Metacomp Technologies, Inc.
CRL India
Chicago, June 26-27, 2010

HiLiftWS1

Trap Wing Flow Predictions

- Solver:
  - CFD++, Unified Grid Finite Volume solver
  - Unstructured Mixed-Element Cell-Based
- Turbulence models (no freestream μ_t decay):
  - k-ε-R_t
    - Tu=1.0%, μ_t/μ=20
  - S-A
    - Tu=1.0%, μ_t/μ=3

Trap Wing Flow Predictions

- Solution information (medium grid)
  - Computer Platform:
    - 1800 compute nodes
    - dual intel Xeon quad Core E5365, 3.0 GHz processors 16 GB memory, 72 GB hard disk
  - Processors used: 128 Cores (16 CPUs)
  - Operating System: XC-3.2.1 with latest updates
  - Compiler: GNU C-compiler
  - Run Time:
    - CPU: 49,253 sec., Wall-Clock: 49,365 sec.
  - Memory Requirements: 192 GB (~1.5 GB/CPU)
  - Peak compute: 180 Tflops, sustained compute: 132.8 Tflops

Trap Wing Flow Predictions

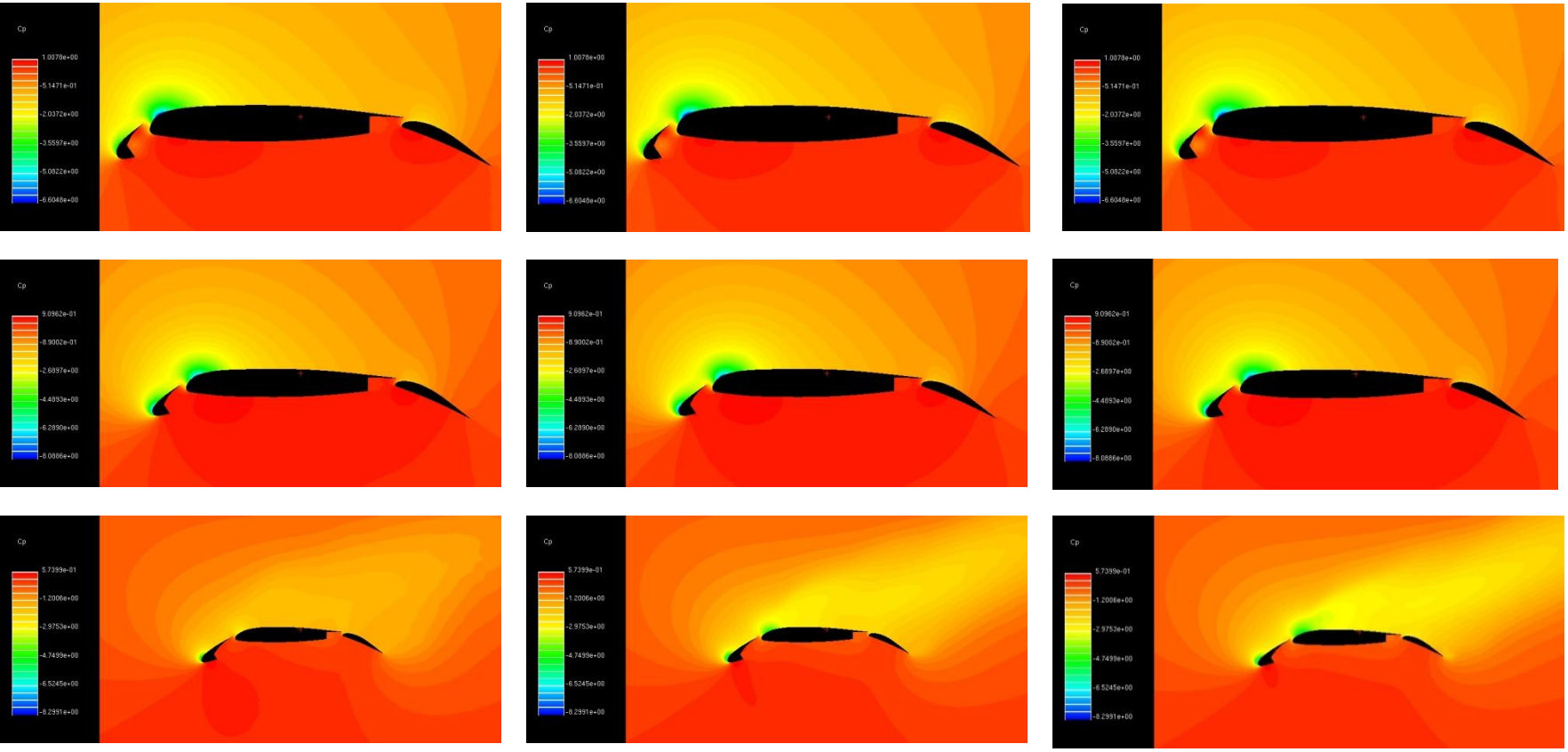
- Tetra mesh (coarse, medium, fine grids)
  - Config. 1
    - k-ε-R_t turbulence model
    - S-A turbulence model
  - Config. 8
    - k-ε-R_t turbulence model
    - S-A turbulence model

Trap Wing Flow Predictions

- Hexa mesh (coarse, medium, fine grids)
  - Config. 1
    - k-ε-R_t turbulence model
  - Config. 8
    - k-ε-R_t turbulence model

Cp contours (α=28°)

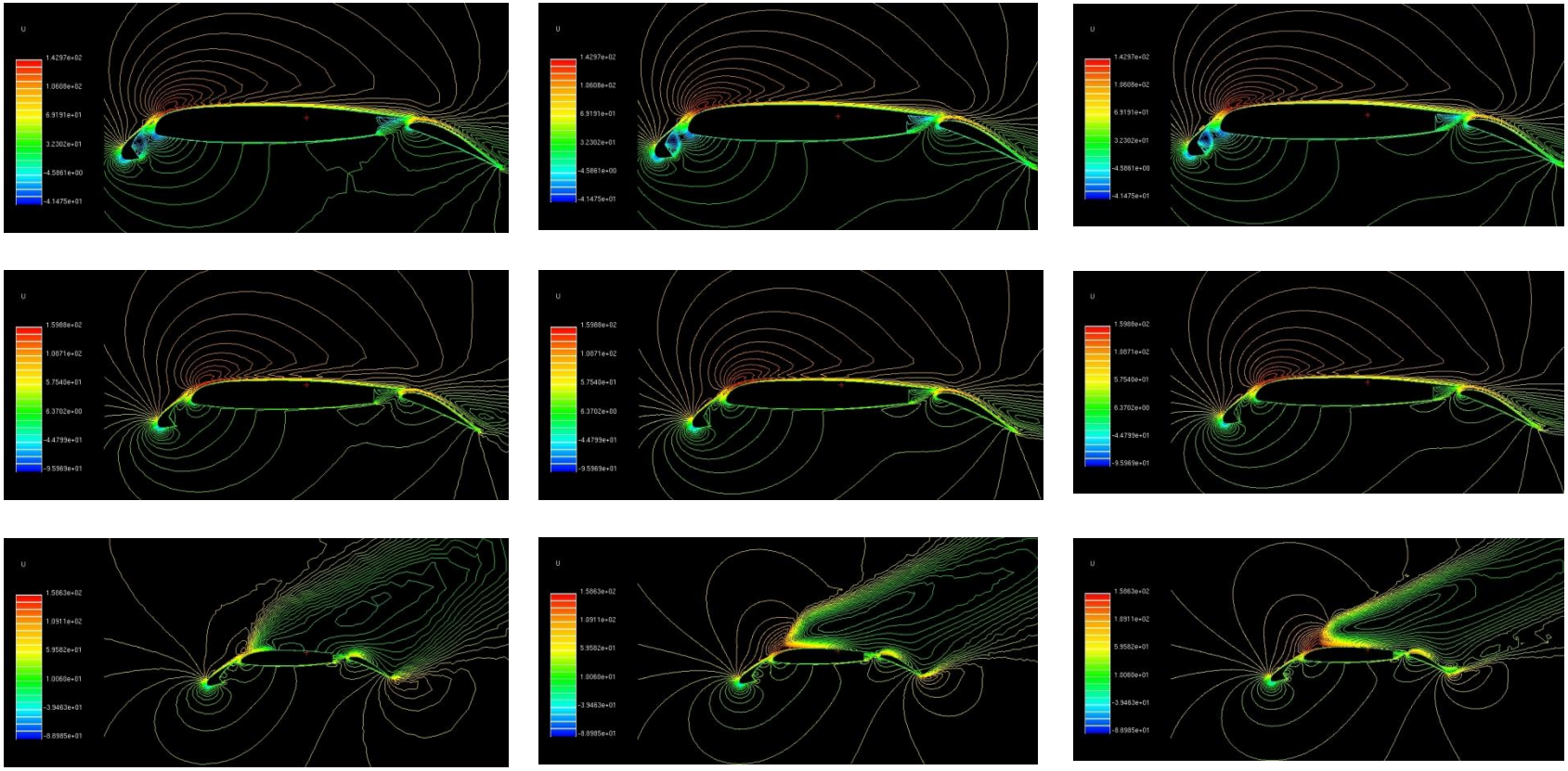
Tet mesh, config 1, k-ε-R_t



Coarse Medium Fine

U-vel. Contours (α=28º)

Tet mesh, config 1, k-ε-Rt



root

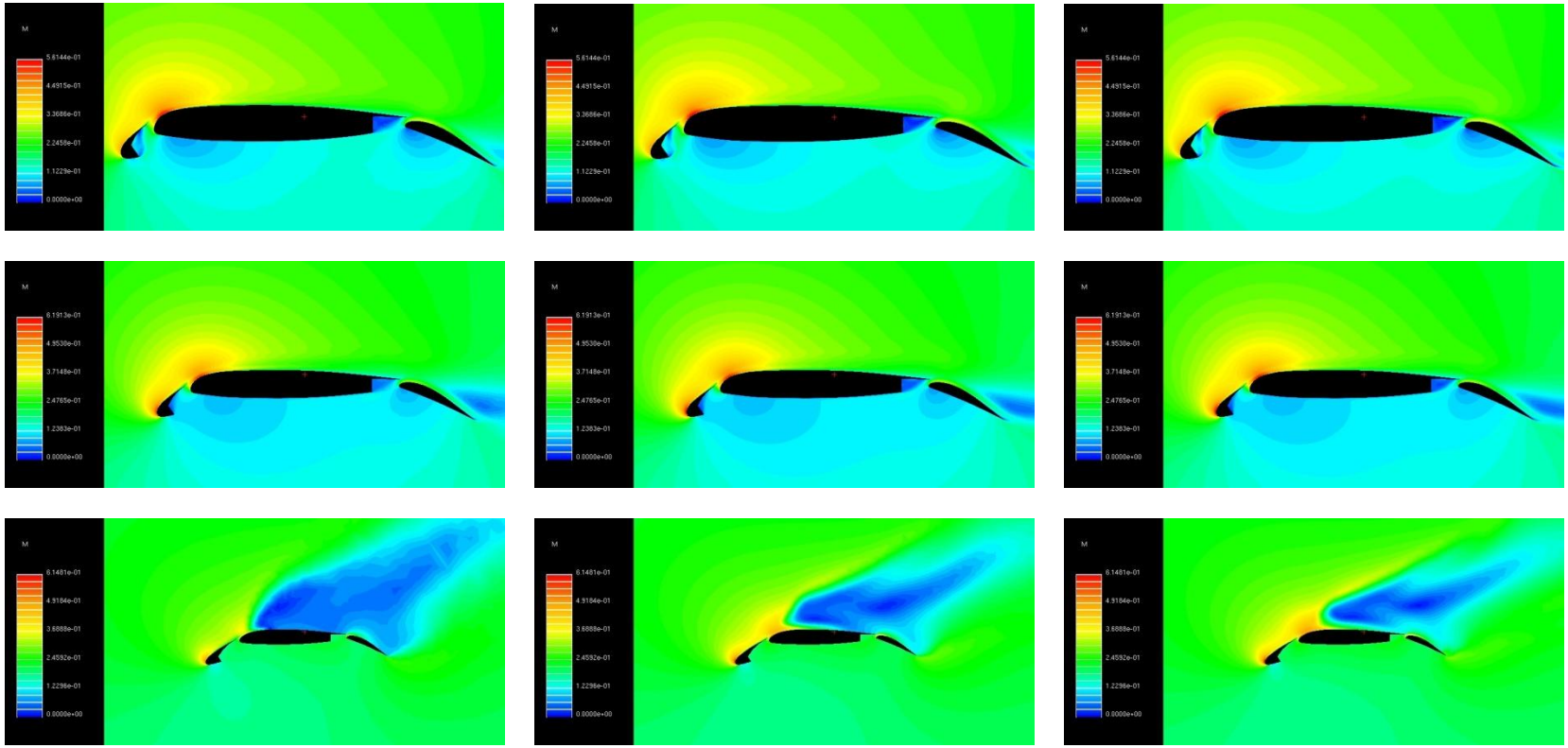
mid

tip

Coarse Medium Fine

Mach contours (α=28°)

Tet mesh, config 1, k-ε-Rt



root

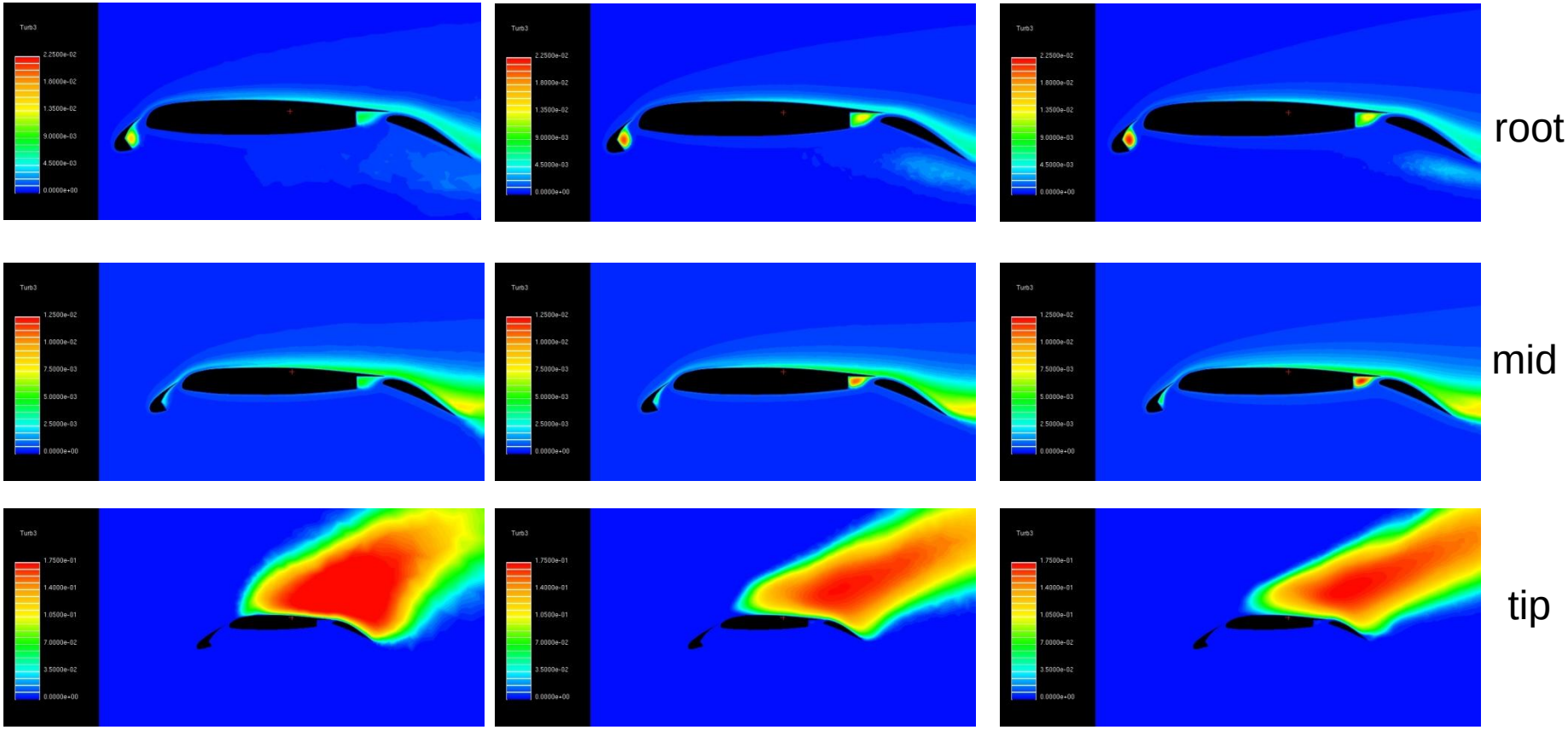
mid

tip

Coarse Medium Fine

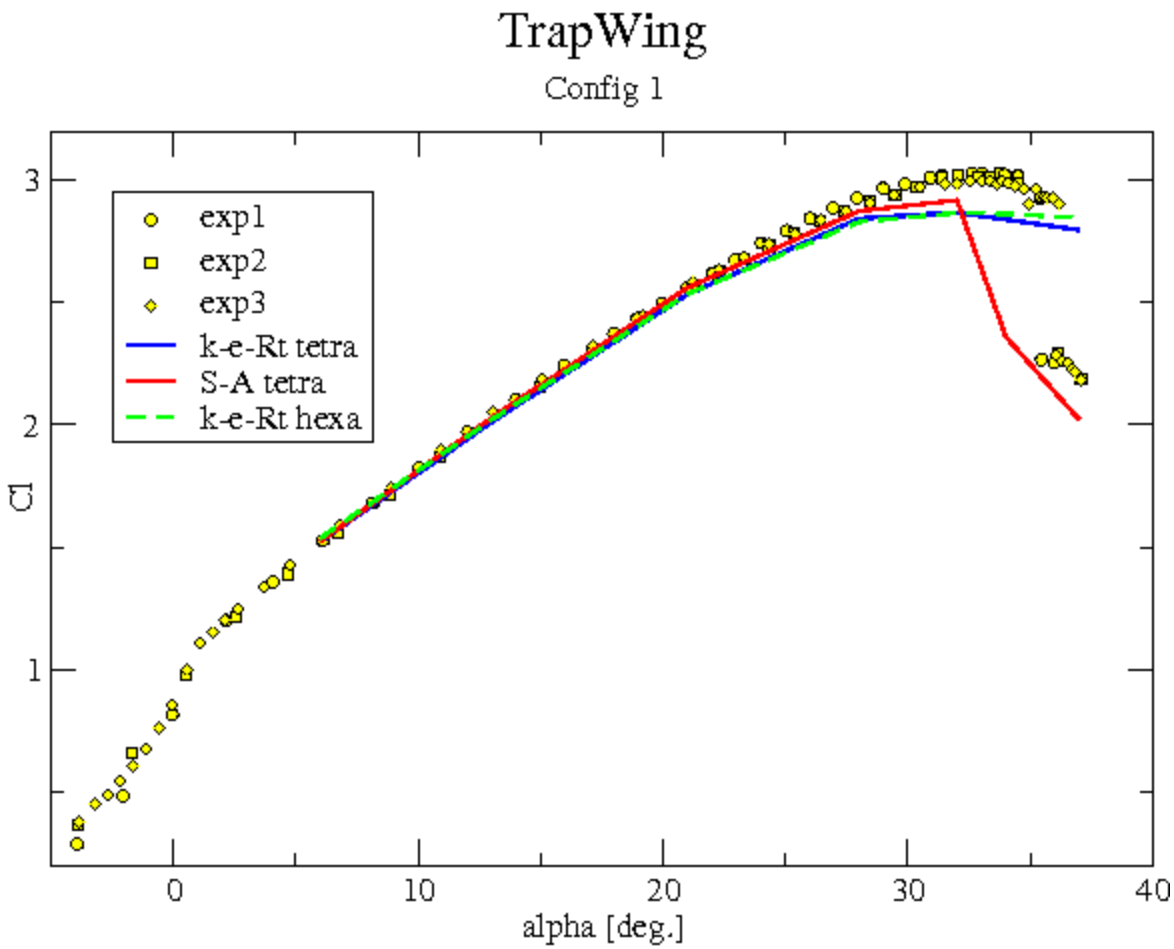
Eddy viscosity contours (α=28°)

Tet mesh, config 1, k-ε-Rt

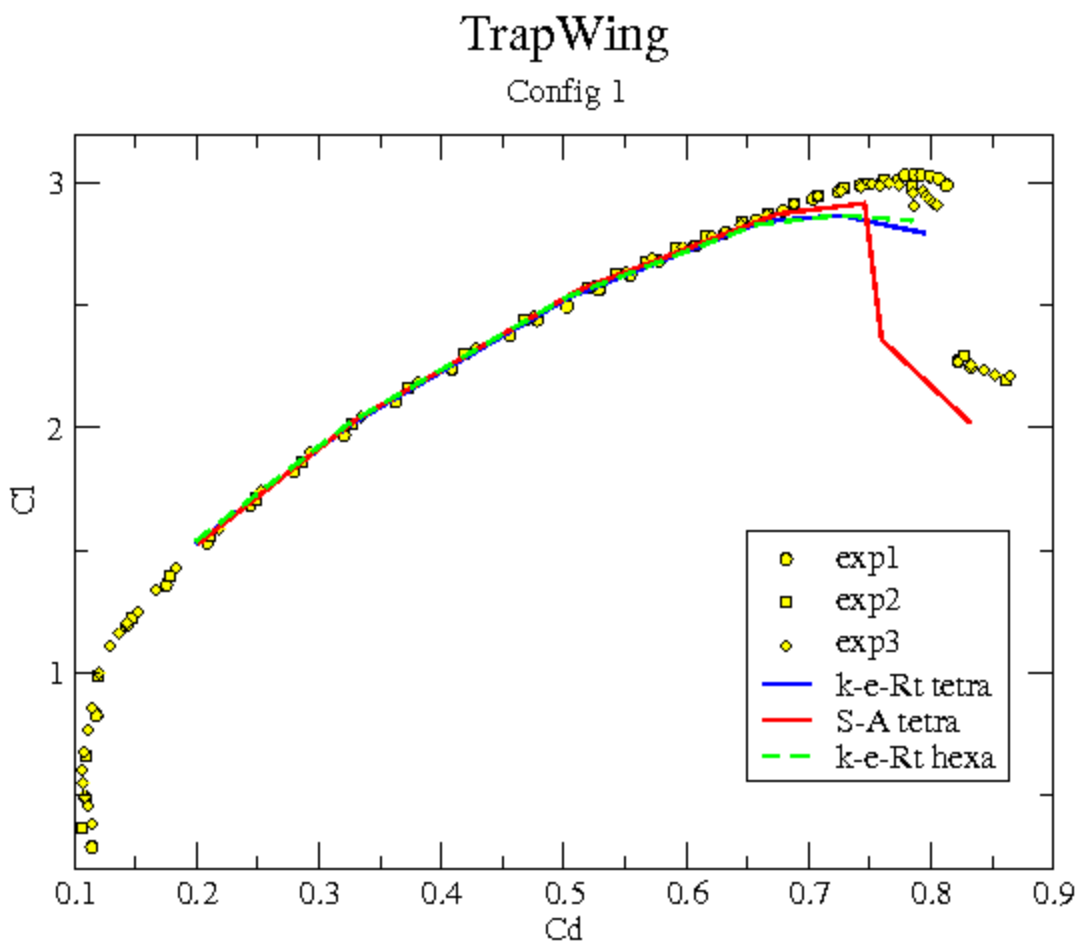


Coarse Medium Fine

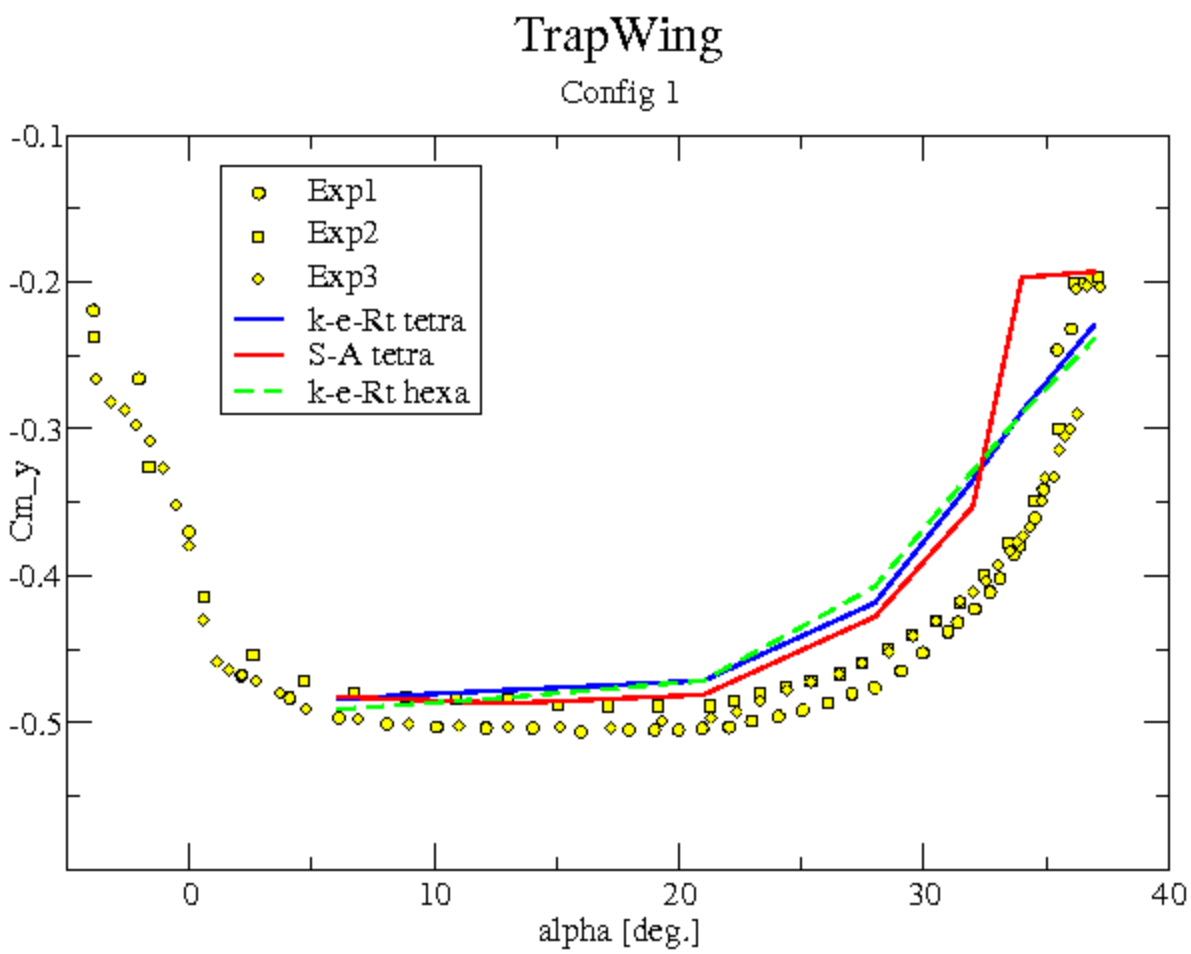
Forces and Moments (1)



Forces and Moments (2)



Forces and Moments (3)

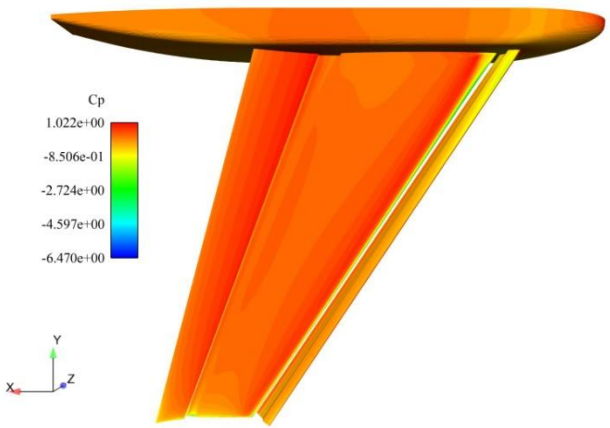


Forces and Moments (4)

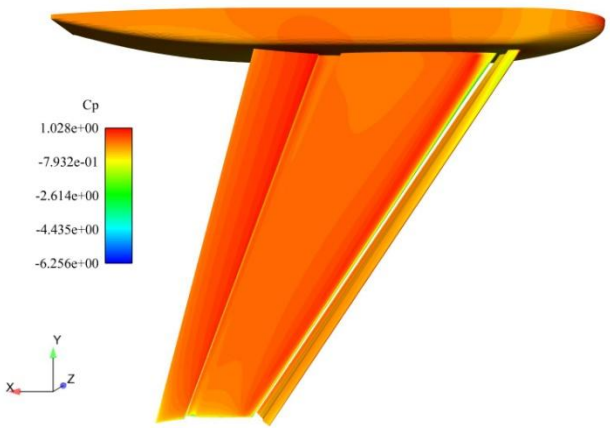
Grid	α [deg.]	C_ℓ	C_d	C_m
Tetra fine	13	2.0160	0.3249	-0.4813
	28	2.8680	0.6660	-0.4318
Hexa fine	13	2.0260	0.3261	-0.4856
	28	2.8605	0.6636	-0.4247
Δ [%]	13	0.49	0.37	0.89
	28	-0.26	-0.36	-1.67

Cp contours, Config 1, α=6°

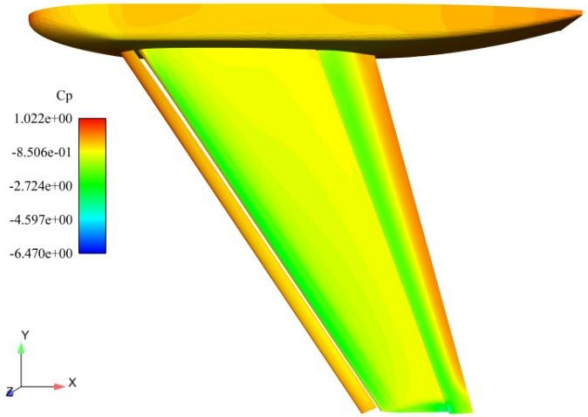
(tet mesh)



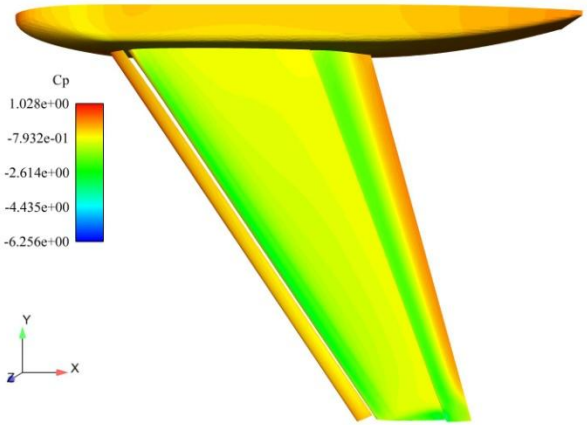
Pressure side, k-ε-R_t



Pressure side, S-A



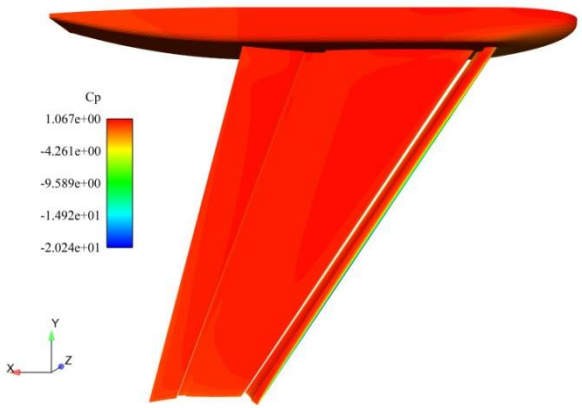
Suction side, k-ε-R_t



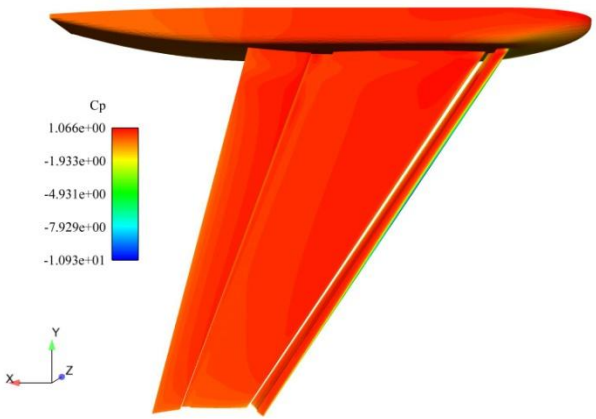
Suction side, S-A

Cp contours, Config 1, α=37°

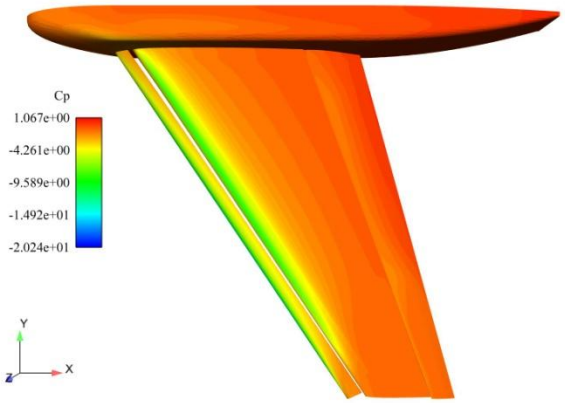
(tet mesh)



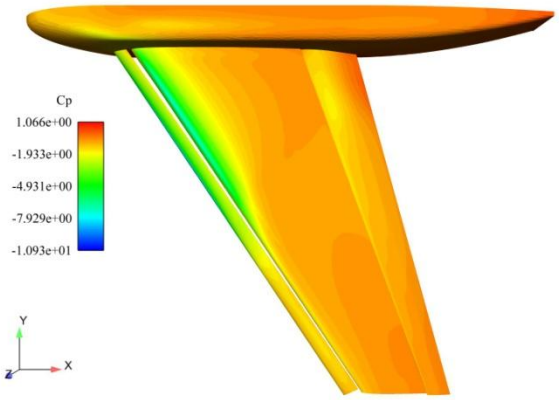
Pressure side, k-ε-R_t



Pressure side, S-A



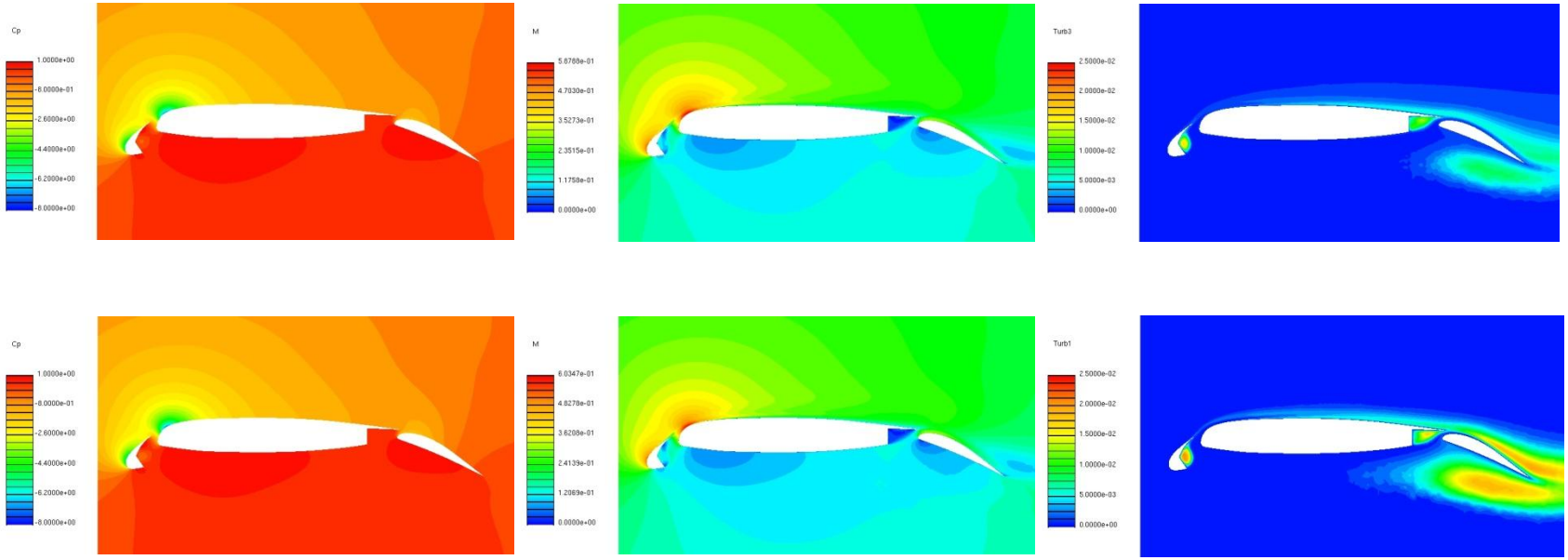
Suction side, k-ε-R_t



Suction side, S-A

$\alpha=32^o$: k-ε-R_t vs. S-A

(tet mesh)



k-ε-R_t

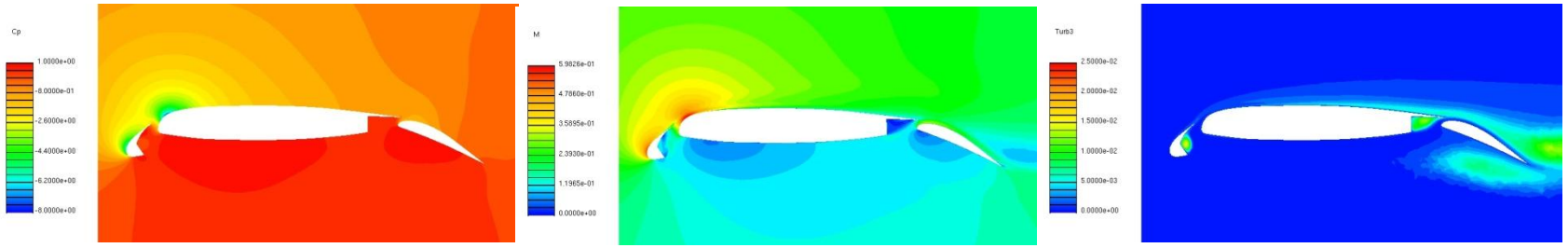
S-A

Cp M R_t, $\tilde{\nu}$

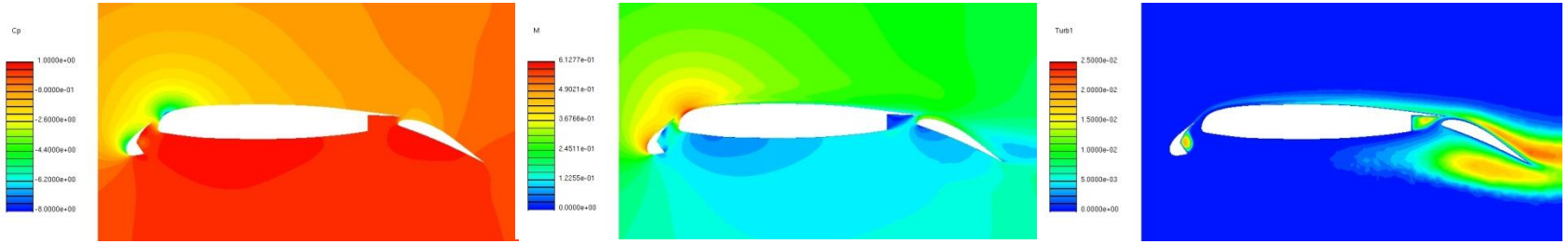
Config 1, η=0.18 (near root)

α=34°: k-ε-R_t vs. S-A

(tet mesh)



k-ε-R_t



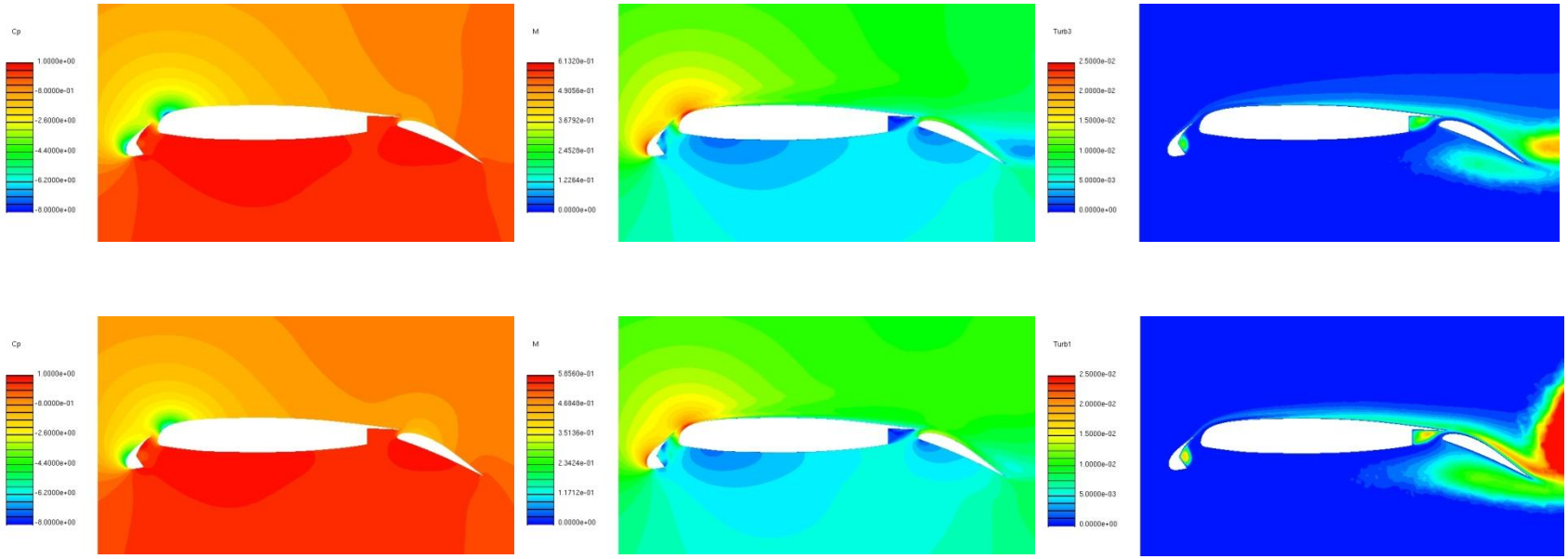
S-A

Cp M R_t, $\tilde{\nu}$

Config 1, η=0.18 (near root)

$\alpha=37^o$: k-ε-R_t vs. S-A

(tet mesh)



k-ε-R_t

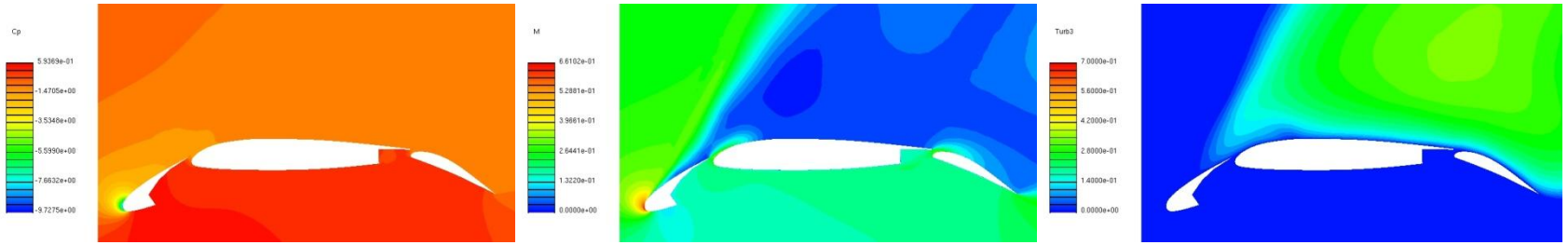
S-A

Cp M R_t, $\tilde{\nu}$

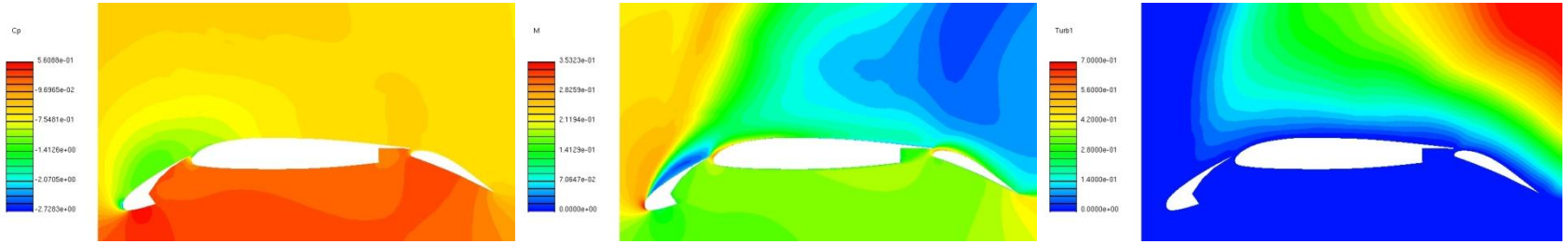
Config 1, η=0.18 (near root)

α=37°: k-ε-R_t vs. S-A (tip)

(tet mesh)



k-ε-R_t



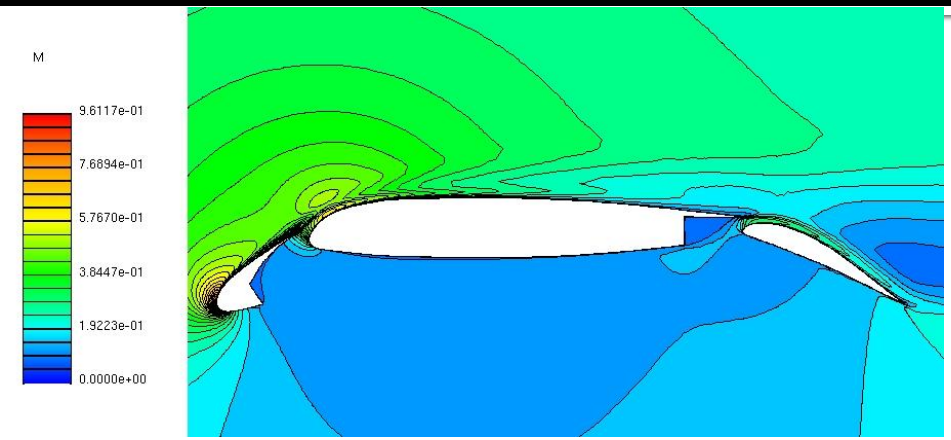
S-A

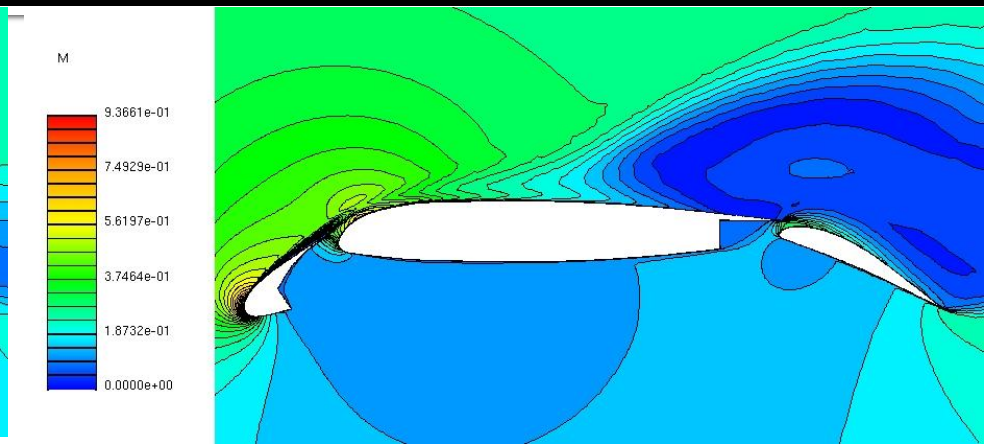
Cp M R_t, $\tilde{\nu}$

Config 1, η=0.98

α=34°: k-ε-R_t vs. S-A **(2/3rd span)**

(tet mesh)





k-ε-R_t

Pre-stall, no flow separation

Correct

S-A

Post-stall, large flow separation

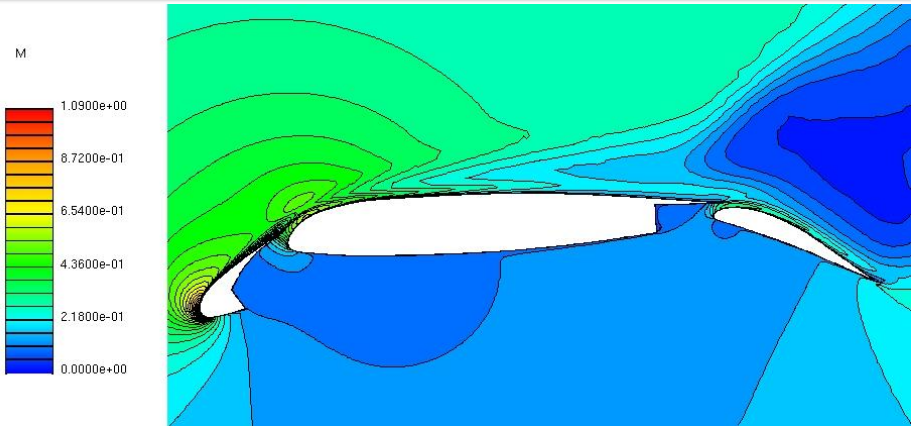
incorrect

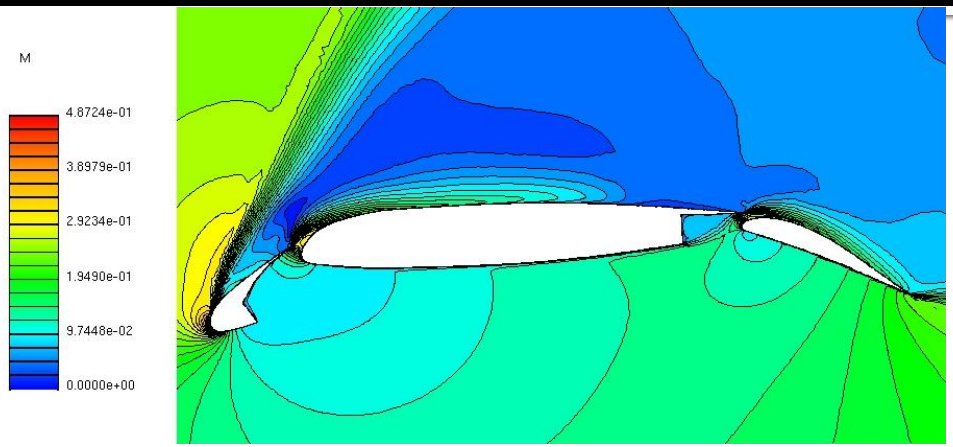
Mach contours

Config 1, η=0.70

$\alpha=37^o$: k-ε-R_t vs. S-A (2/3rd span)

(tet mesh)





k-ε-R_t

Pre-stall, t.e. separation

incorrect

S-A

Post-stall, massively separated

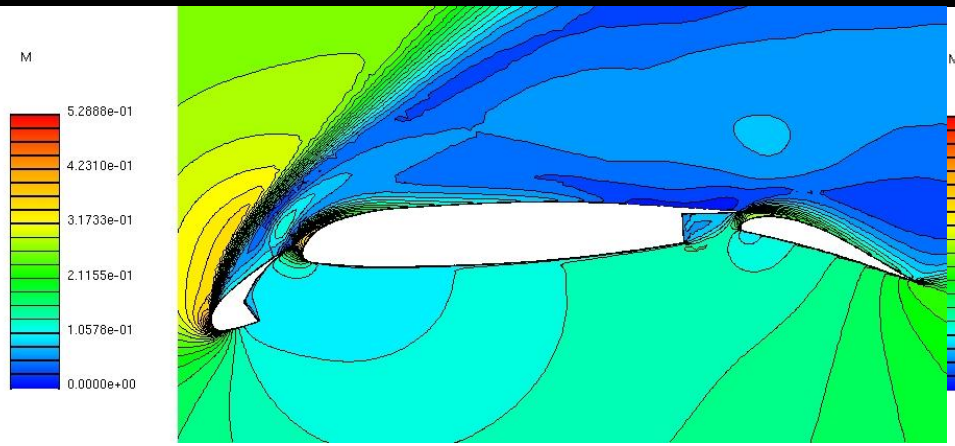
correct

Mach contours

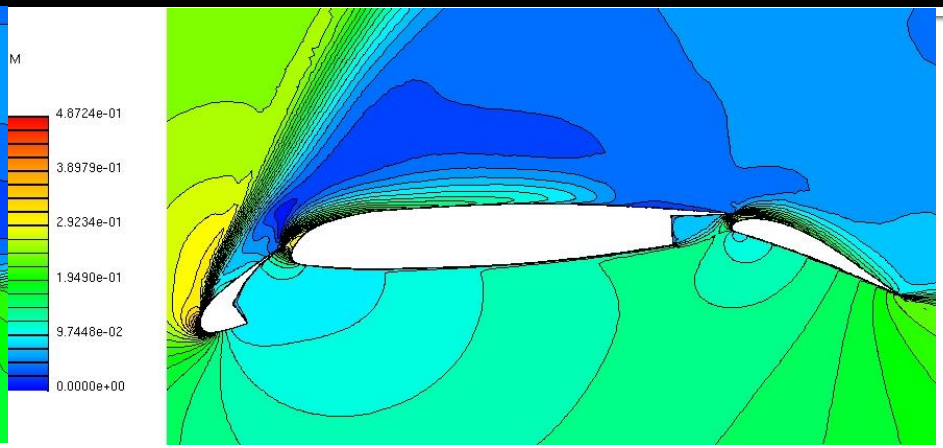
Config 1, η=0.70

α=37° S-A model **(2/3rd span)**

(tet mesh)



Config 8 (flap 20)



Config 1 (flap 25)

Mach contours, η=0.70

Summary and Conclusions

- CFD++ flow solver used for Trap-Wing flow computations

1. k-ε-R_t and S-A turbulence models invoked on unstructured tetra meshes
2. k-ε-R_t closure invoked on unstructured hexa meshes

- k-ε-R_t model doesn't predict stall by α=37°
- S-A closure predicts stall too soon ($\alpha \approx 33^o$)
- C_ℓ, C_d vs. α predicted within Δ<0.5% between tetra and hexa fine grids
- RANS + eddy viscosity models require more fine-tuning to adequately predict stall