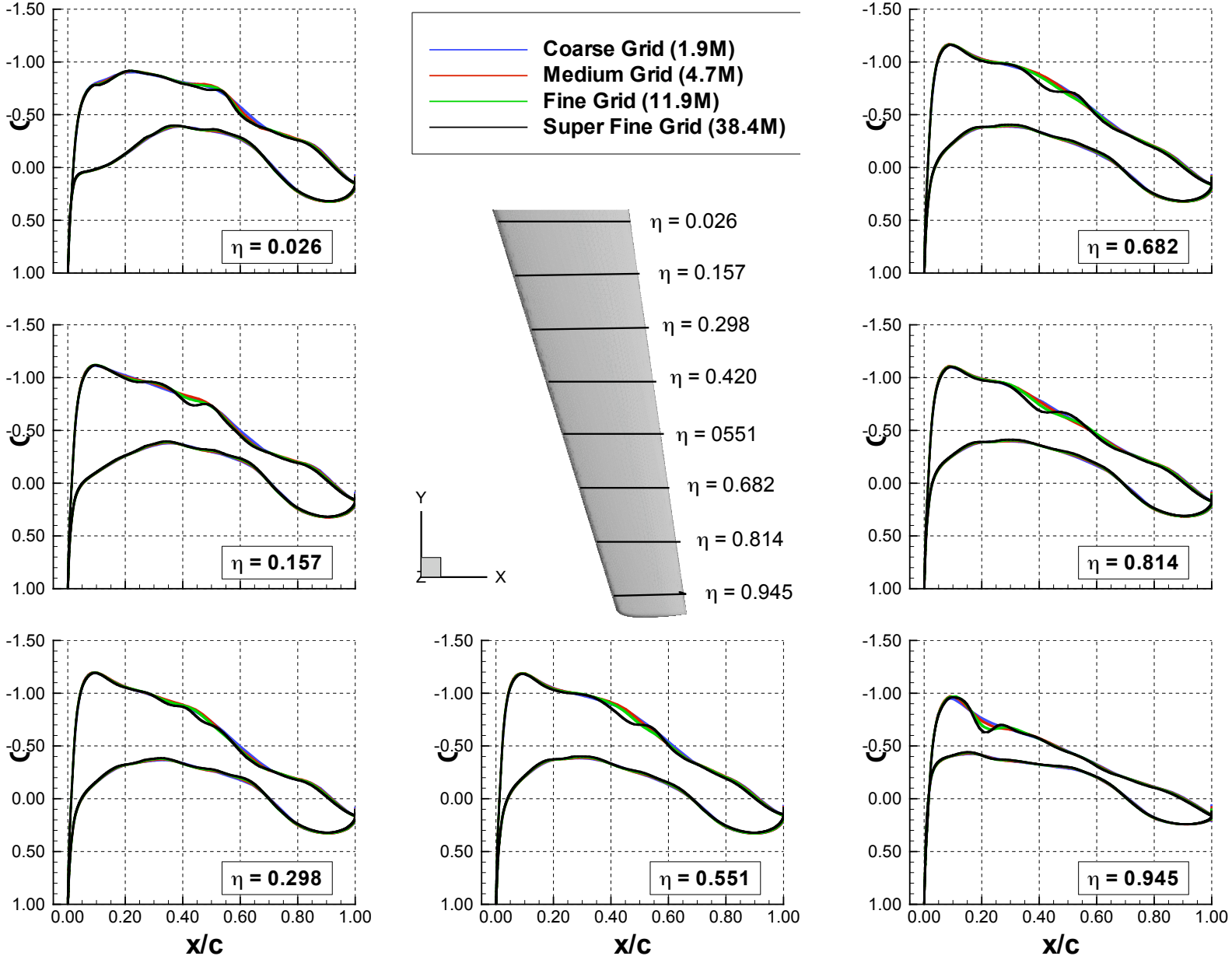




Wing 1 Grid Refinement

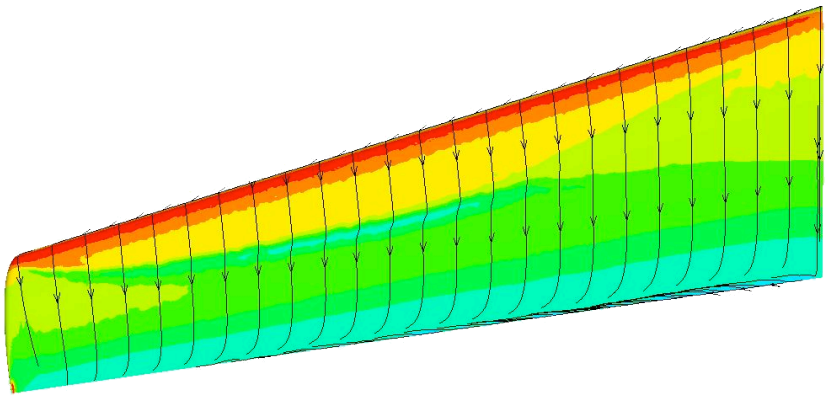


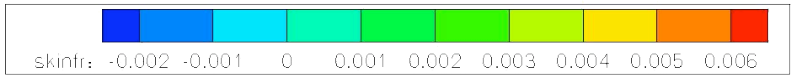
Wing 2 Grid Refinement



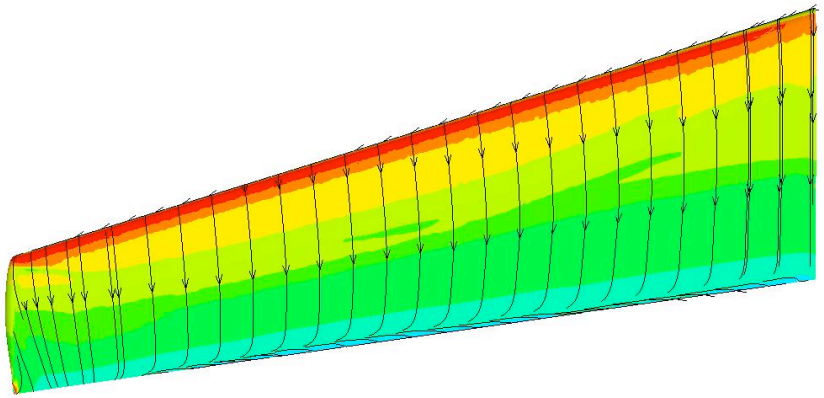
Wing Alone Super-Fine Grid Skin Friction

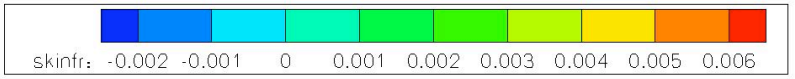
Wing 1
α = 0.5deg



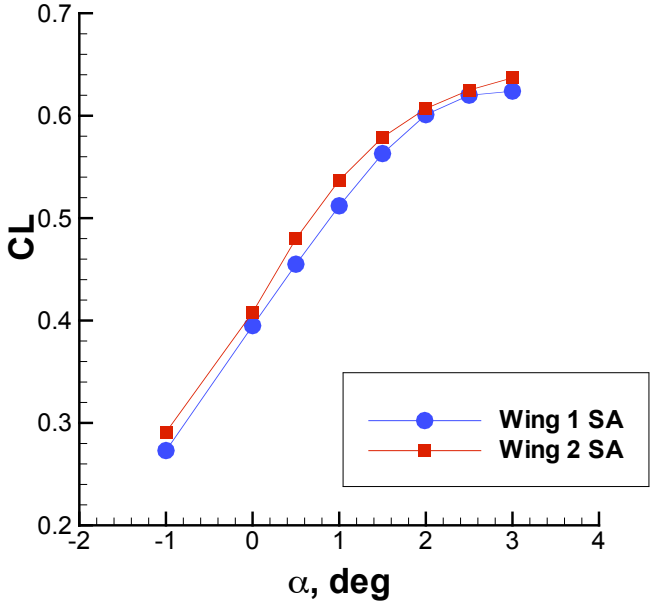


Wing 2
α = 0.5deg





Wing Alone Polar

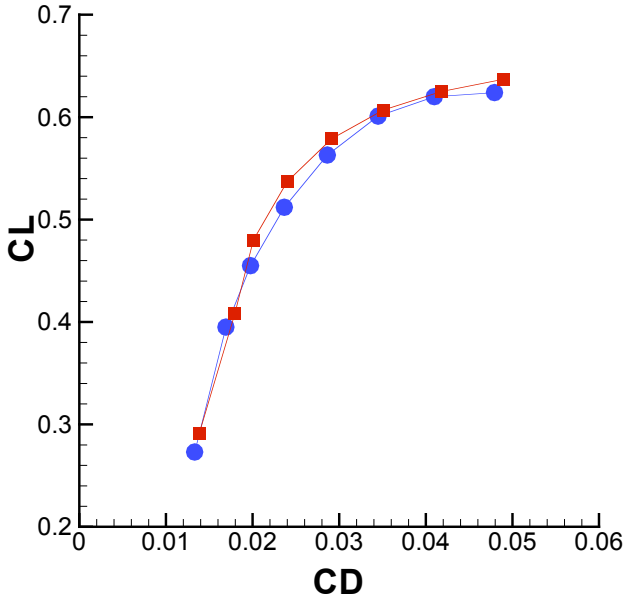


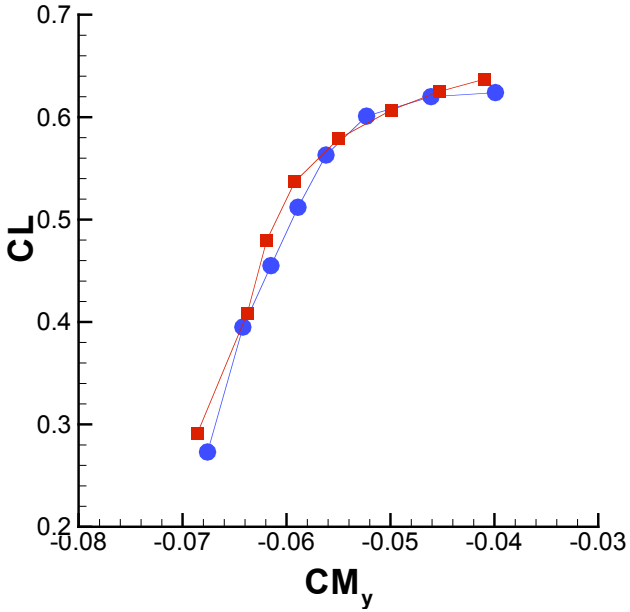
Mach = 0.76

$Re_c = 5x10^6$

Spalart-Allmaras

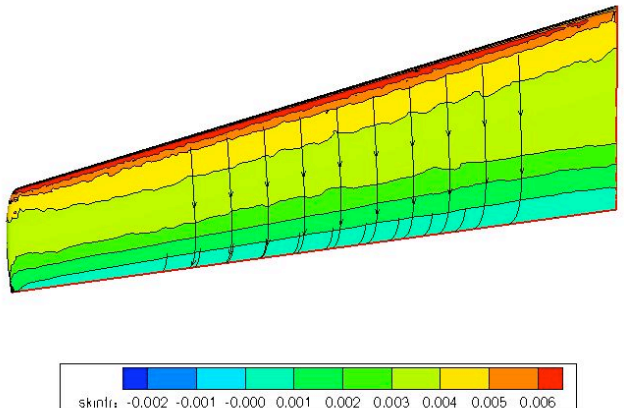
Fully Turbulent



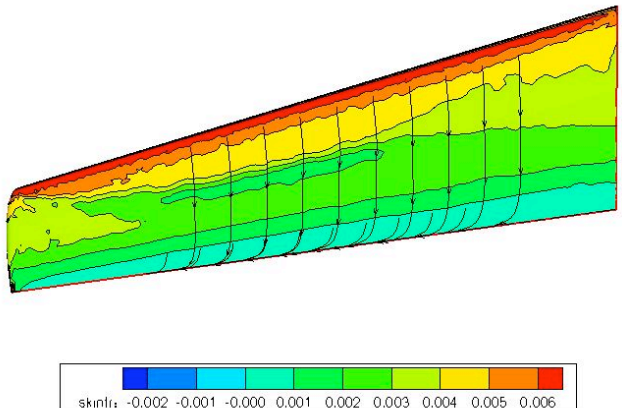


Wing 1 Skin Friction

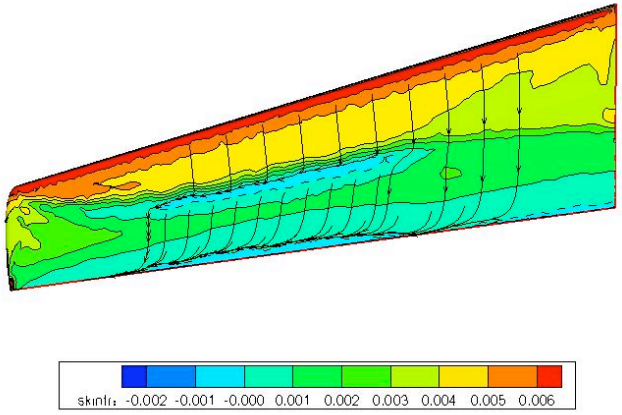
α = -1.0deg



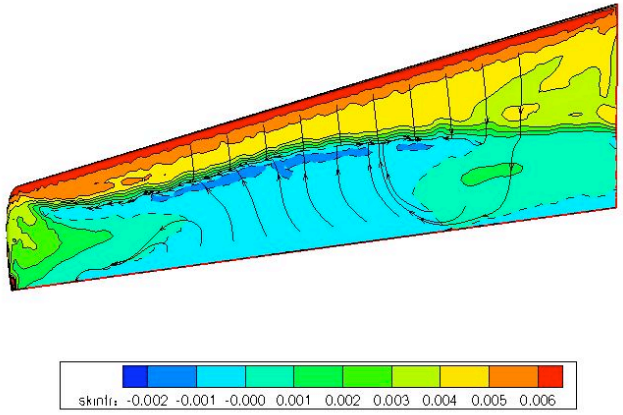
α = 0.5deg



α = 1.5deg

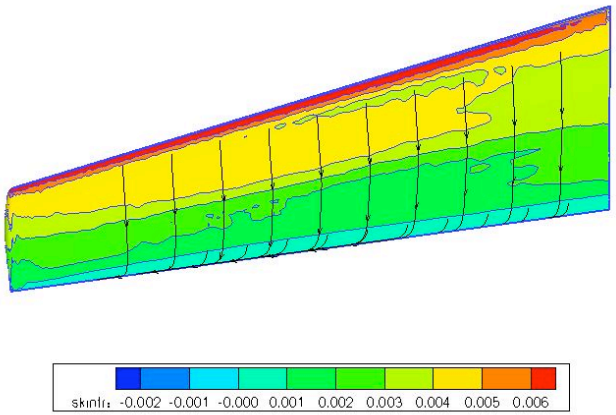


α = 3.0deg

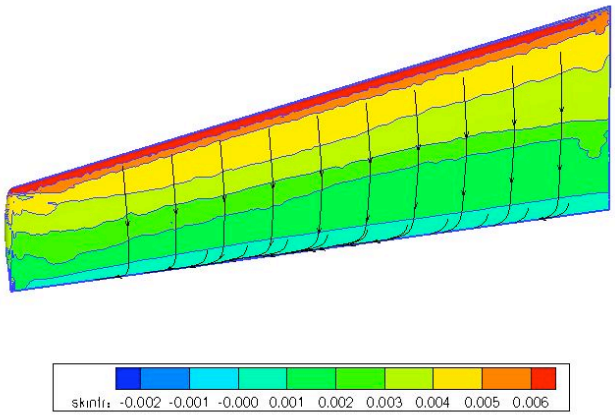


Wing 2 Skin Friction

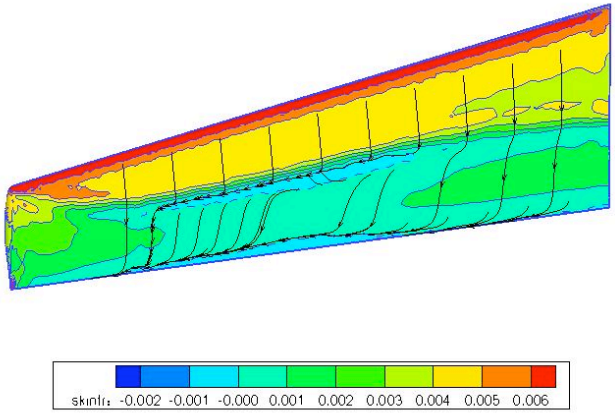
α = -1.0deg



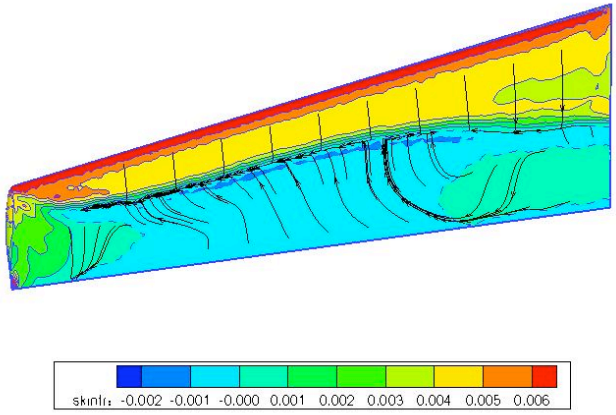
α = 0.5deg



α = 1.5deg



α = 3.0deg



Summary

- Case 2A- W1
  - Drag and lift are decreasing with grid refinement
  - Small trailing edge separation on superfine grid
- Case 2A-W2
  - Drag and lift are decreasing with grid refinement
  - Small trailing edge separation on superfine grid
- Case 2B
  - Improved performance of W2 at design point
  - Both wing start to separate around α = 1.5deg