Metacomp Technologies, Inc.

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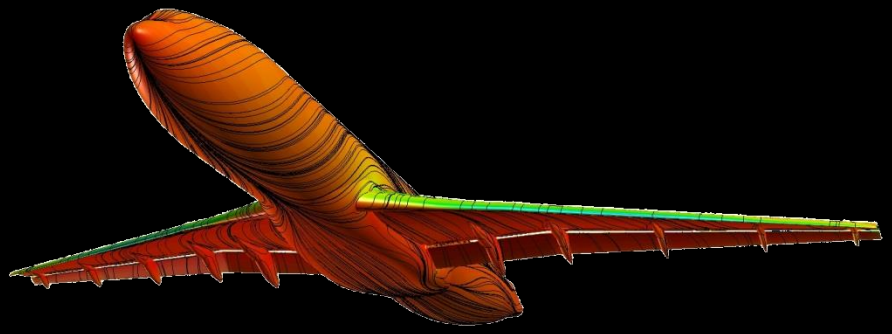
HiLiftPW2



DLR F11 Flow Predictions

- Solver:
  - CFD++, Unified Grid Finite Volume solver
  - Unstructured Mixed-Element Cell-Based
  - 2nd order HLLC Riemann solver
  - Preconditioned
  - Multigrid acceleration
  - Run fully turbulent

DLR F11 Flow Predictions

Turbulence Model	Freestream Turbulence Level (%)	Eddy viscosity Ratio (μ_t/μ)	Remarks
k-ε-Rt	0.05	20	no freestream μ_t decay
S-A	0.05	1	no freestream μ_t decay
SST	0.05	20	

DLR F11 Flow Predictions

- Solution information (**Case 1** medium grid, 32M cells, unstructured hexa)
  - Computer Platform:
    - Up to 14 nodes used
    - Each node: 2 AMD Opteron 6172 (12 cores), 128 GB ram
    - Up to 336 cores used
    - Operating System: Centos/Redhat OS 5.5
    - Compiler: gcc 3.2.3
    - Run Time: 700 steps, incl. files outputs, 7.5 hours (288 cores)
    - Memory used: ~560 MB/process, 107 GB total (288 cores)
    - Lift and drag converged in 500 iterations or about 5 hours

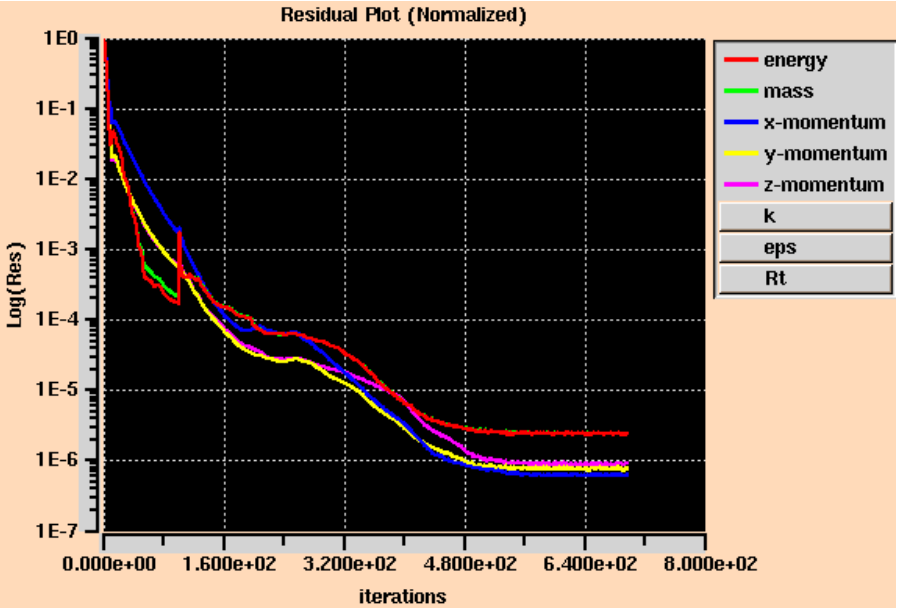
DLR F11 Case 1 (grid sensitivity)

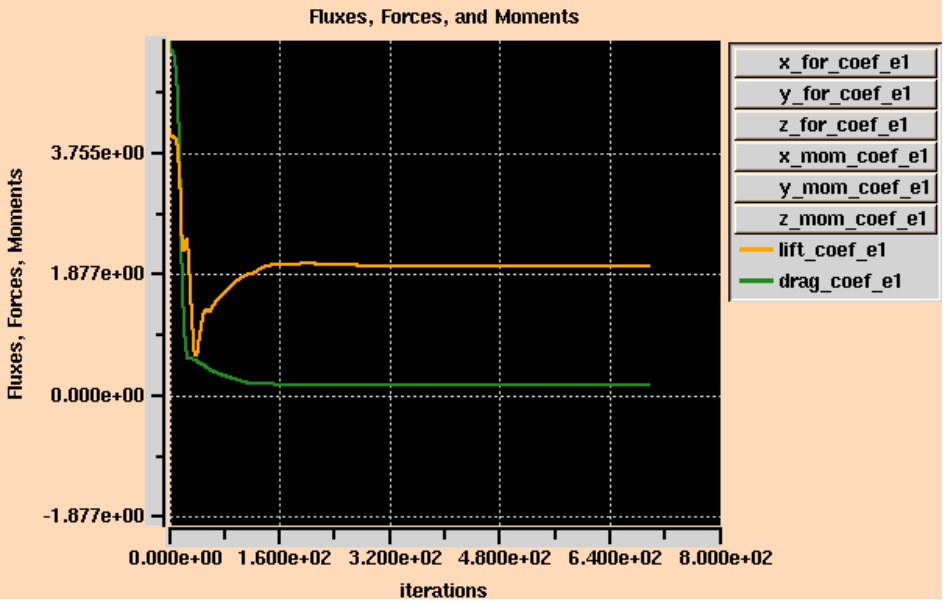
- Hexa mesh (coarse, medium, fine grids)
- ICEM (A_uns_1to1_Case1Config2_v2)

MESH	No. of cells
Coarse	9,556,725
Medium	31,998,440
Fine	100,561,536

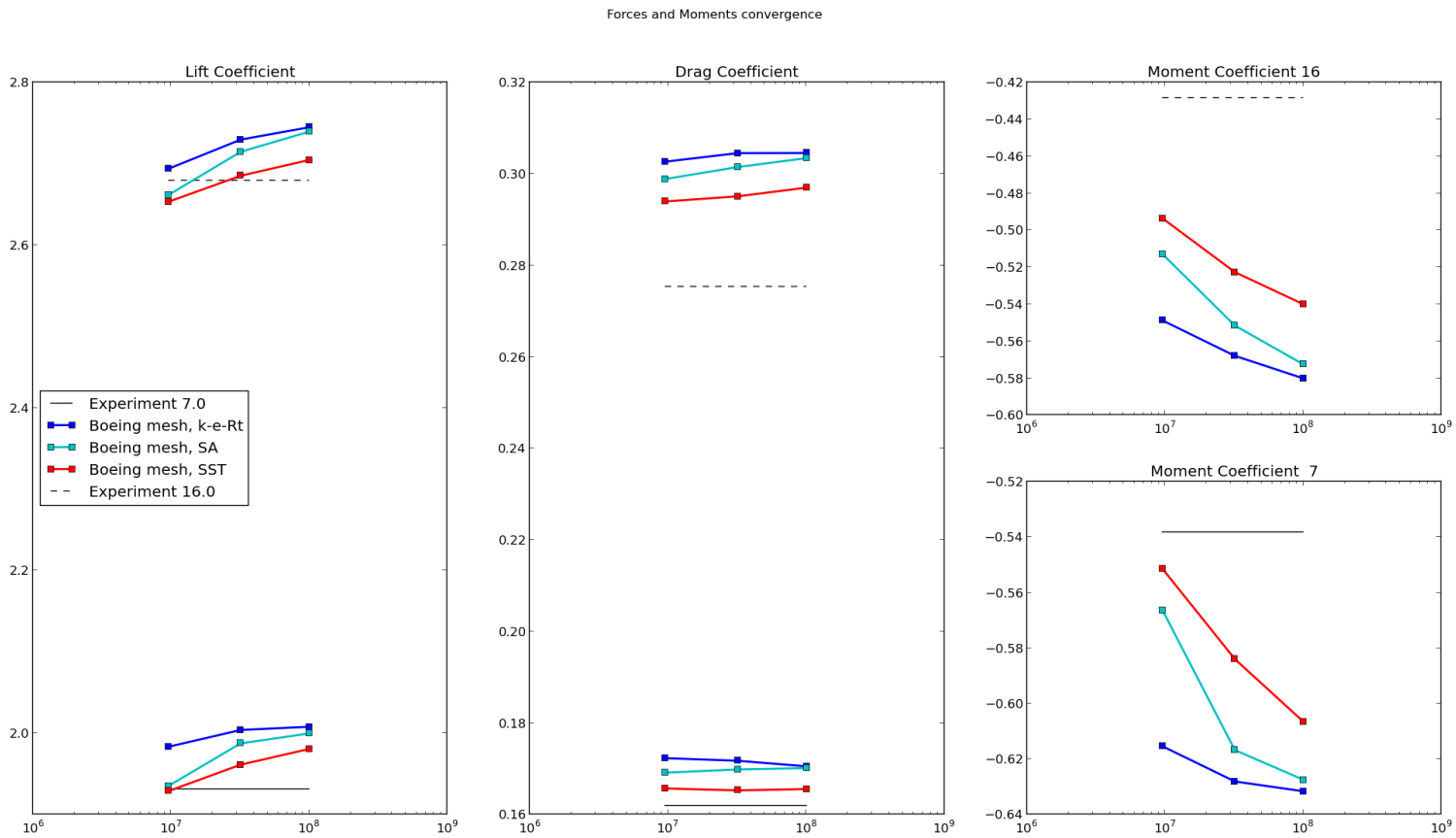
DLR F11 Flow Predictions

Typical convergence history with k-ε-Rt model



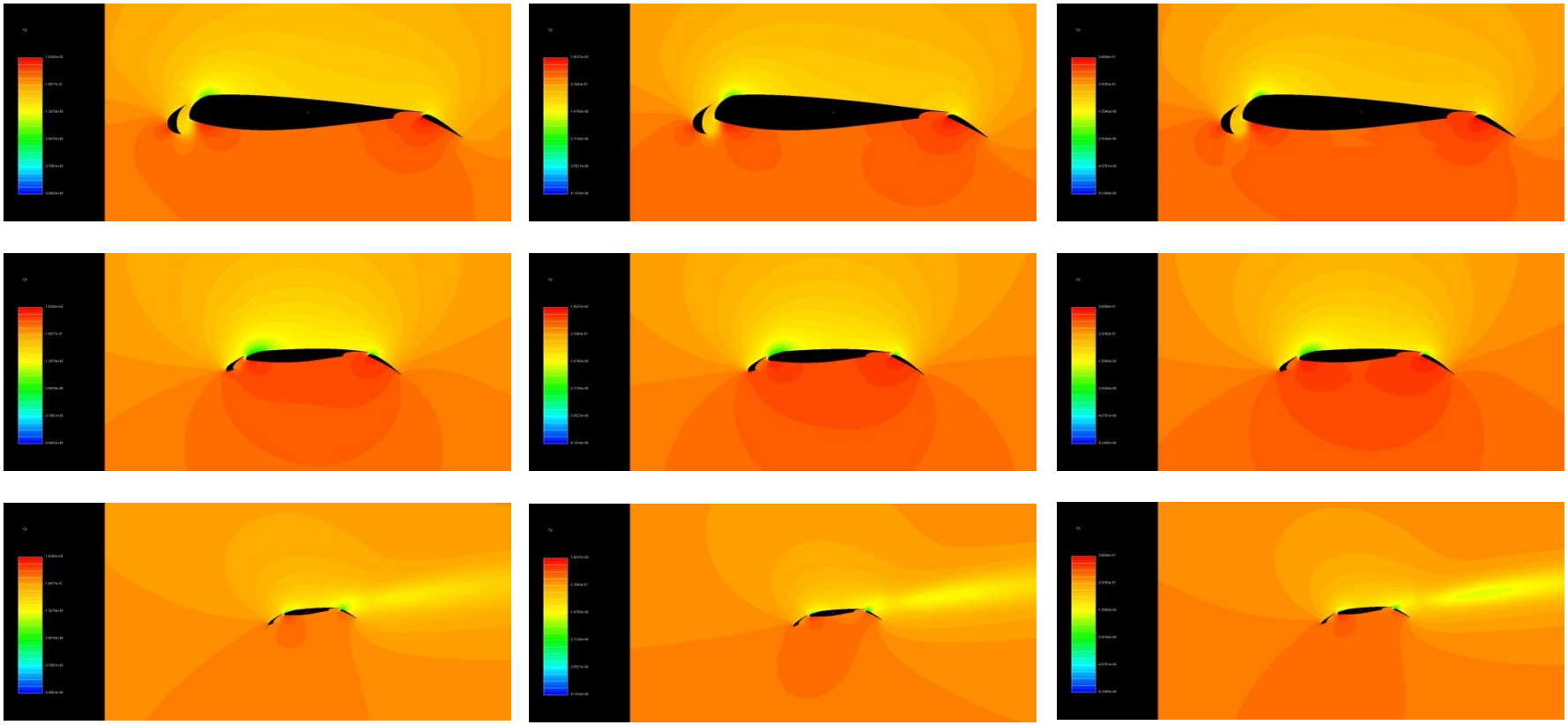


DLR F11 Case 1 (grid sensitivity)



Case 1 Cp contours (α=7°)

k-ε-R_t



root

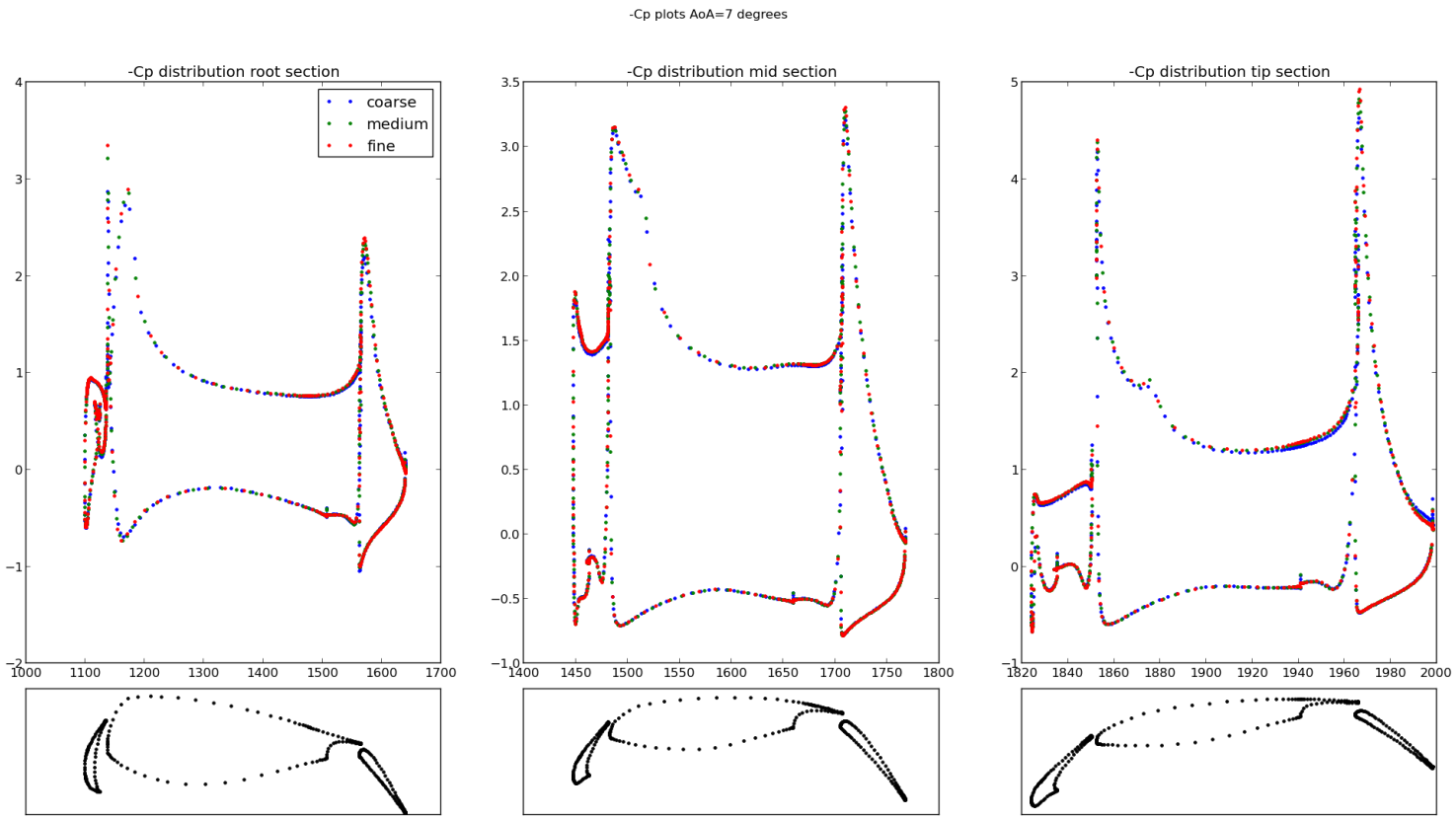
mid

tip

Coarse Medium Fine

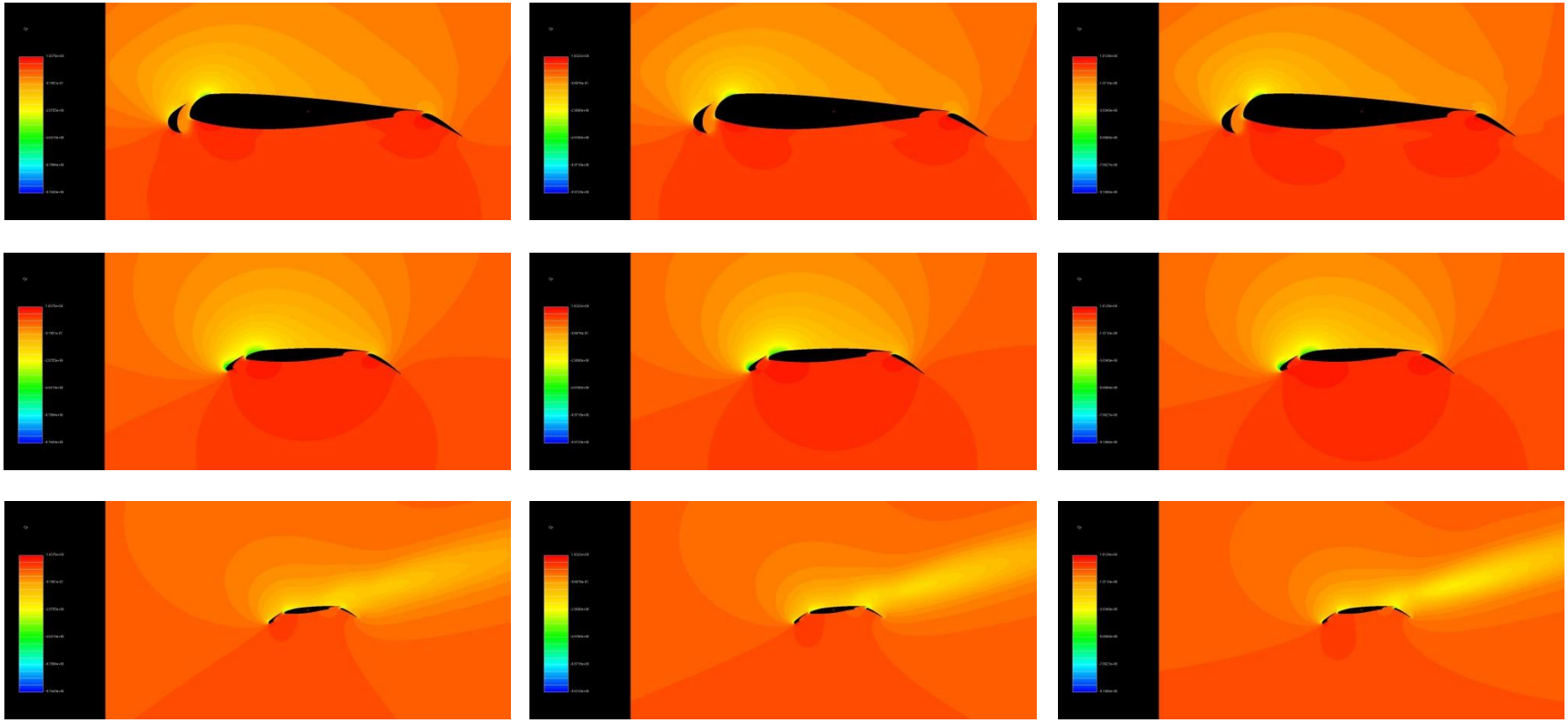
Case 1 Cp plots (α=7°)

k-ε-R_t



Case 1 Cp contours (α=16°)

k-ε-R_t



root

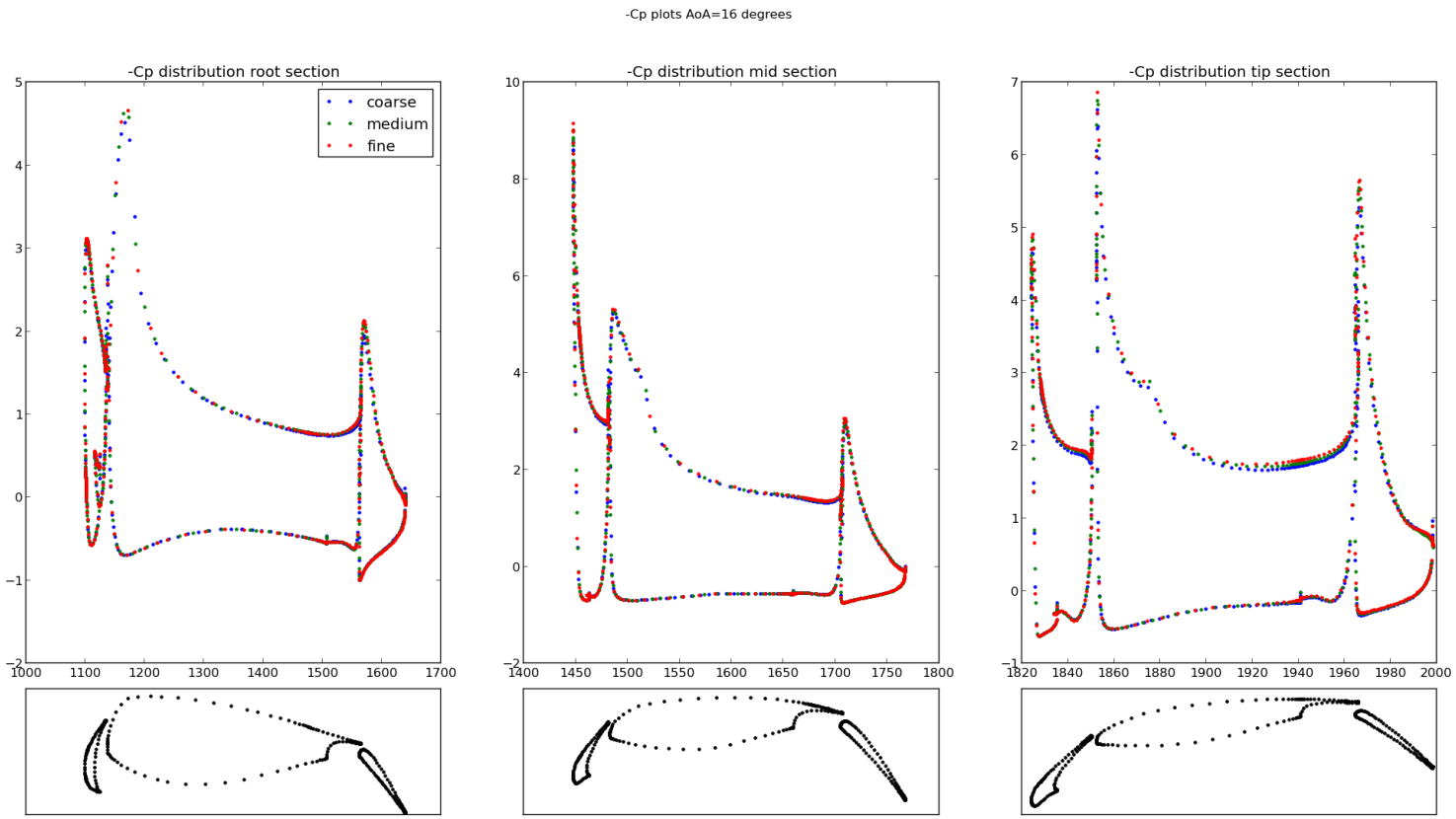
mid

tip

Coarse Medium Fine

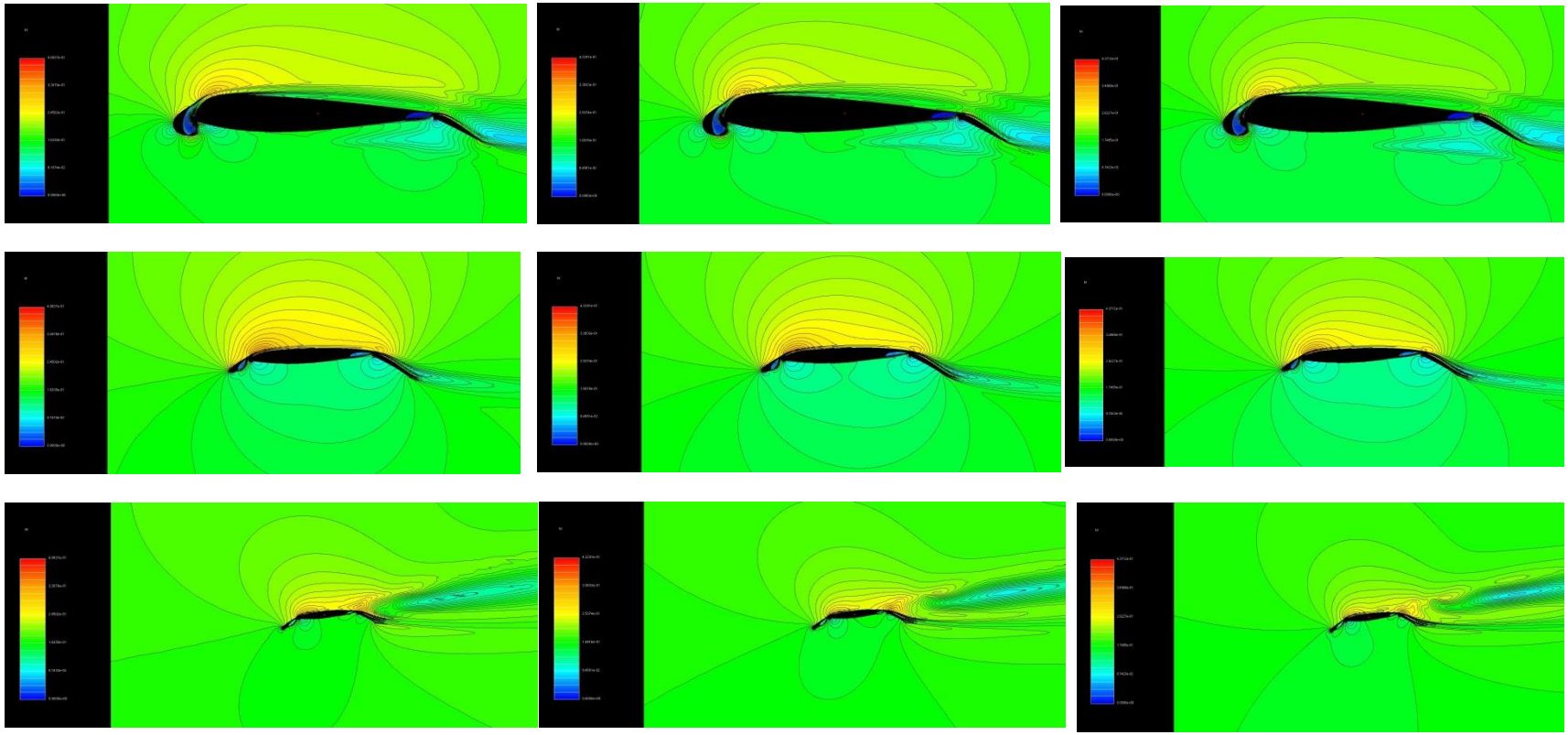
Case 1 Cp plots (α=16°)

k-ε-R_t



Mach contours (α=7°)

k-ε-R_t



root

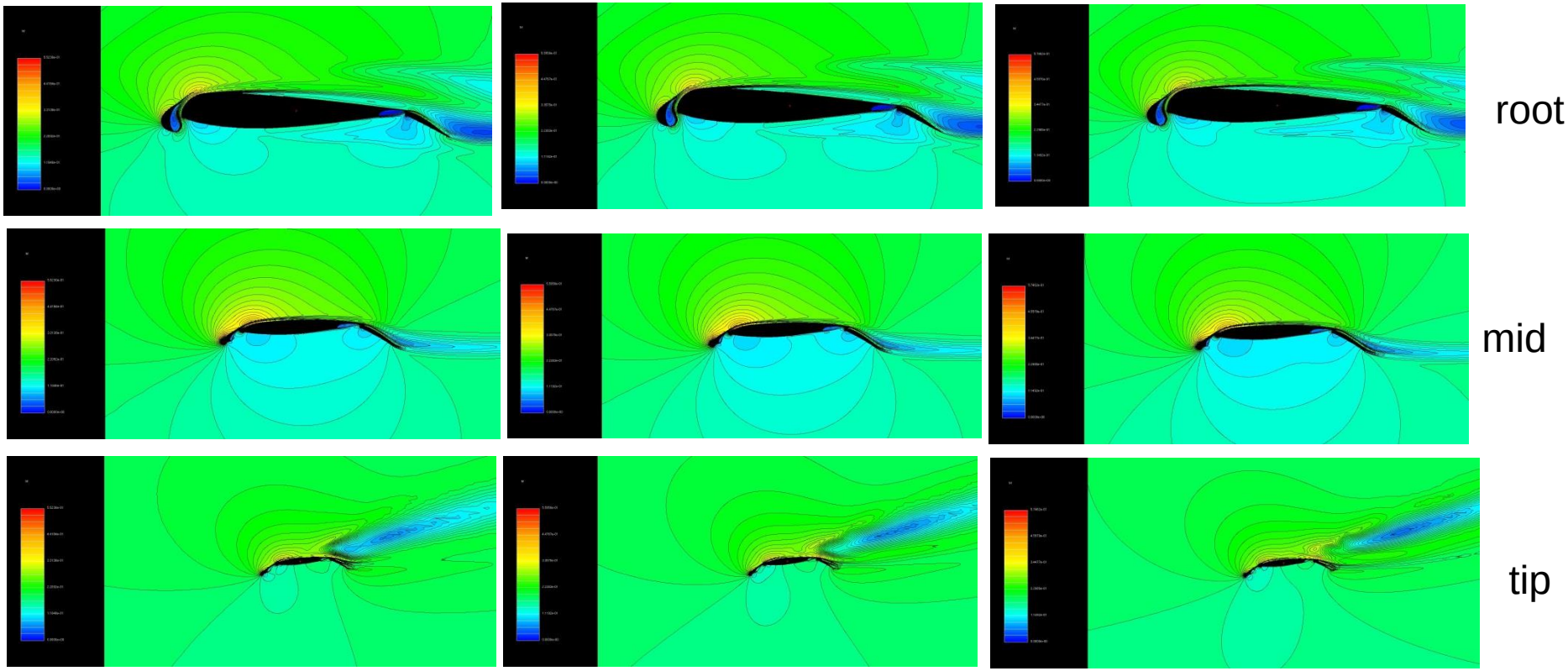
mid

tip

Coarse Medium Fine

Mach contours (α=16°)

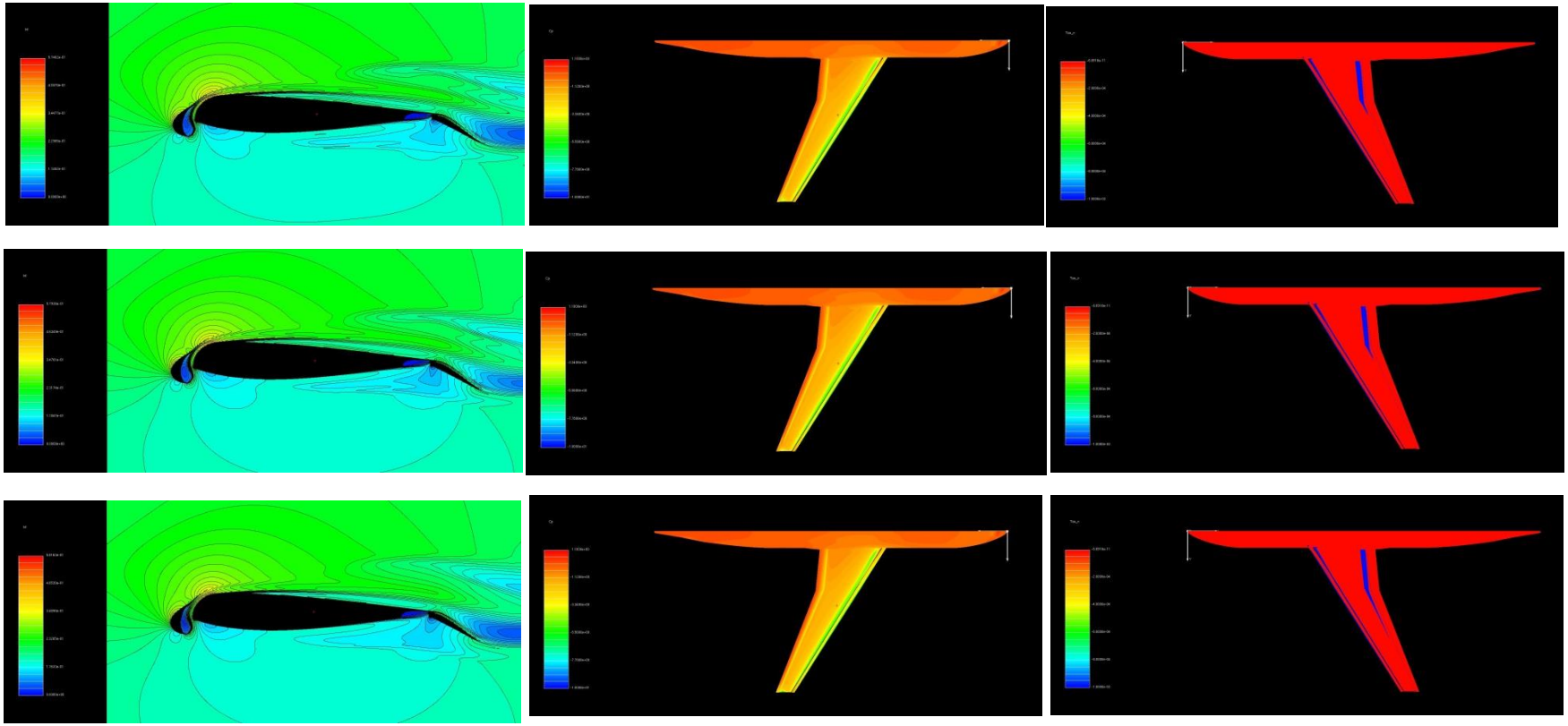
k-ε-R_t



Coarse Medium Fine

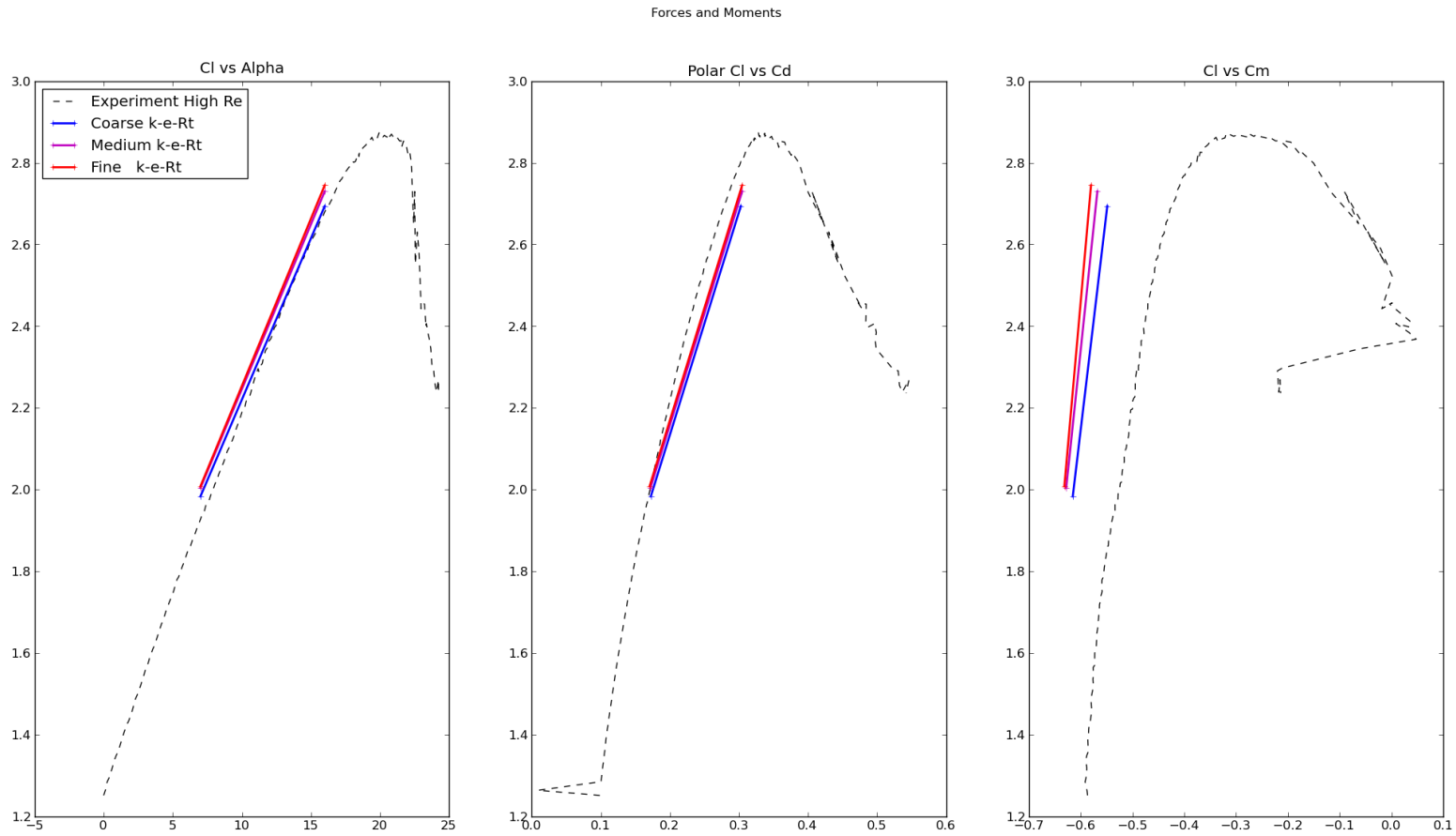
Fine grid contours (α=16°)

k-ε-R_t , SST, S-A

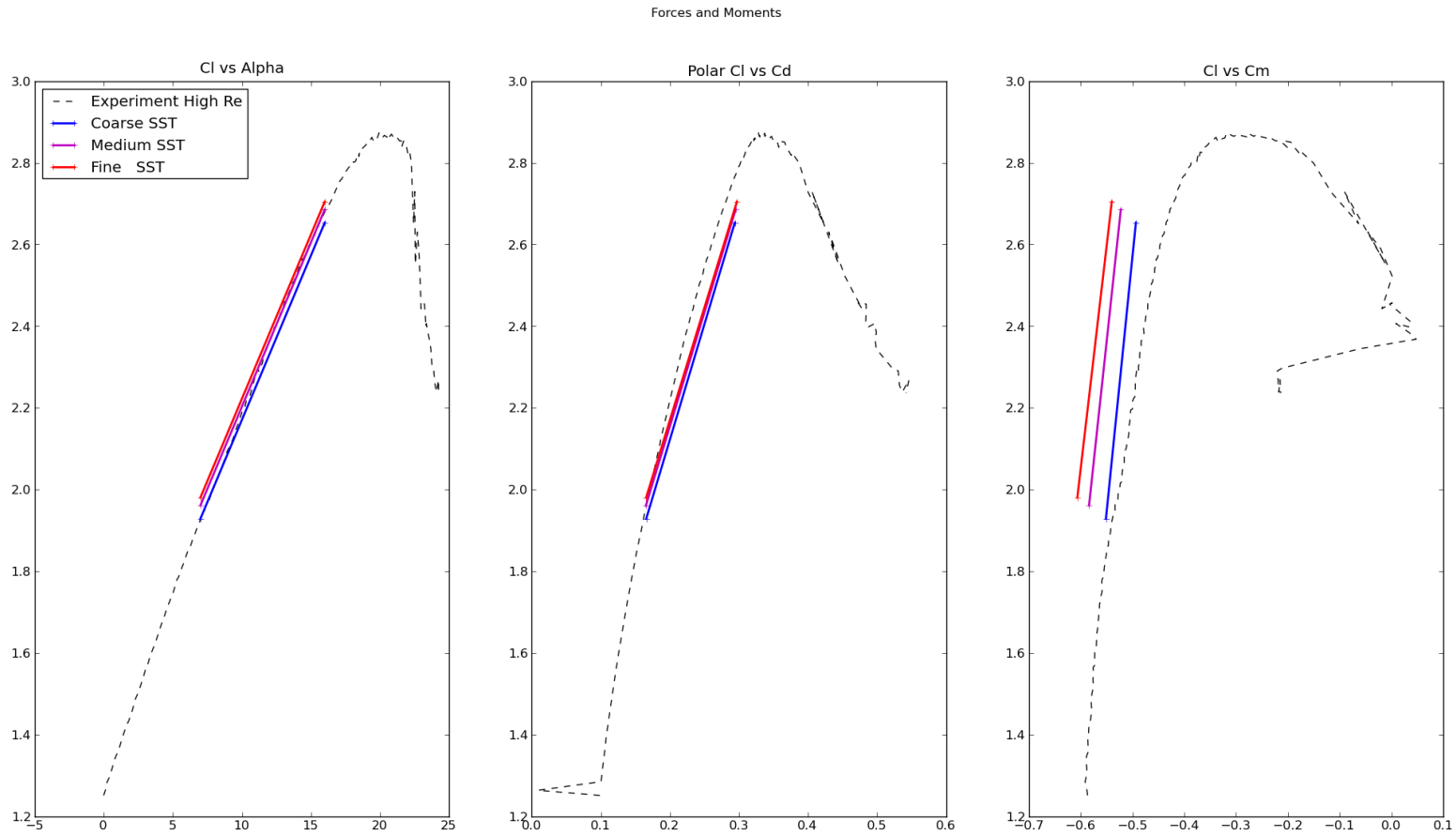


Root Mach Upper Cp Lower τ_x

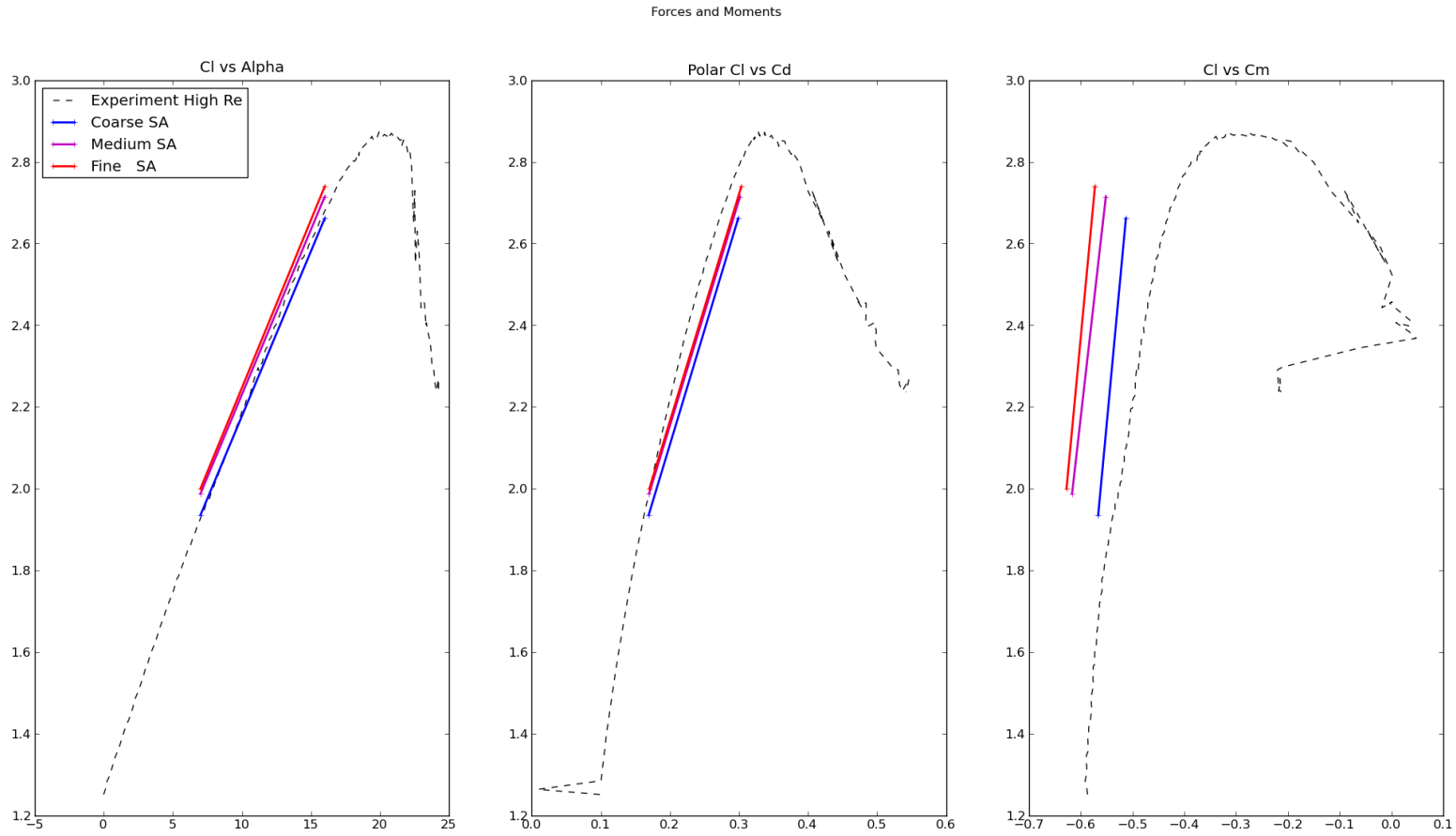
Case 1 Forces/Moments Summary (k-ε-Rt)



Case 1 Forces/Moments Summary (SST)



Case 1 Forces/Moments Summary (SA)



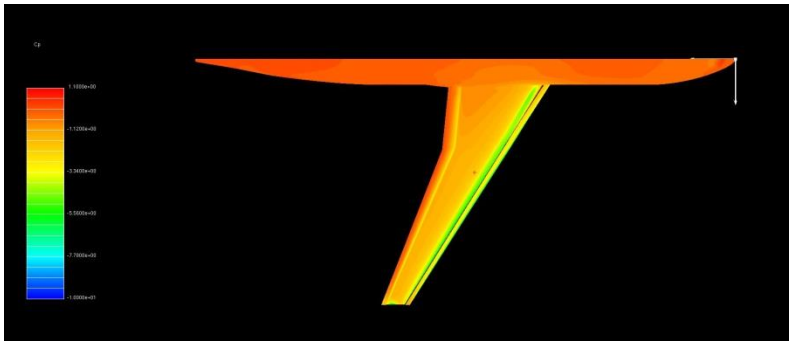
Precon. vs. Non-precon.

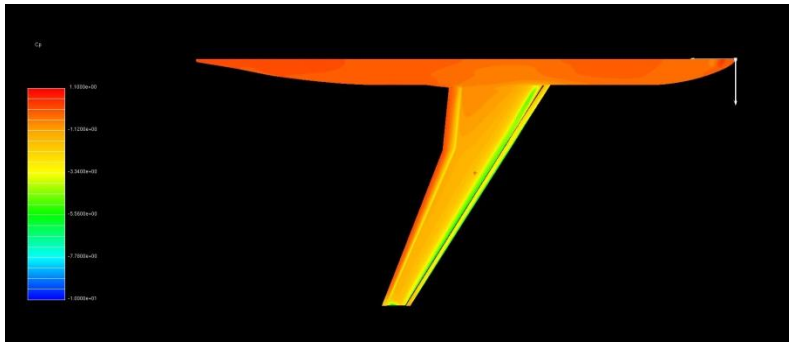
- As a unique exercise for this Workshop we ran both pre-conditioned and non-preconditioned modes to answer the often asked questions:
  1. What is the effect of pre-conditioning?
  2. Which approach is better?
- Both modes were used on coarse, medium and fine grids
- As expected, preconditioned results show better and much faster grid convergence
- On the finest meshes, non-preconditioned results edge toward the preconditioned ones as seen in the following slides

Precon. vs. non-precon. α=16°

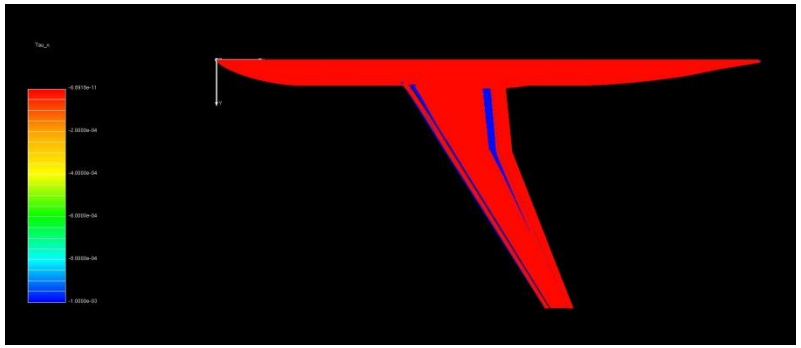
S-A MODEL, FINE MESH

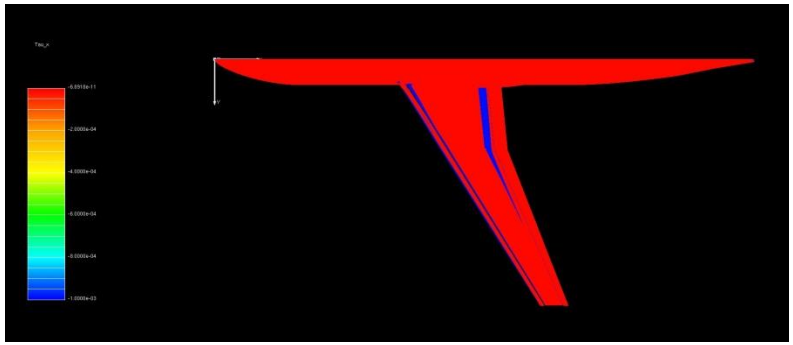
- Non-preconditioned
- Preconditioned





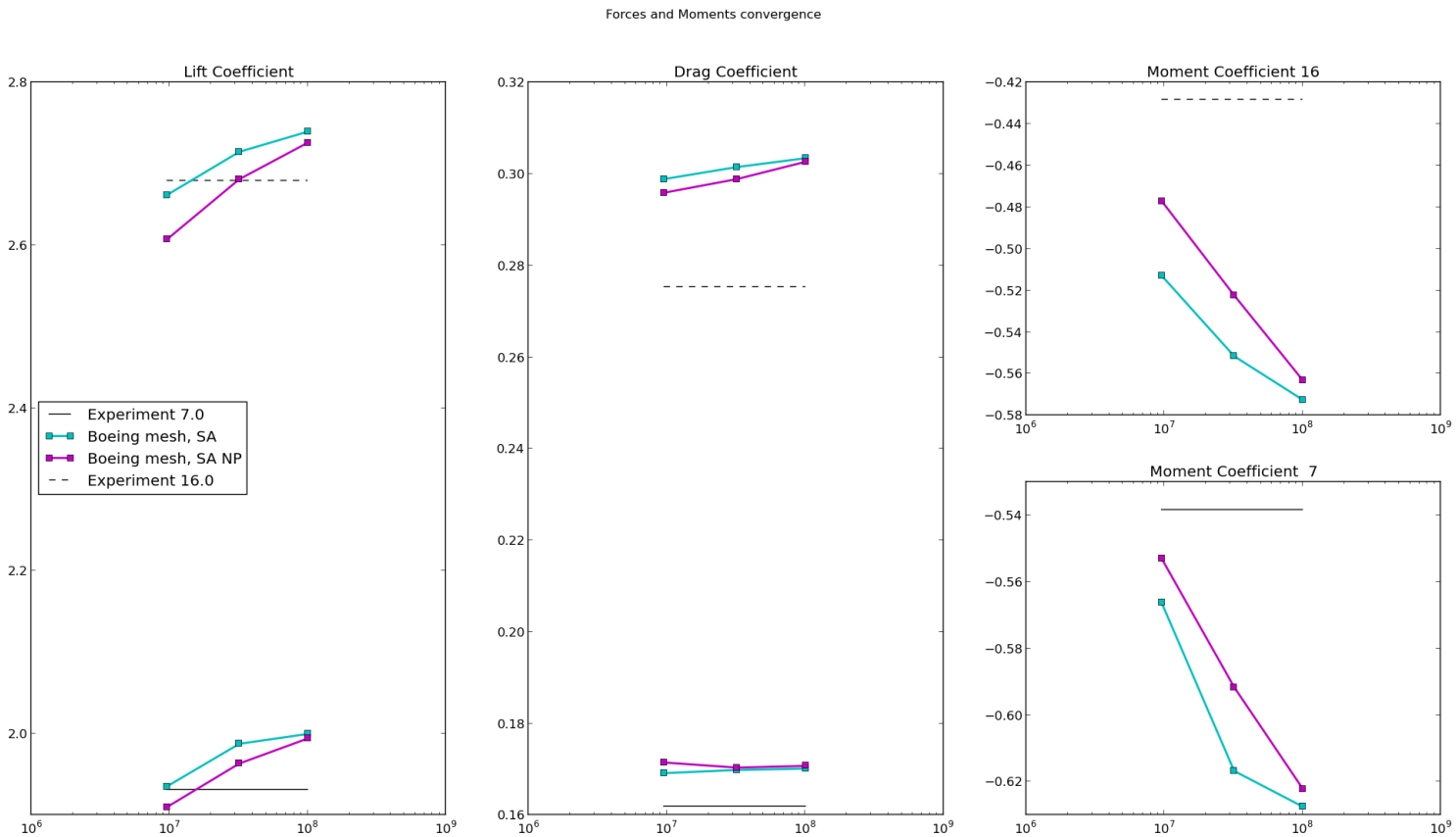
Upper Cp





Lower τ_x

Precon. vs. Non-precon. (S-A)



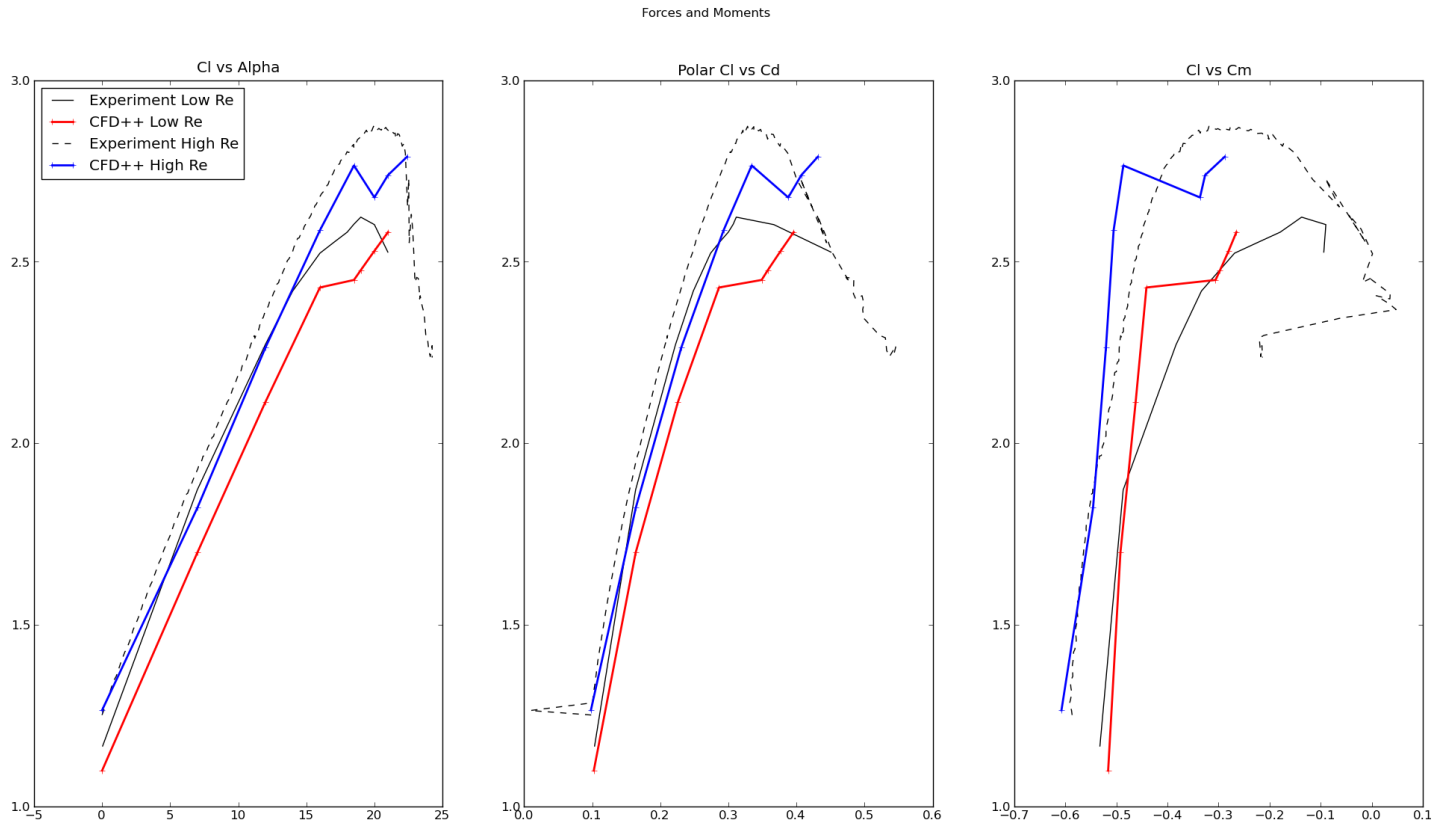
DLR F11 Cases 2 (forces & moments)

- Prisms/Tets mesh (medium grid)
- Pointwise (C_uns_mix_Case2Config4_v1)

MESH	No. of cells
Medium	149,963,804

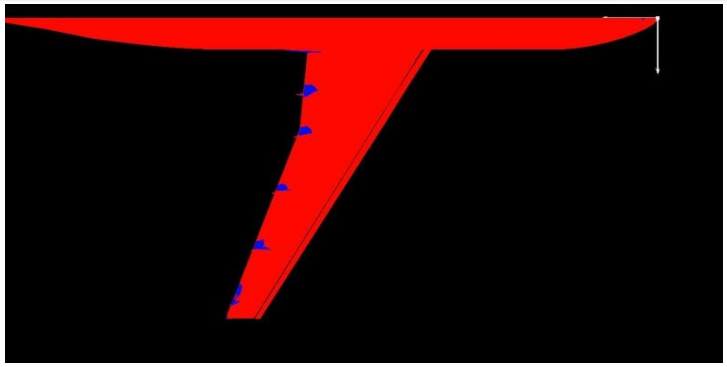
DLR F11 Case 2(a+b) (forces & moments)

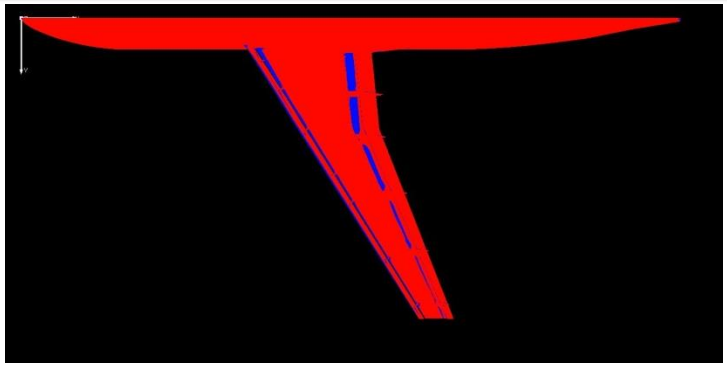
S-A Model



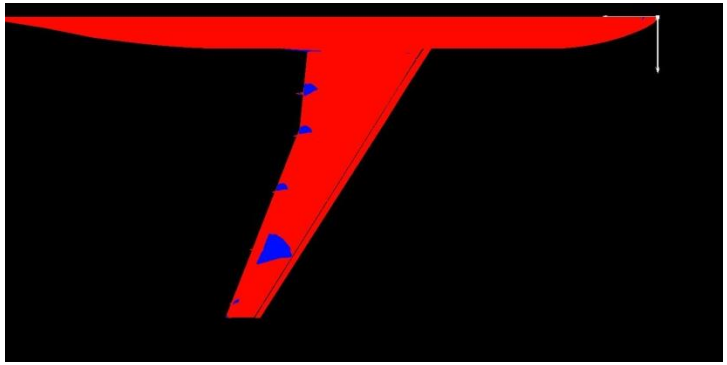
DLR F11 Case 2a (τ_x)

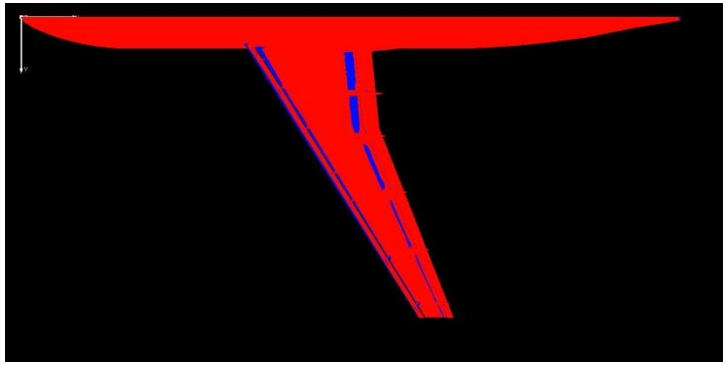
16.0°



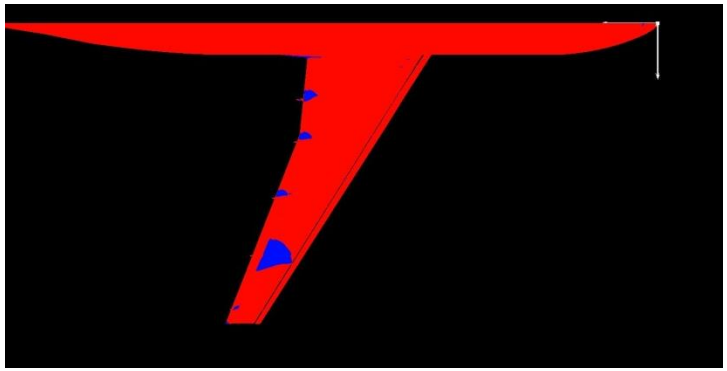


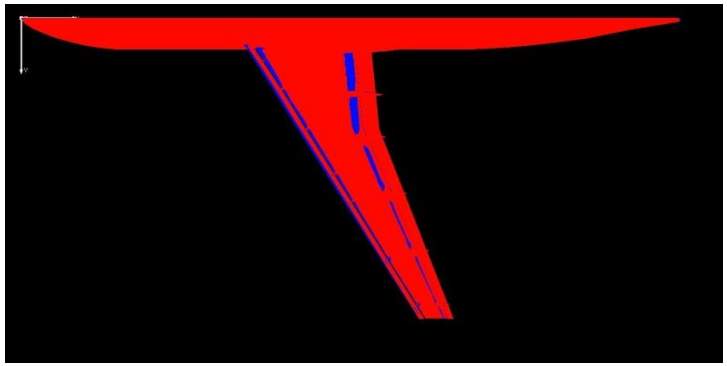
18.5°



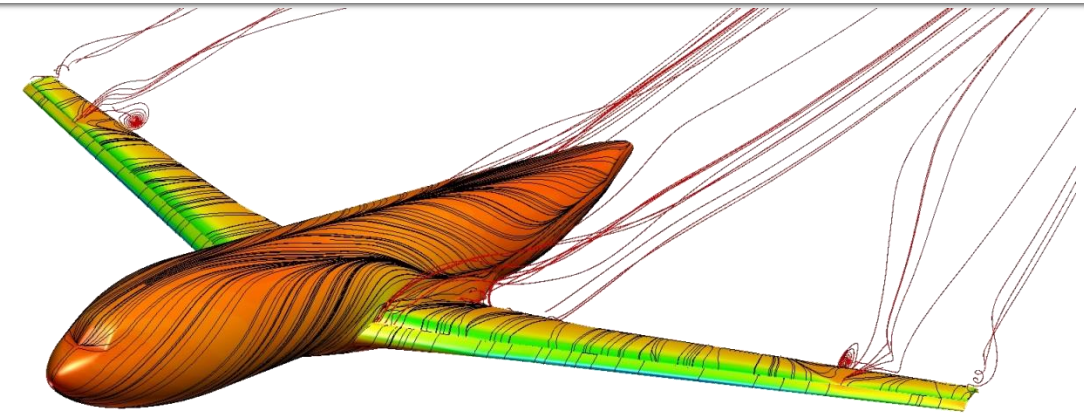


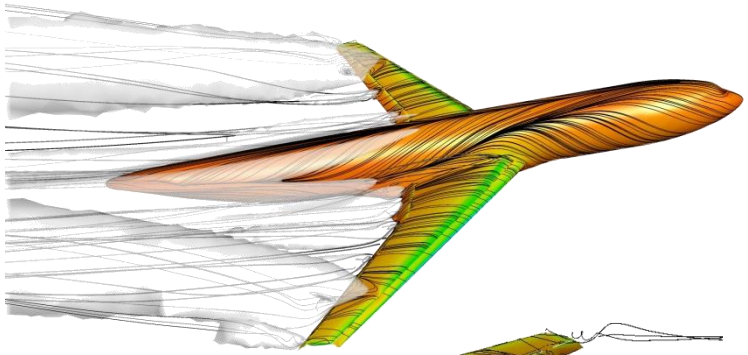
20.0°

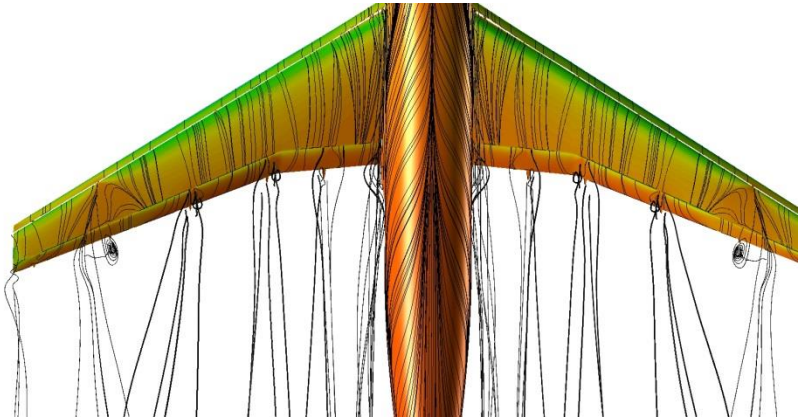


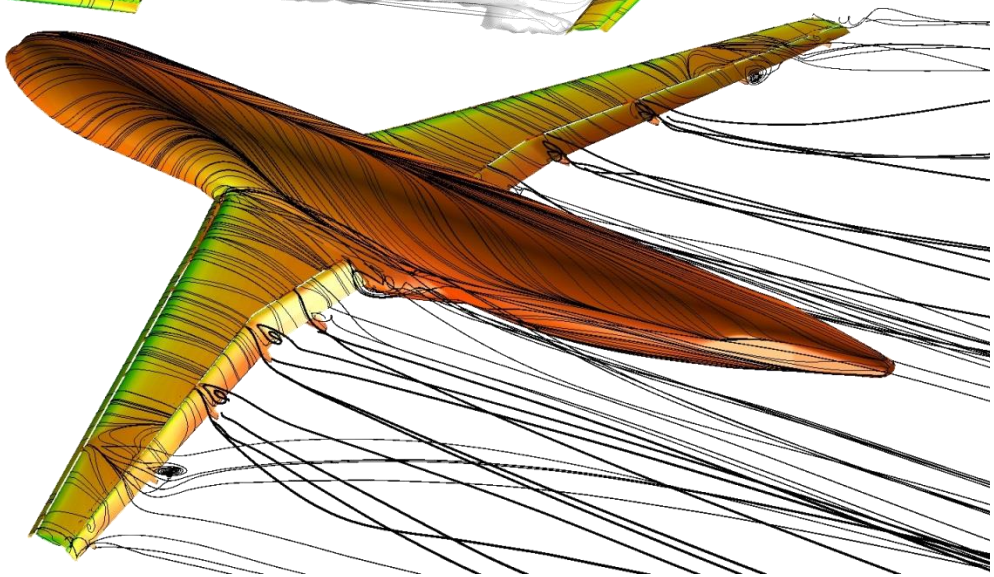


DLR F11 Case 2a



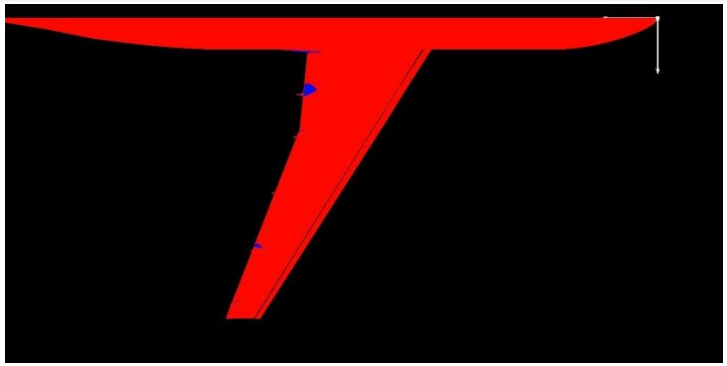


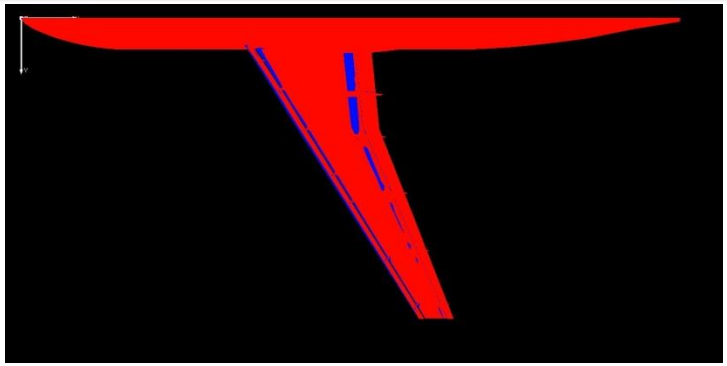




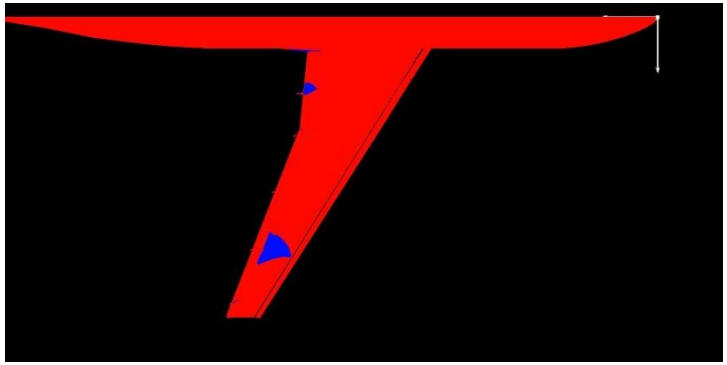
DLR F11 Case 2b (τ_x)

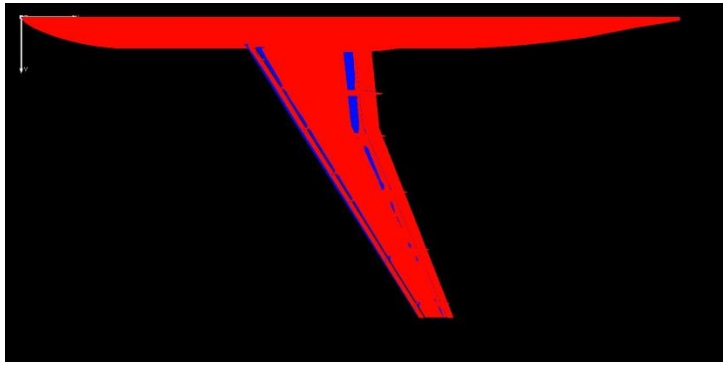
18.5°



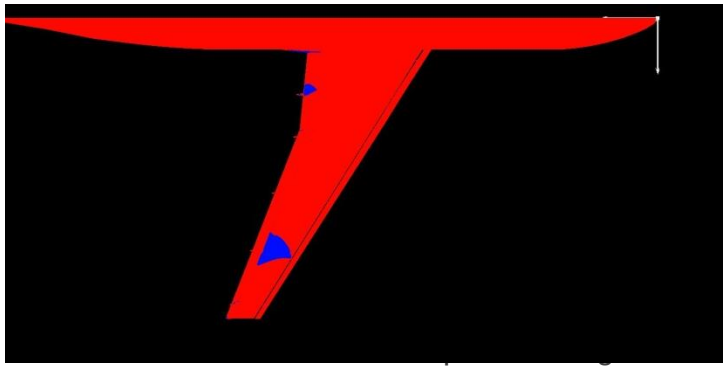


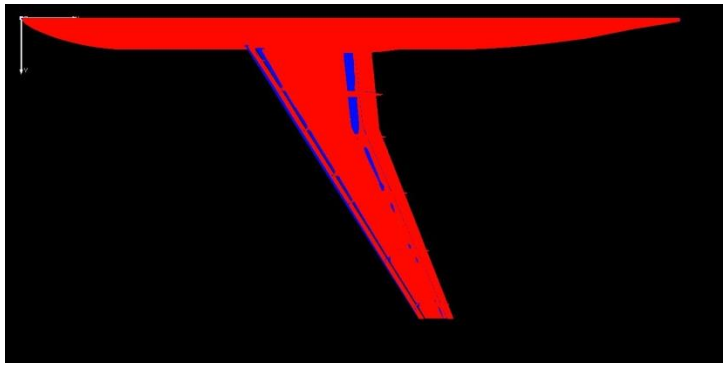
20.0°





21.0°





Summary and Conclusions

- CFD++ flow solver used for DLR F11 high-lift flow computations
- k-ε-R_t, SST and S-A turbulence models invoked on various unstructured and structured meshes provided by NASA
- Predictions on medium and fine grids very close for $C\ell$, Cd
- Preconditioning enables faster and better grid convergence than non-preconditioned computations
- S-A closure predictions shown for Cases 2 (a) and (b)
- High Reynolds predictions closer to data than the low-Re ones (may be a transitional effect not taken into account)