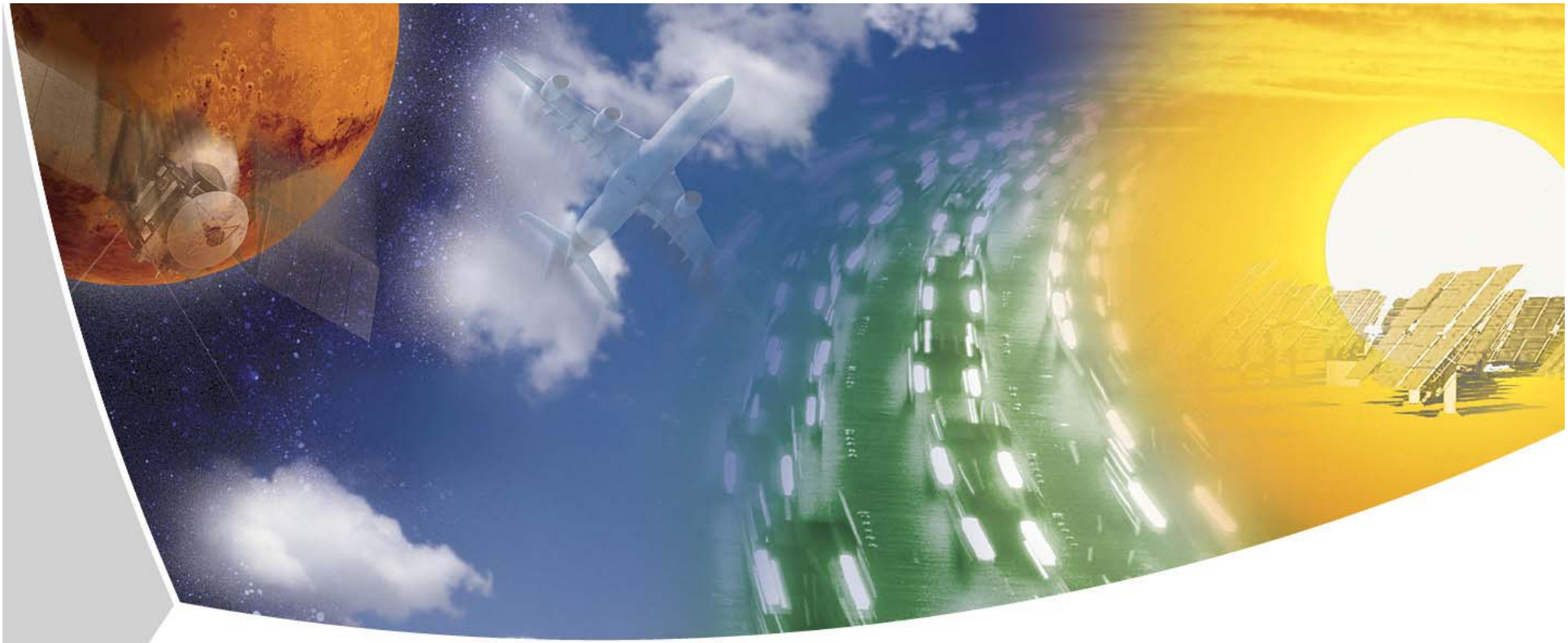

W1 / W2 DPW-3 Results

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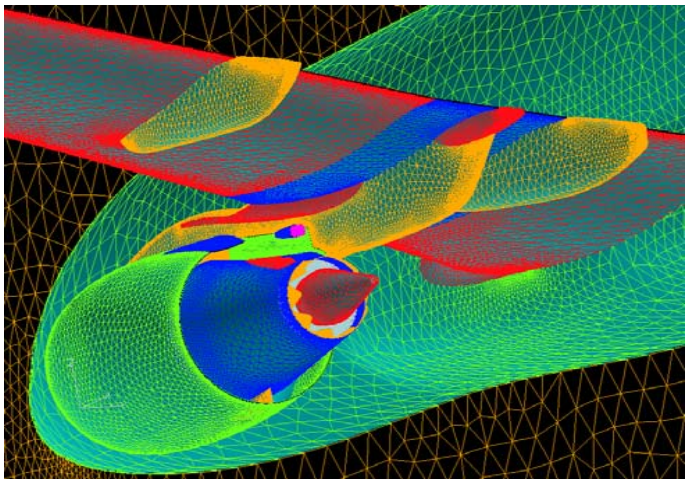
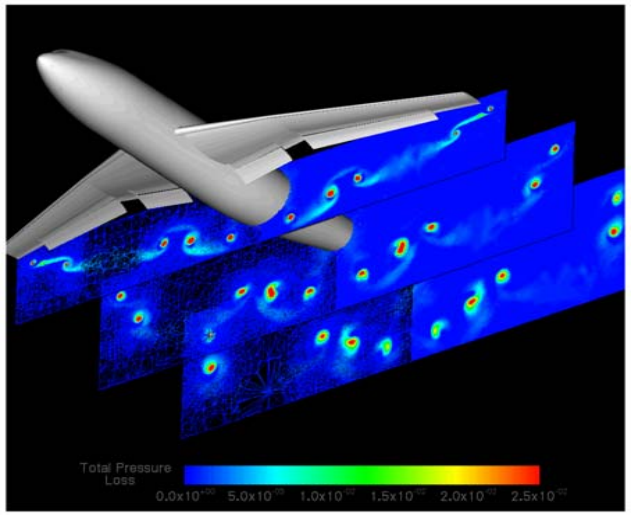
AIAA American Institute of Aeronautics and Astronautics

Unstructured Method: TAU

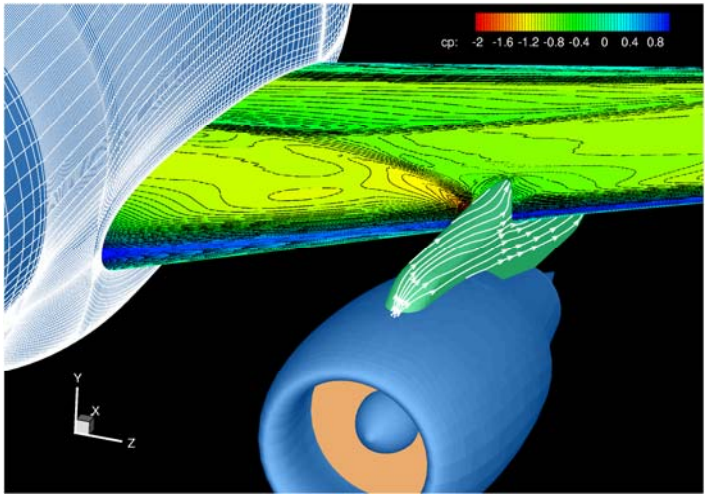
- RANS solver DLR TAU
- Unstructured database
- State-of-the-Art algorithms
- 1- and 2-eq. turbulence models
- Fluid-Structure coupling
- Overlapping grids
- Grid adaptation
- Hypersonic extensions
- C code and Python scripting
- High performance on parallel machines
- Applied in European aircraft industry and research

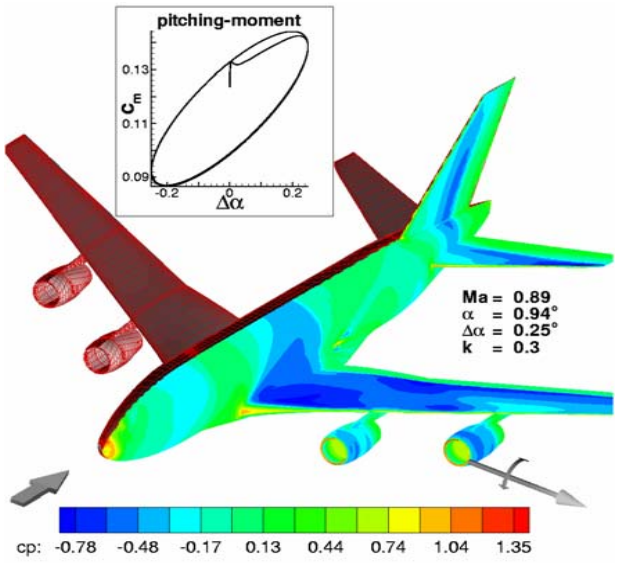




Structured Method: FLOWer

- RANS solver DLR FLOWer
- Structured database
- Advanced turbulence and transition models
- Top-level algorithms (FV, MG, dual time)
- Steady and unsteady flows
- Chimera technique for moving bodies
- Flow / structure coupling
- Design options (inverse design, adjoint)
- Fortran, portable code
- Optimized for vector computers
- Parallelized code

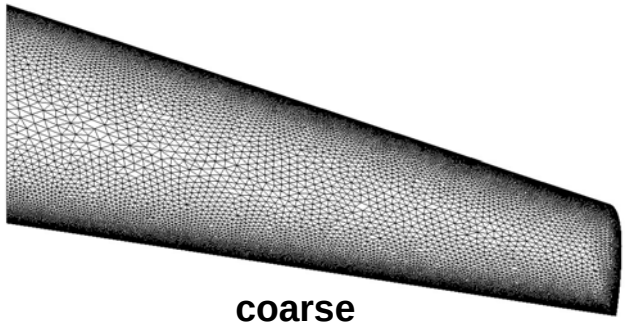




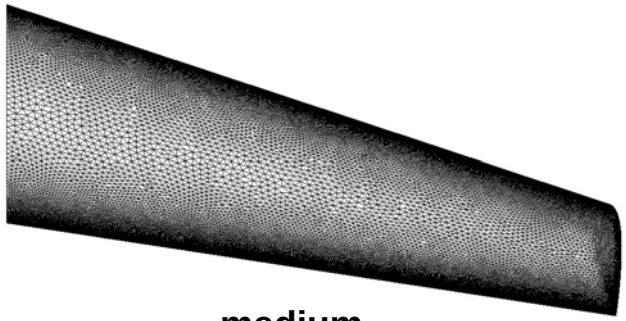
Unstructured Grids

- Unstructured hybrid grids generated with Centaur from Centaursoft
- 3 grid densities
- Specification of sources
- 4. grid by TAU adaptation

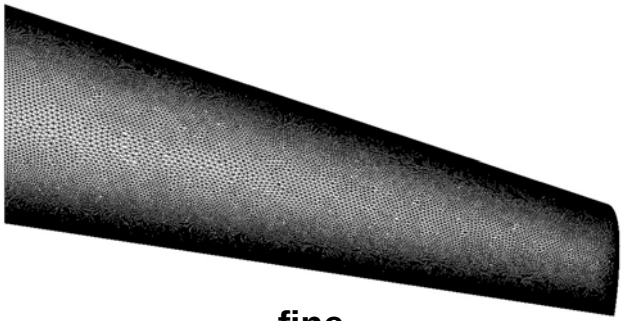
	Coarse	Medium	Fine	Fine Adap
Nodes	2.1 / 1.9	5.3 / 5.0	10.1 / 9.9	17.0 / 16.6
Boundary nodes	49489 51186	113182 114677	186787 188794	355163 352802
Prismatic layers	20	30	40	40



coarse



medium



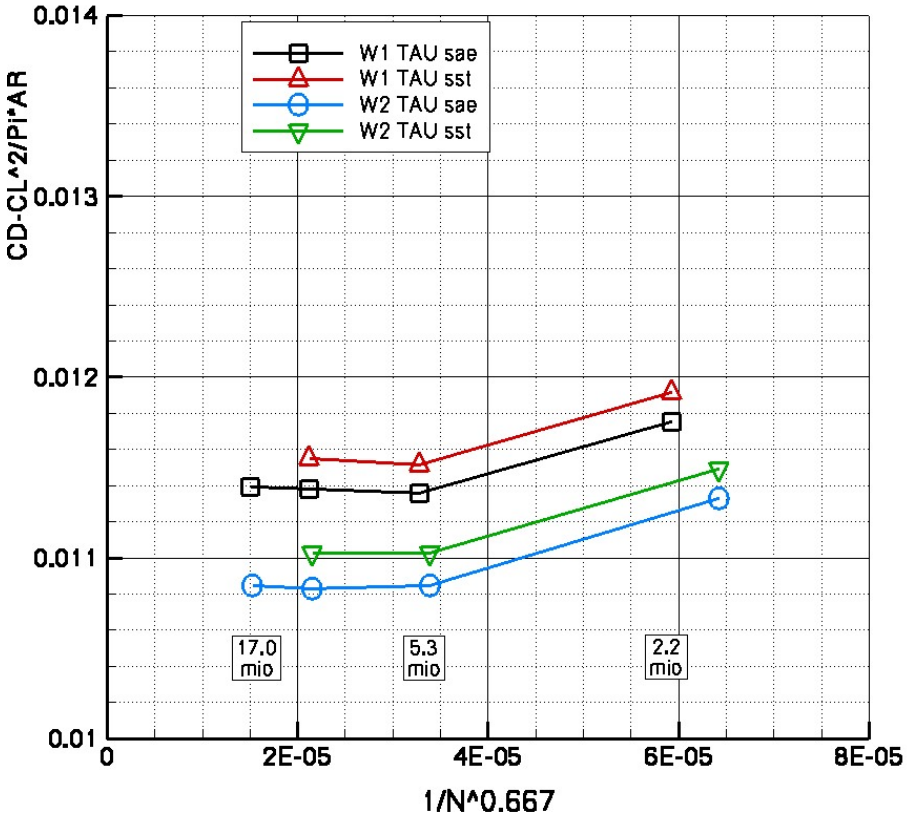
fine

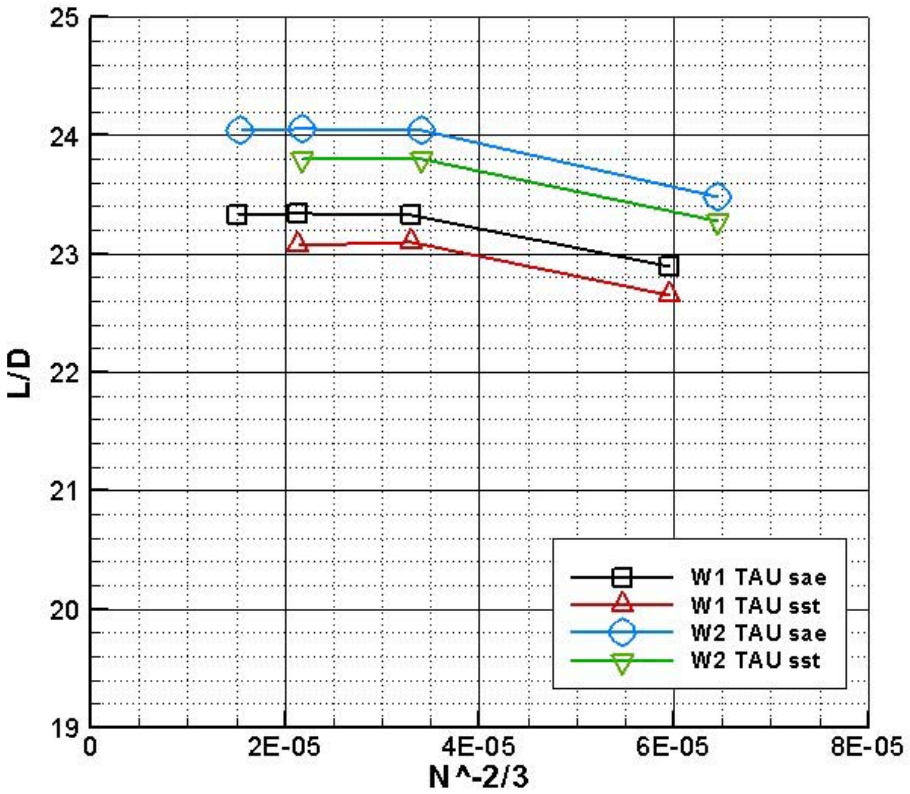
fine adapted

TAU Results

Grid Convergence Study of CD, α=0.5°

Influence of SAE / kw-SST

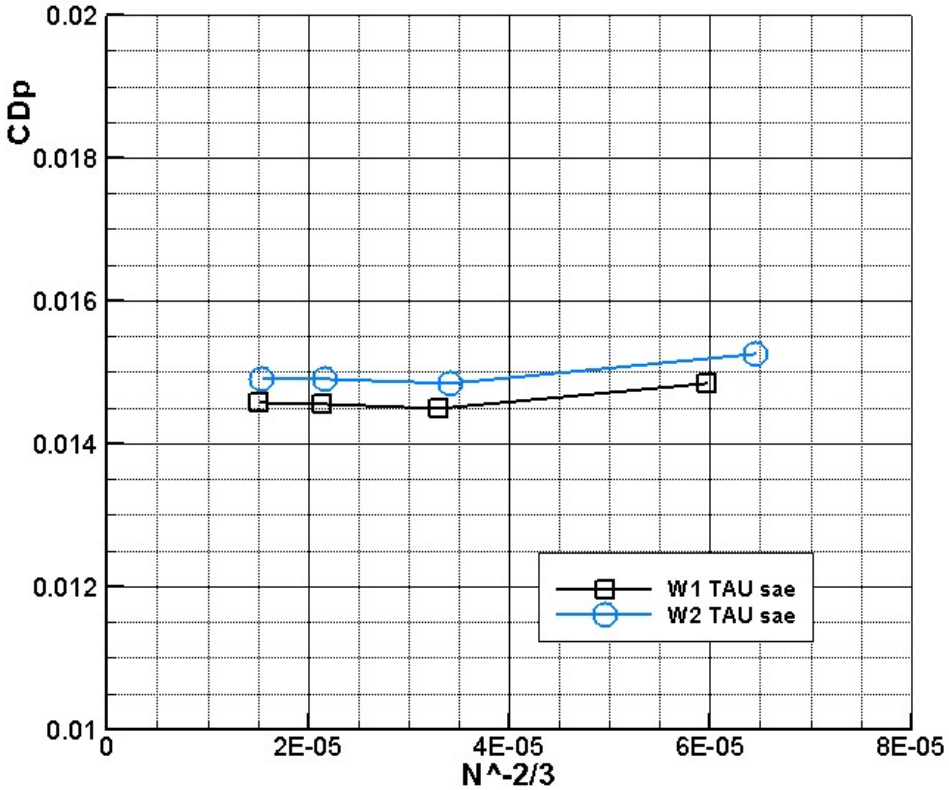


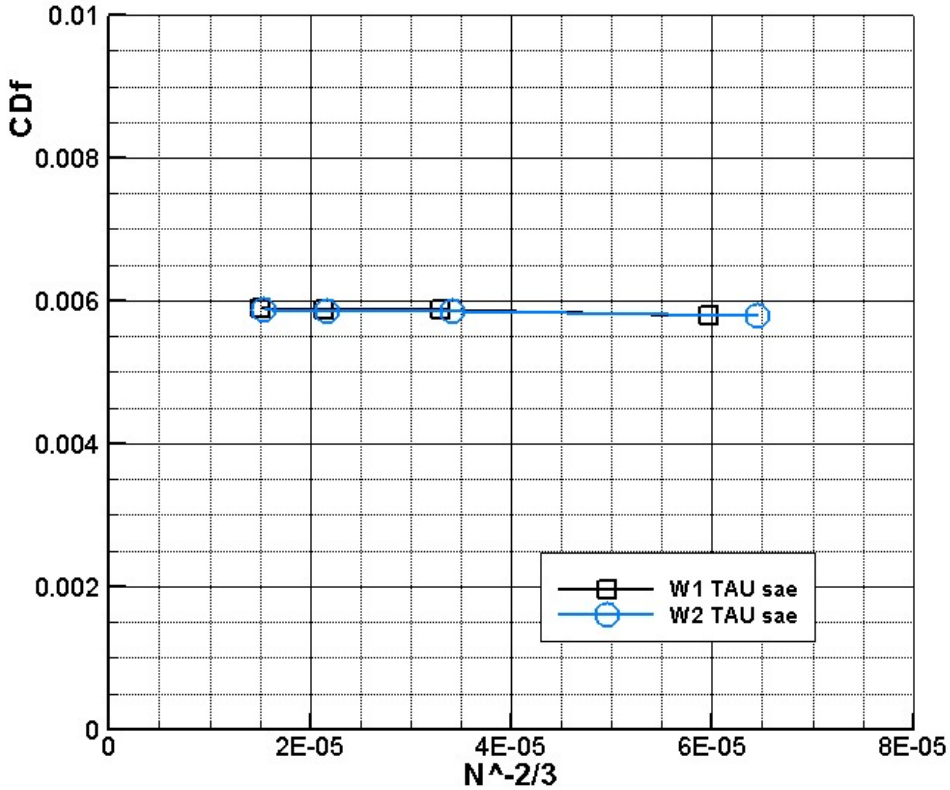


TAU Results

Grid Convergence Study of CD, α=0.5°

Influence of SAE / kw-SST



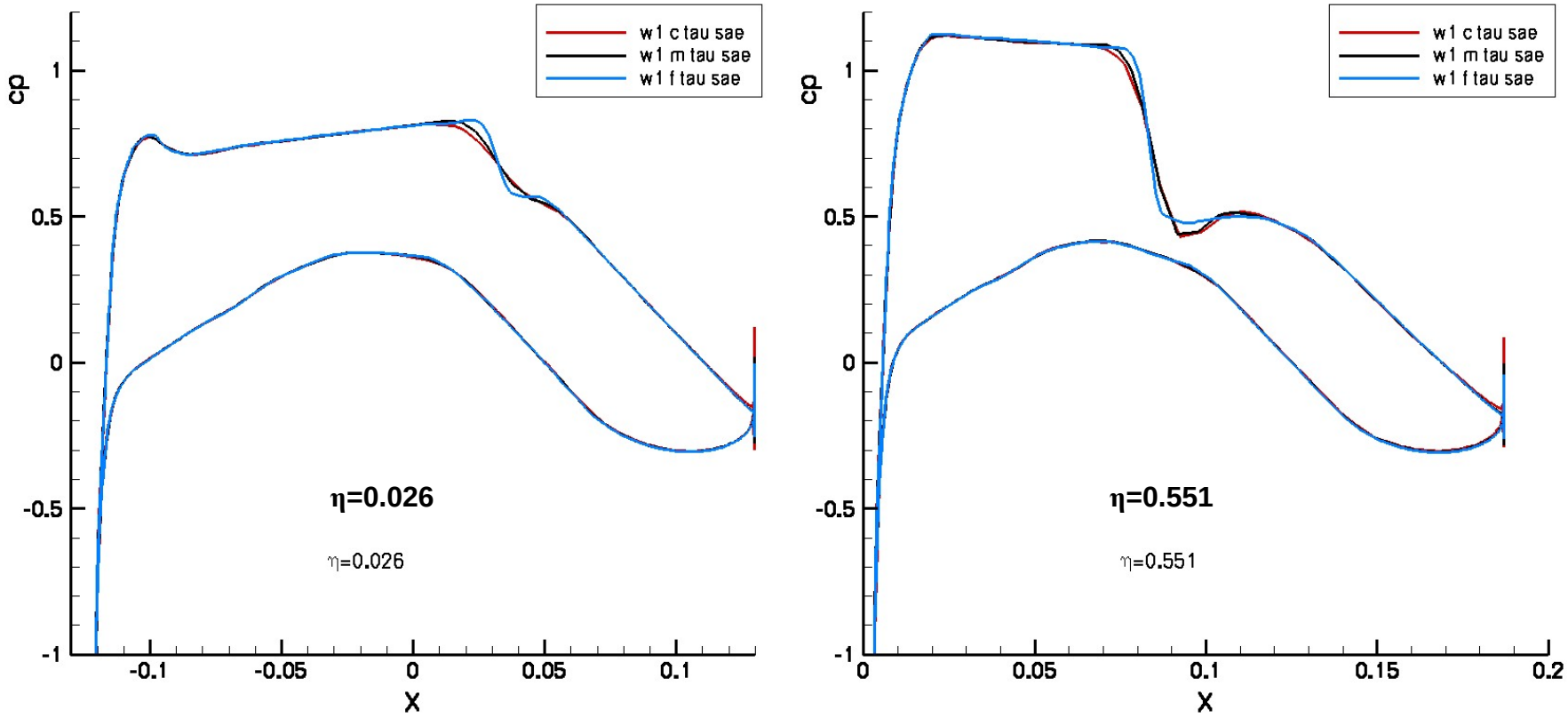


TAU Results

Grid Influence on Cp, α=0.5°

SAE model

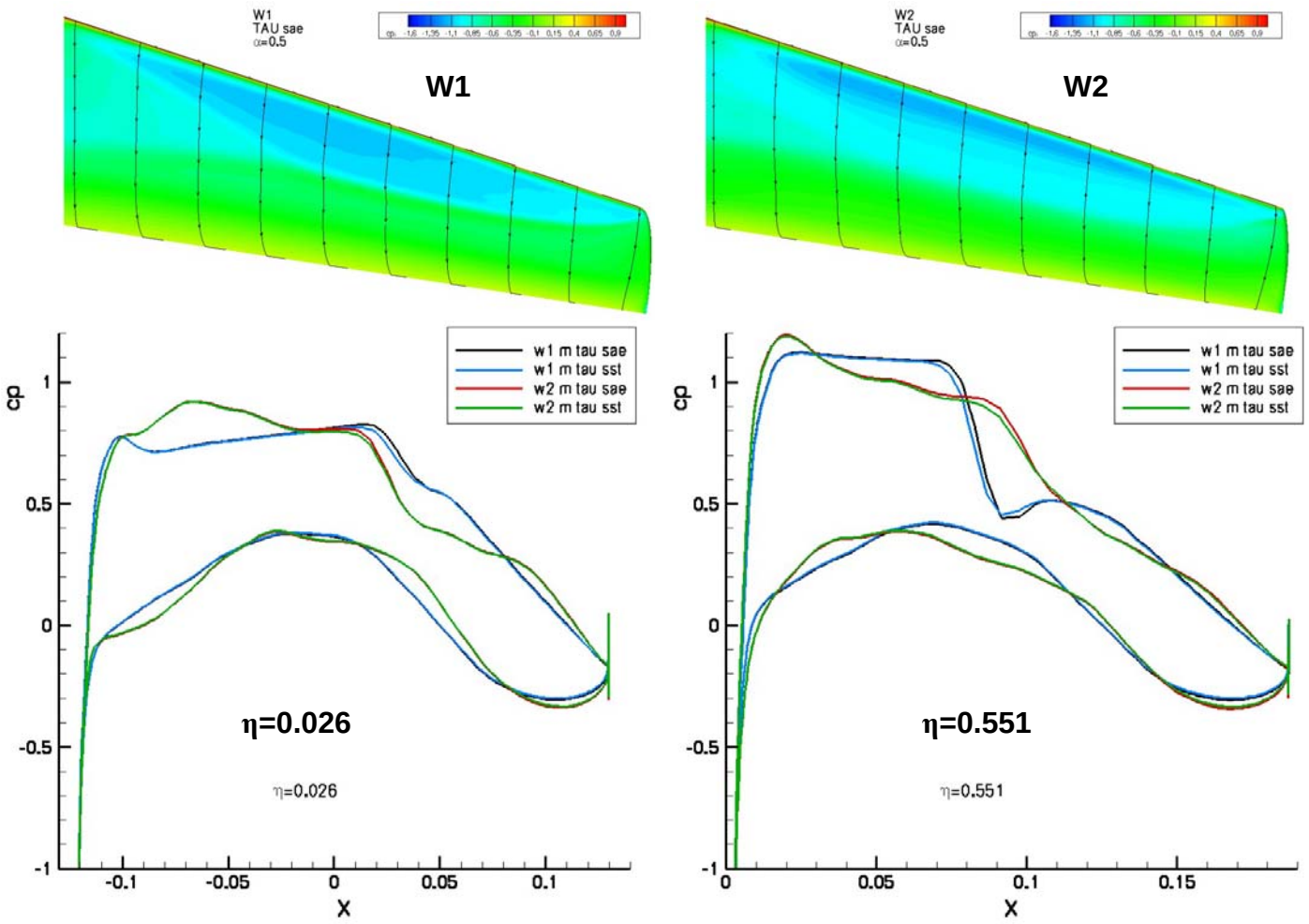
W1



TAU Results

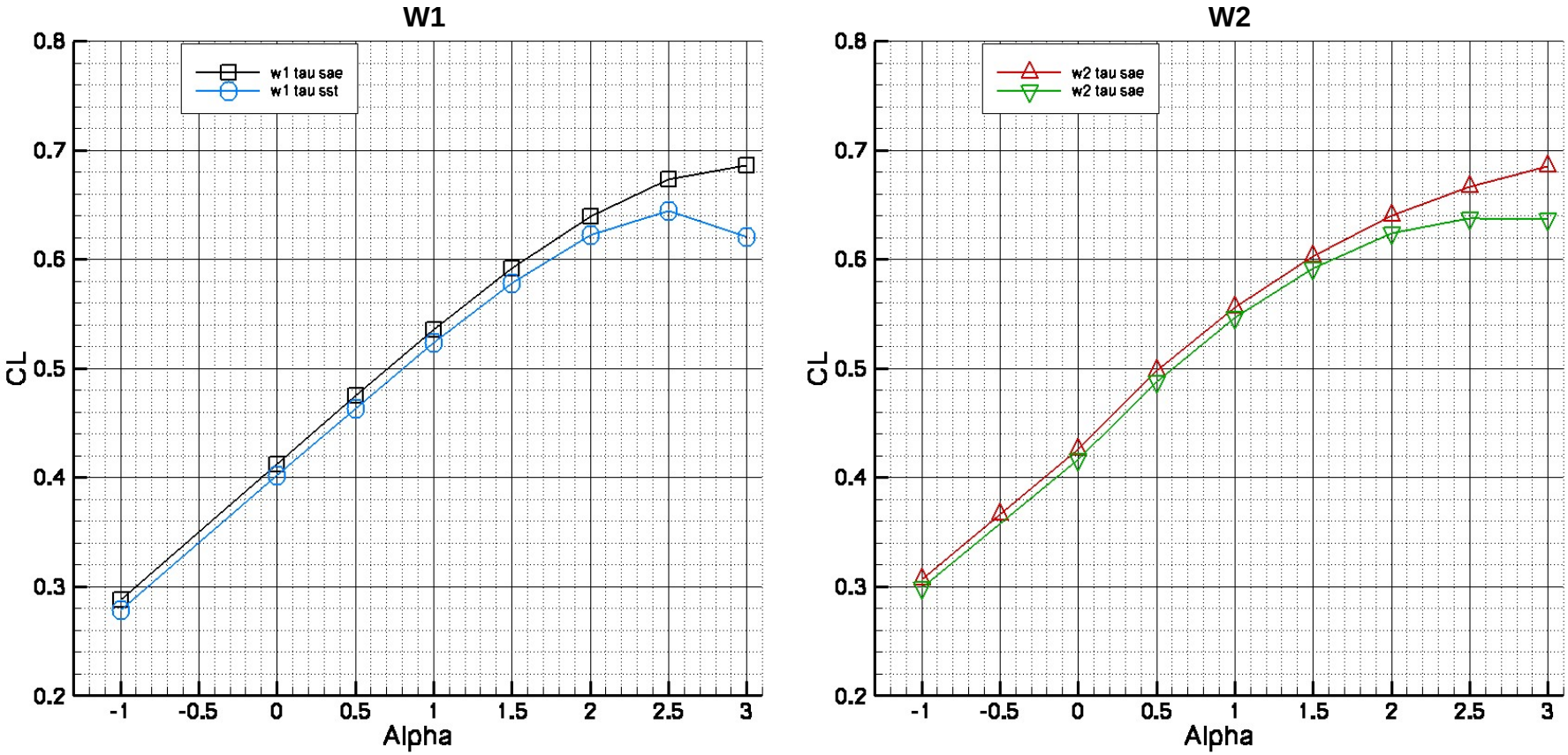
Influence W1 / W2

SAE / SST



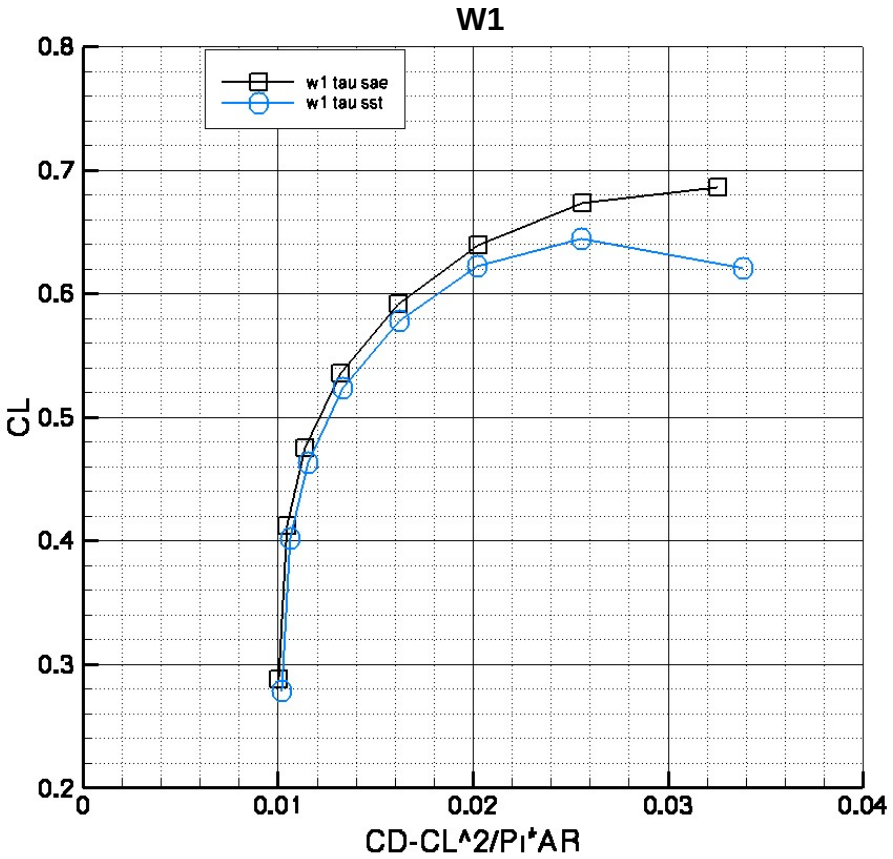
TAU Results

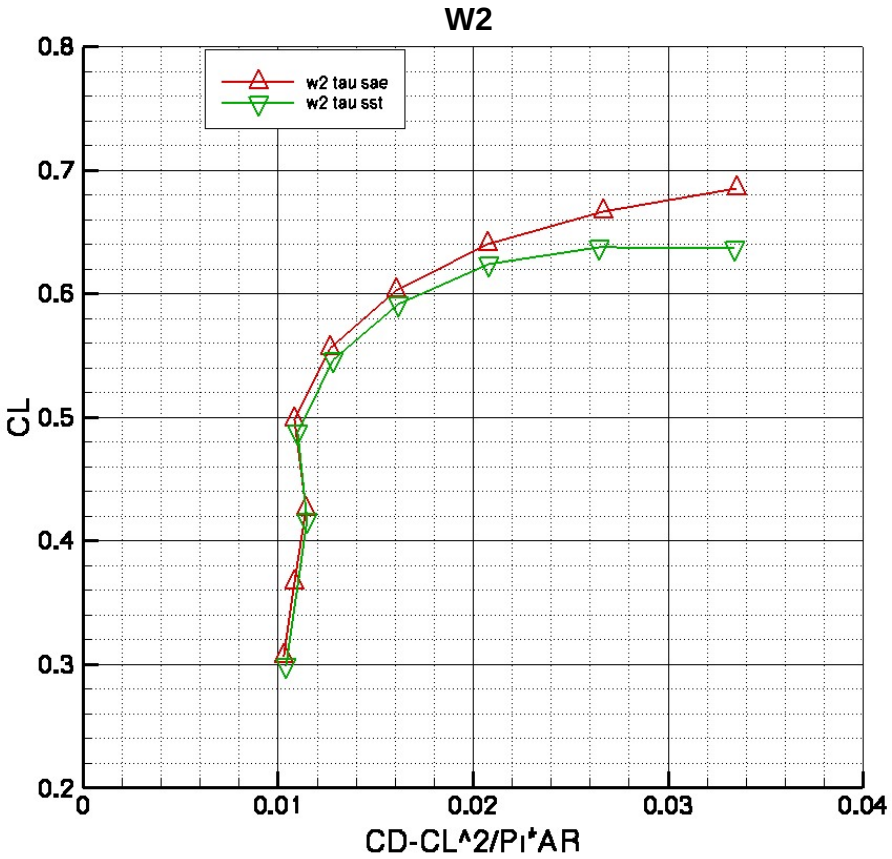
Influence of Turbulence Models SAE / kw-SST



TAU Results

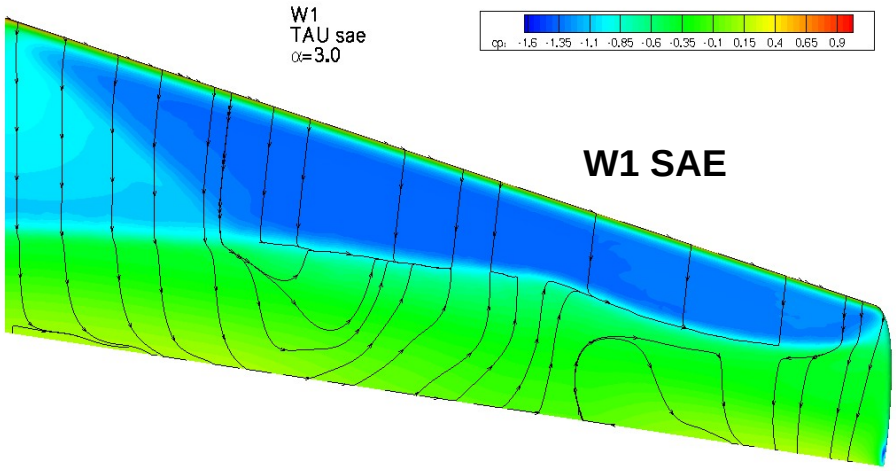
Influence of Turbulence Models SAE / kw-SST

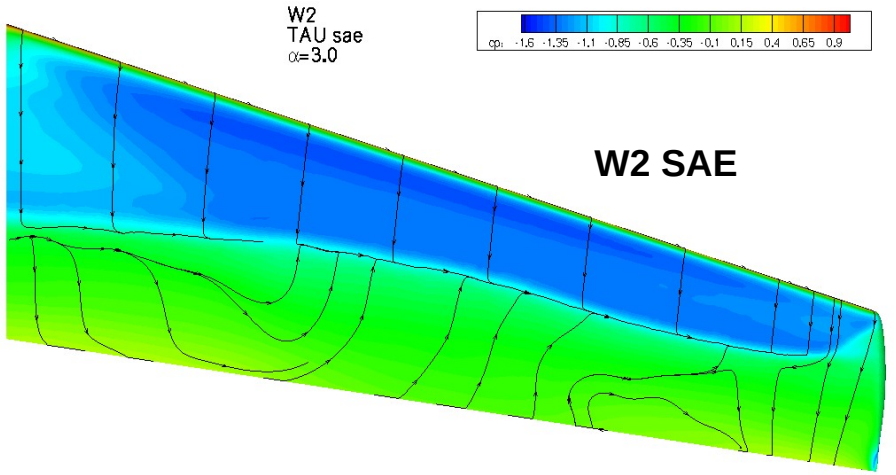


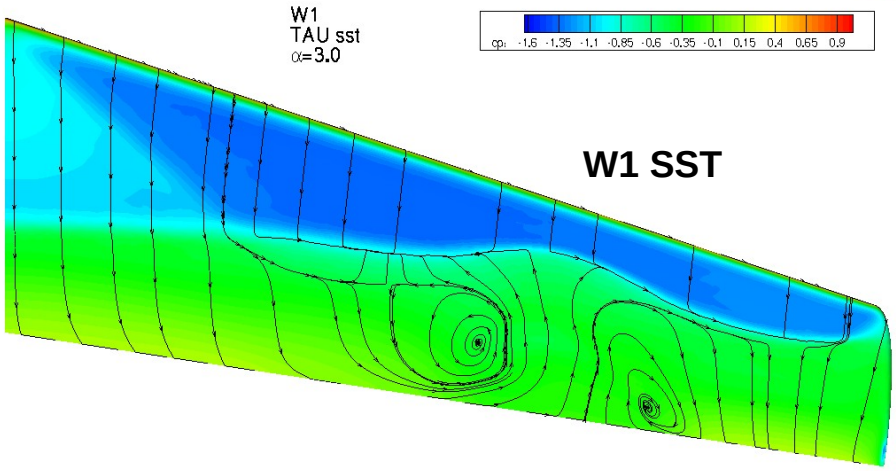


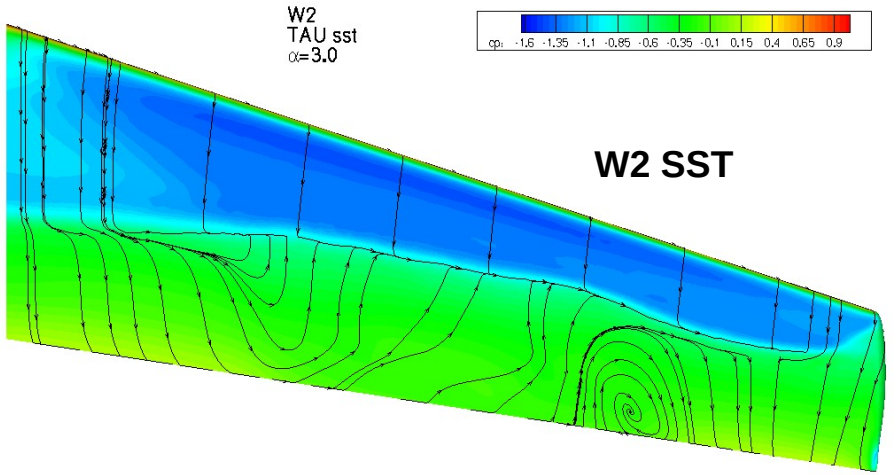
TAU Results

Influence of Turbulence Models SAE / kw-SST



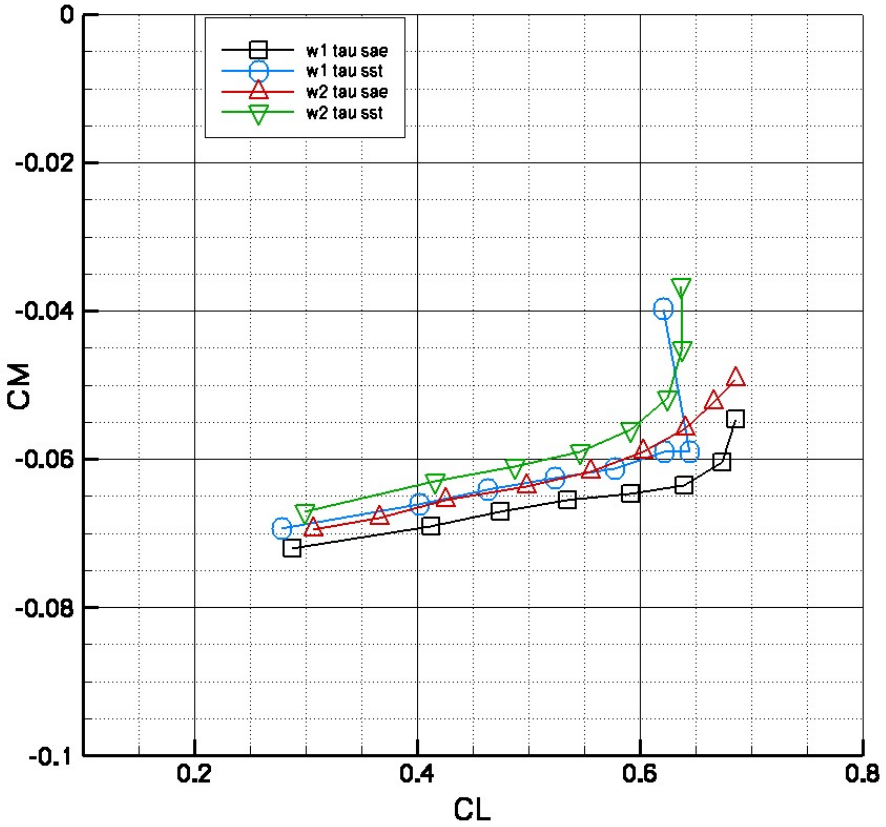


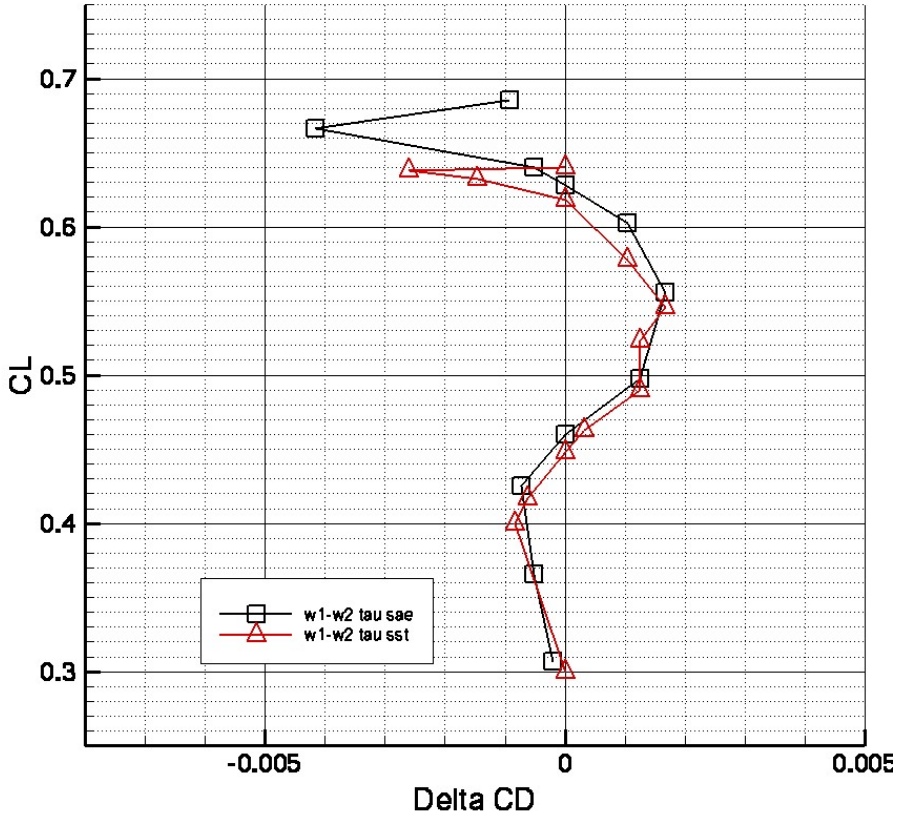




TAU Results

Influence of Turbulence Models SAE / kw-SST





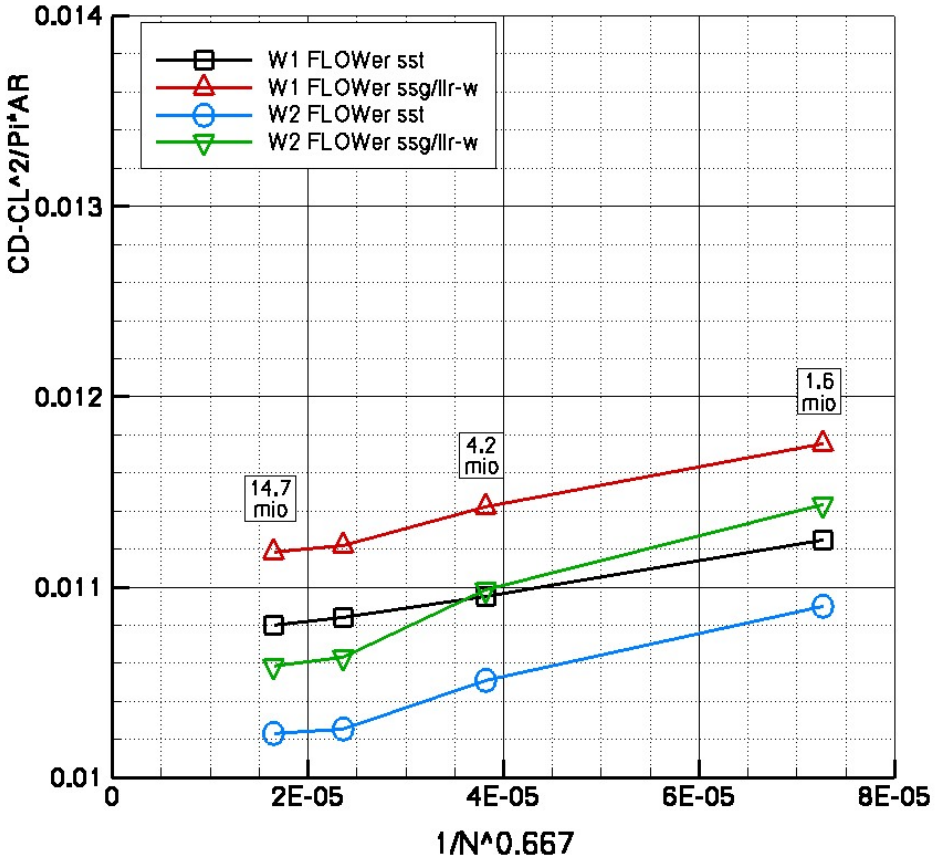
Structured Grids

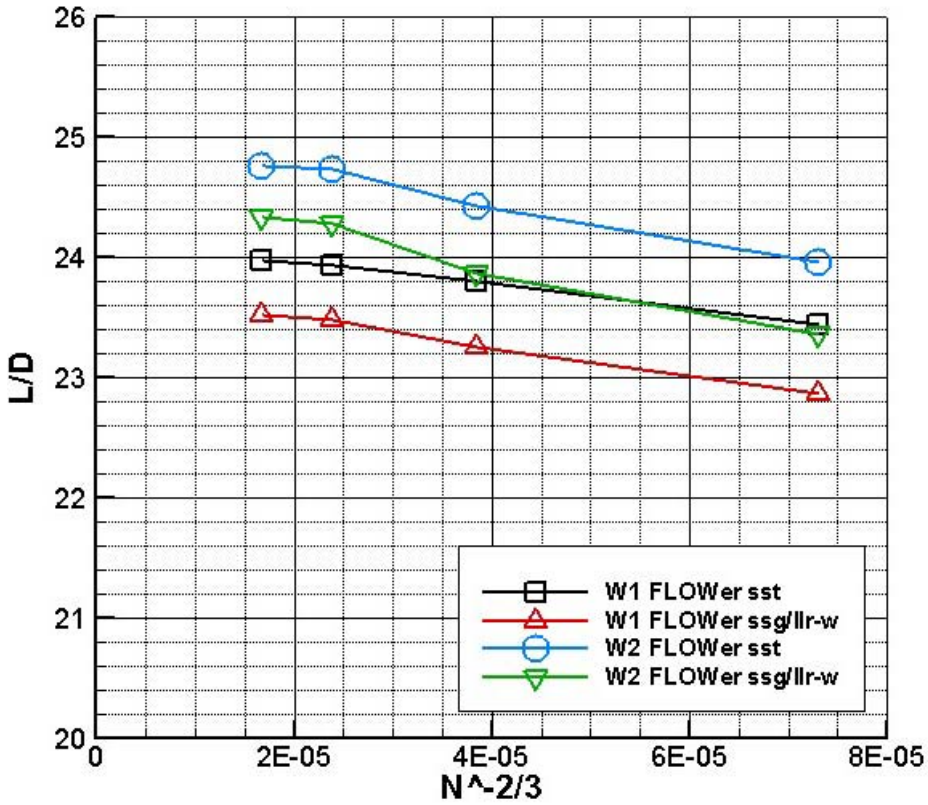
- Structured grids generated by Boeing using ICEM

	Coarse	Medium	Fine	Very fine
Nodes	**1.6**	**4.2**	**8.6**	**14.8**

FLOWer Results

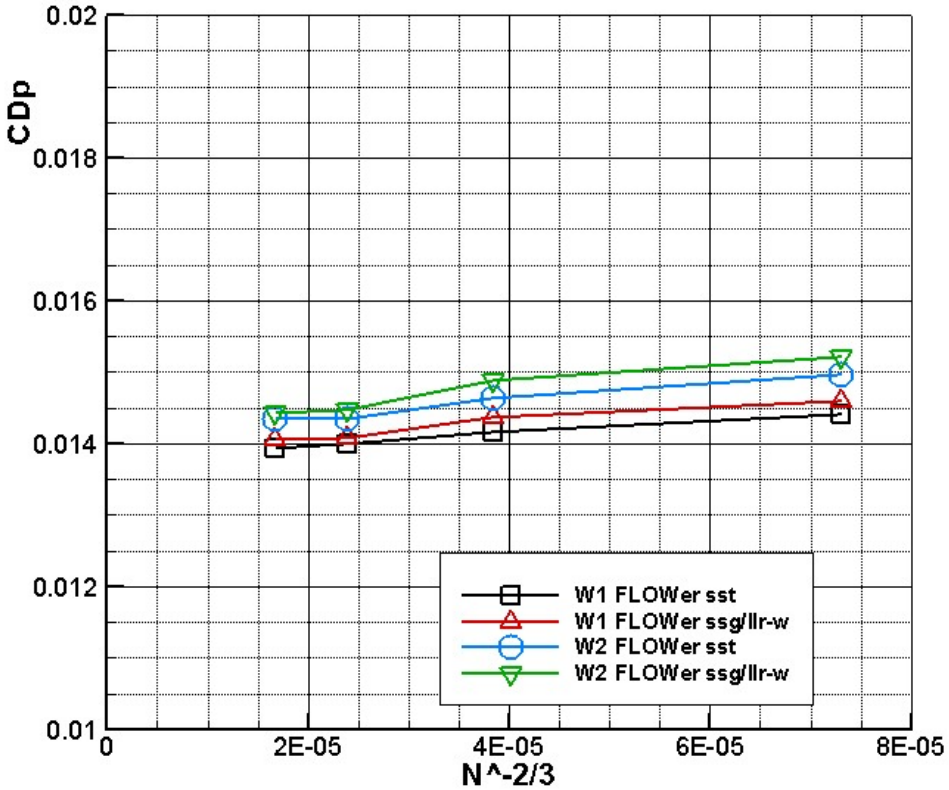
Grid Convergence, SST / SSG-LLR-w, α=0.5°

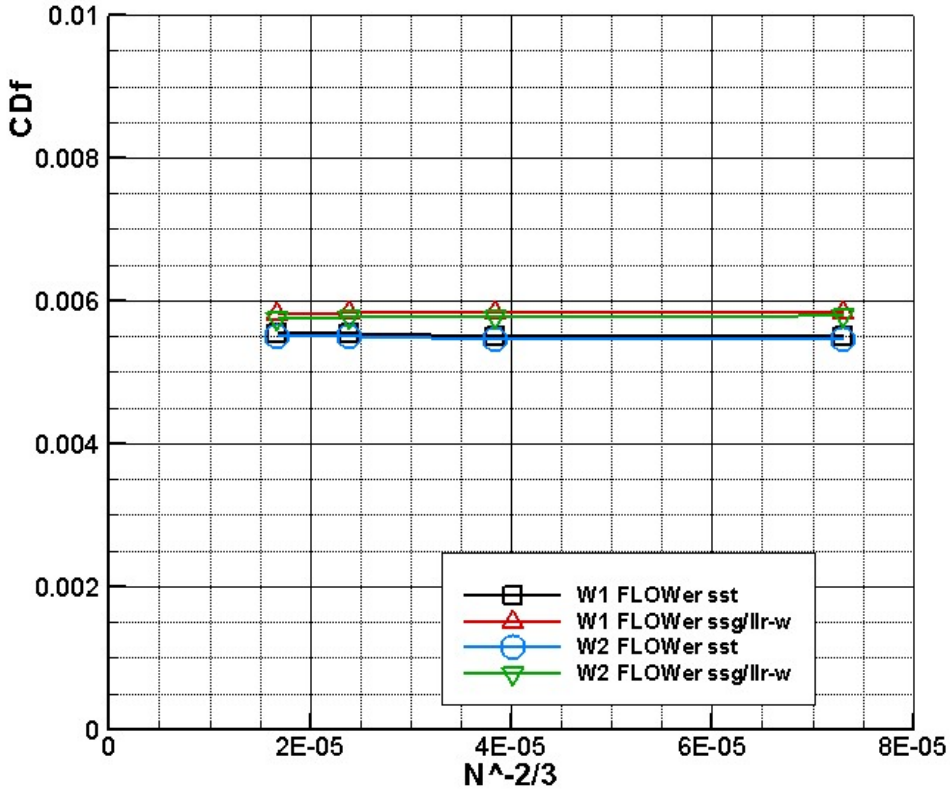




FLOWer Results

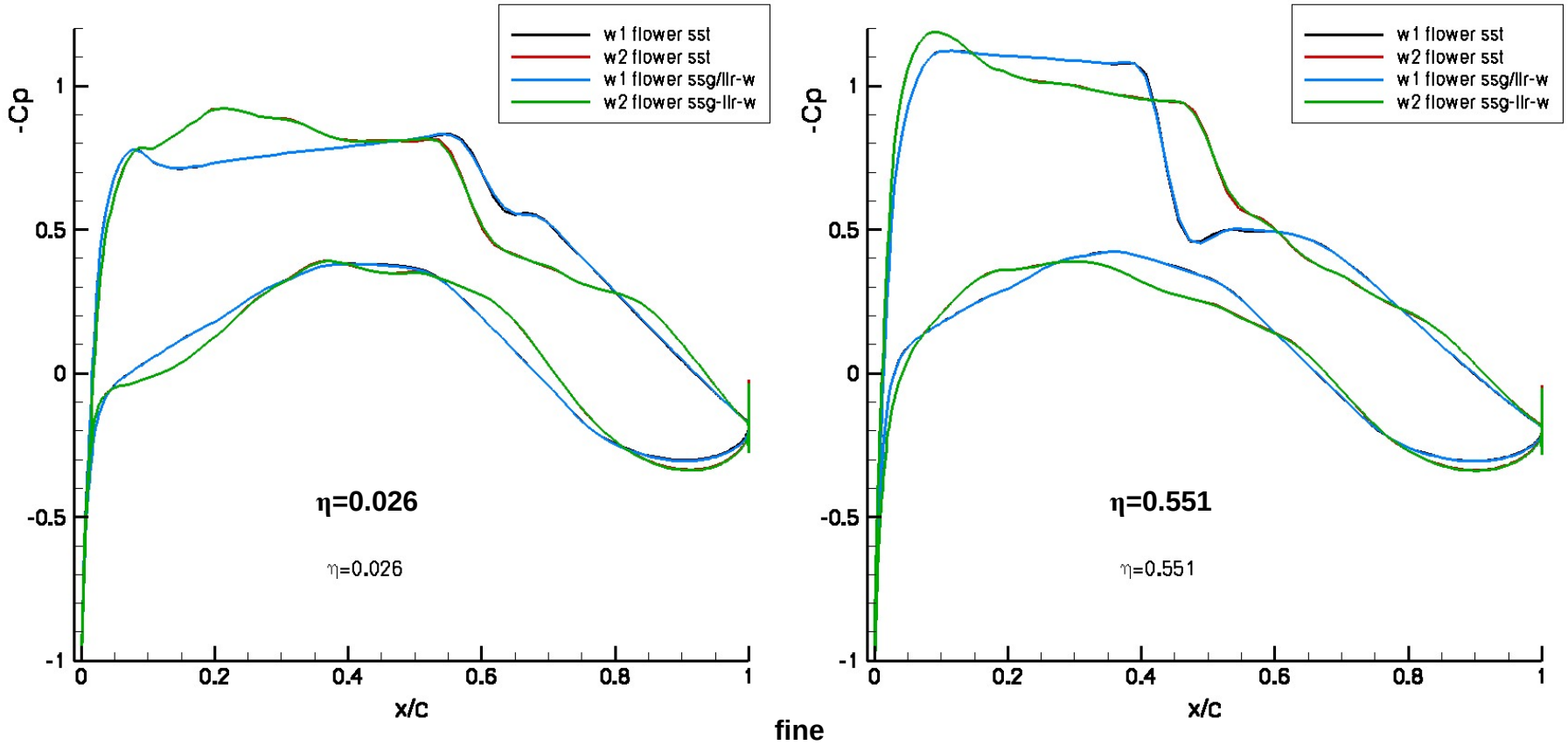
Grid Convergence, SST / SSG-LLR-w, α=0.5°





FLOWer Results

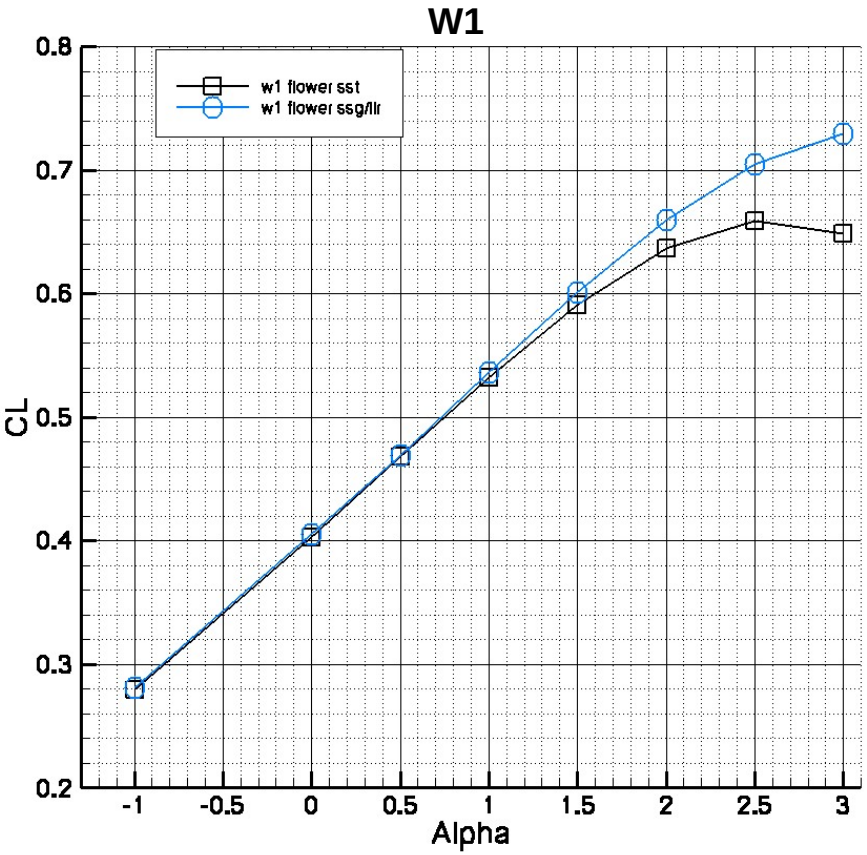
Influence of Turbulence Models SST / SSG-LLR-w

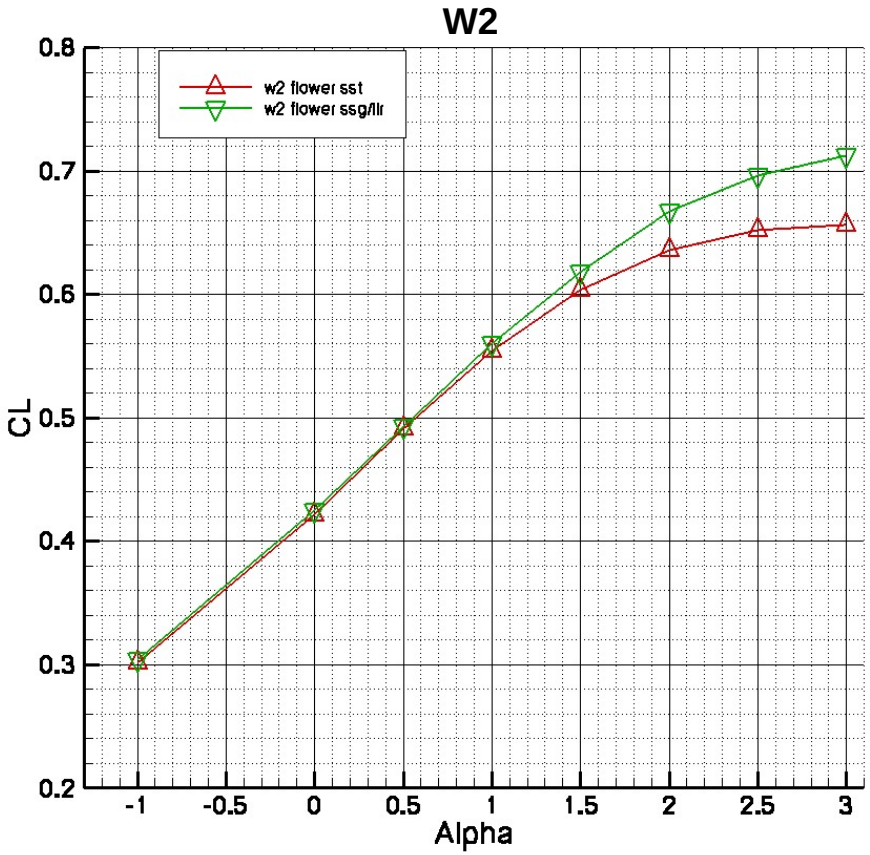


fine

FLOWer Results

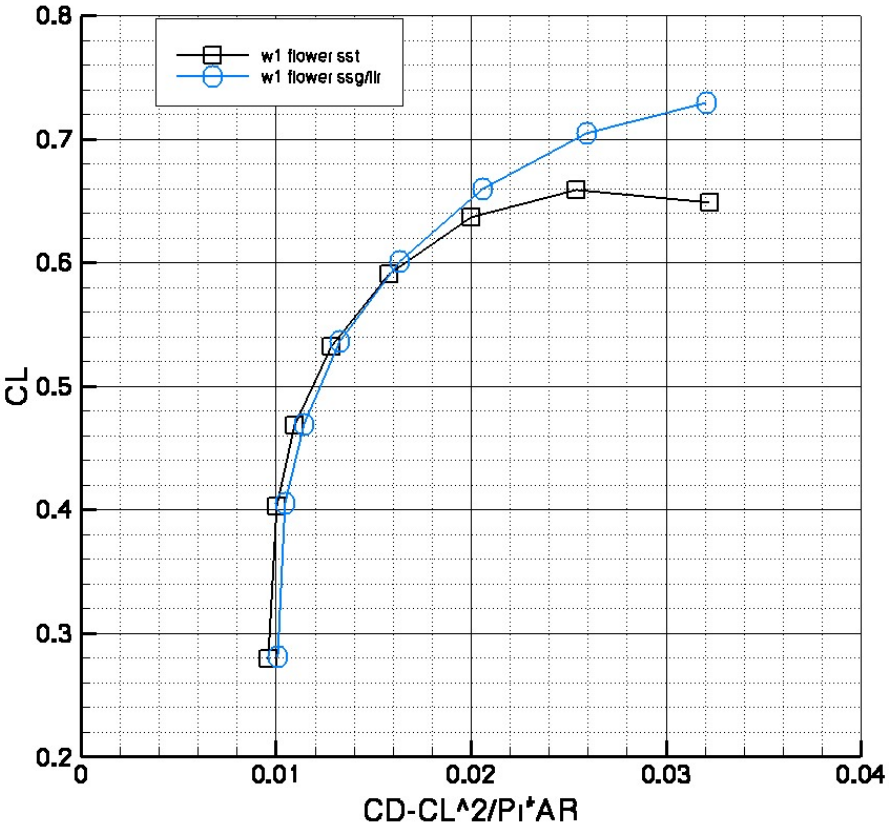
Influence of Turbulence Models SST / SSG-LLR-w

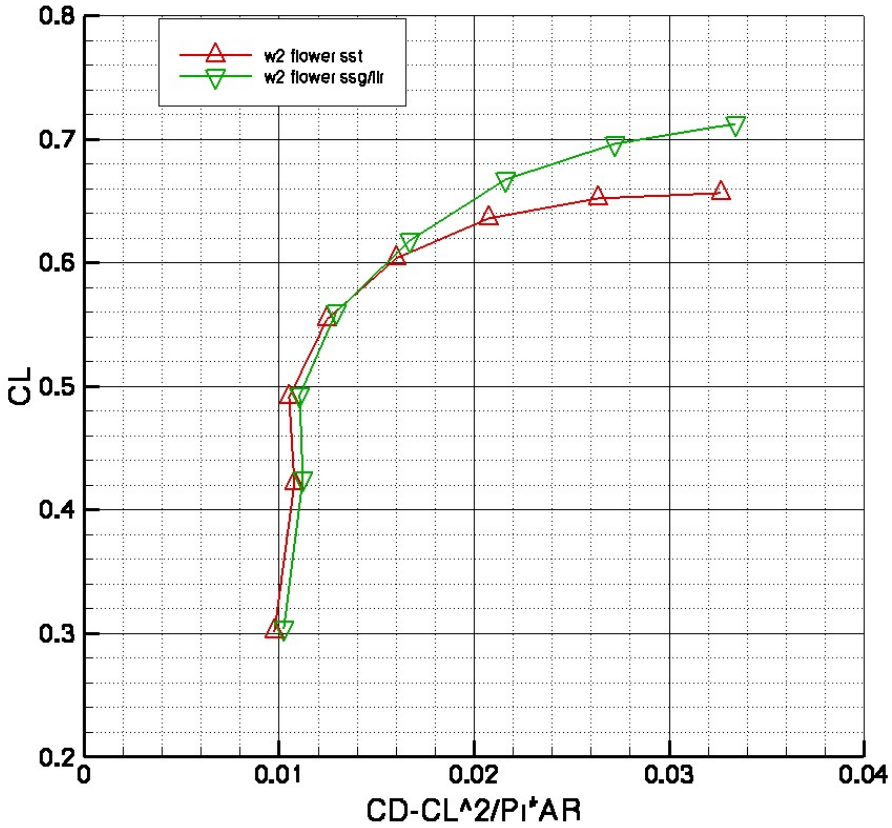




FLOWer Results

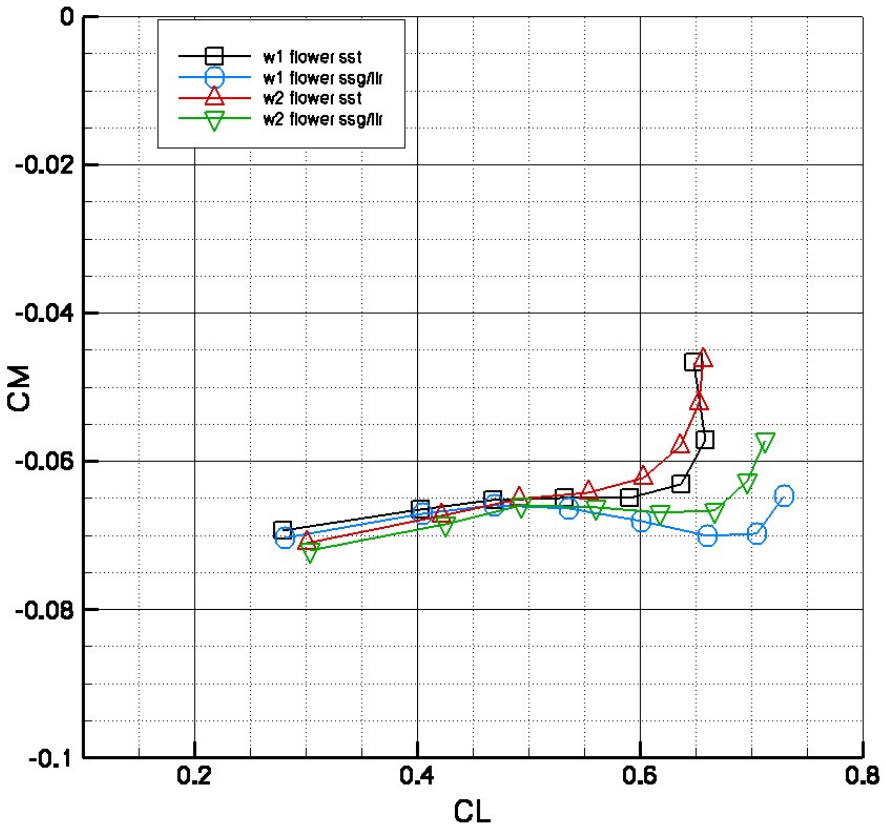
Influence of Turbulence Models SST / SSG-LLR-w

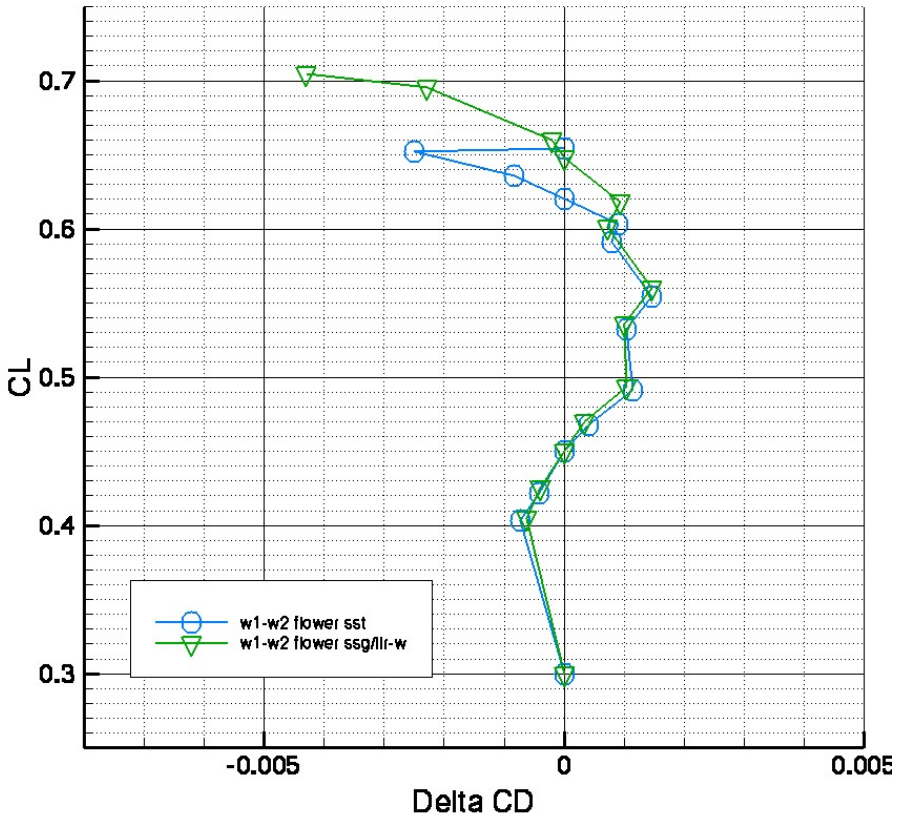




FLOWer Results

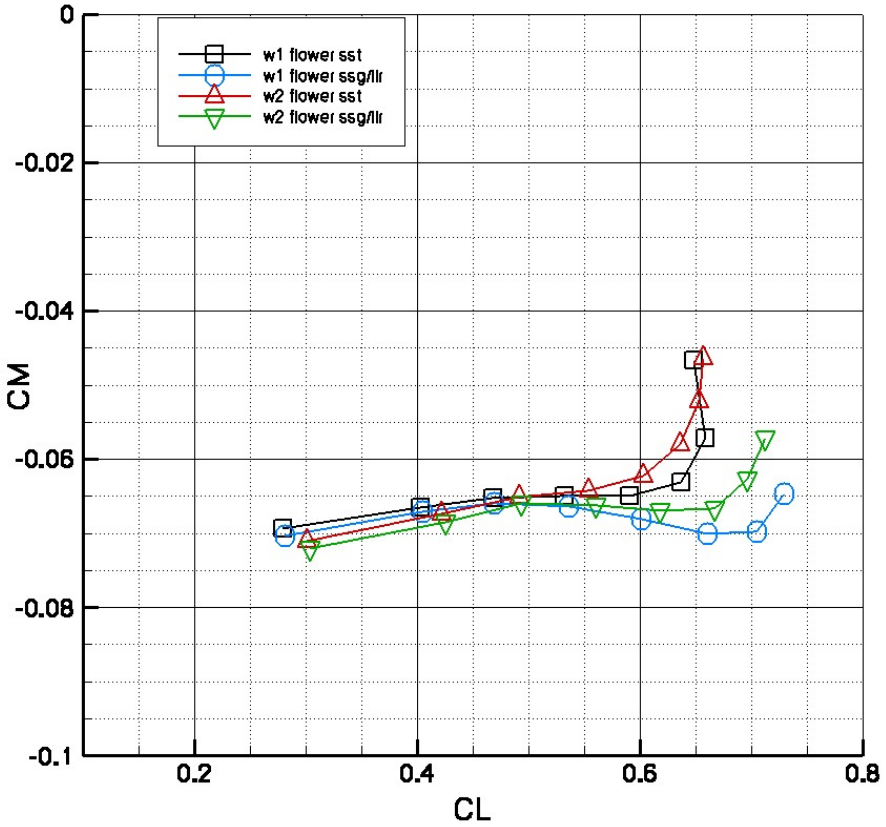
Influence of Turbulence Models SST / SSG-LLR-w

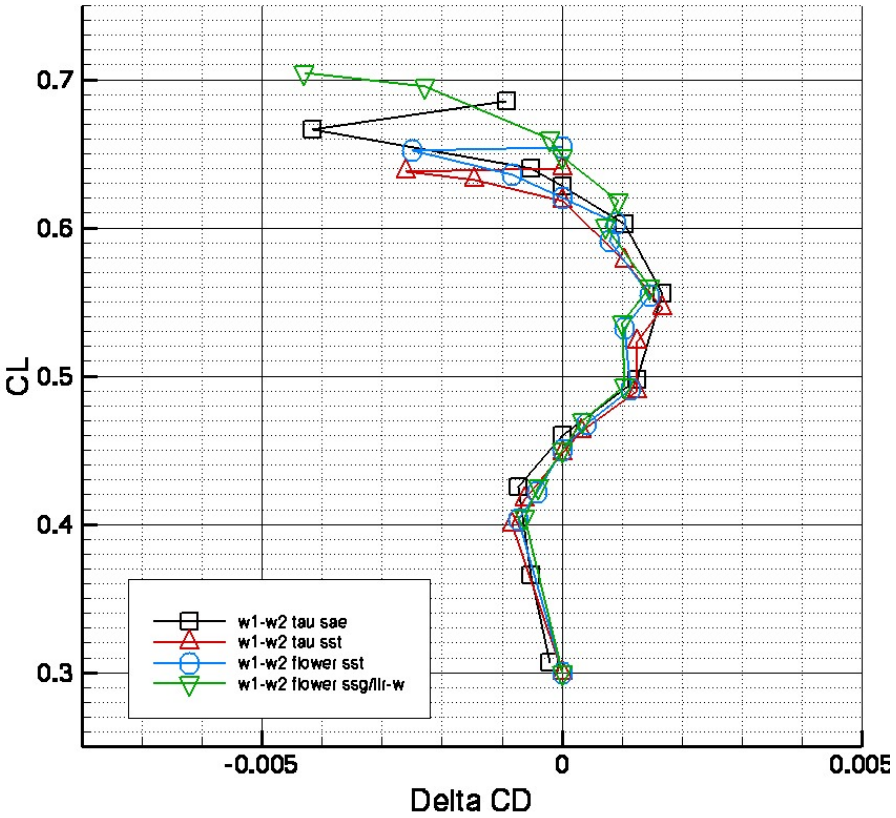




FLOWer Results

Influence of Turbulence Models SST / SSG-LLR





Summary

- TAU SAE / kw-SST and FLOWer SST / SSG-LLR-w results show good grid convergence behaviour
- Grid refinement improves shock resolution
- TAU:
  - Small upstream shift of shock location for SST vs. SAE
  - SAE shows higher CL_{max} and lower CD (vers. SST)
- FLOWer:
  - No significant differences of Cp for SST / SSG-LLR-w
  - SSG-LLR-w shows higher CL_{max} and lower CD (vers. SST)
  - SSG-LLR-w shows higher CD in linear range ($\alpha<1.5^{o}$); lower CD above
- Similar delta drag W1-W2 for both methods / turbulence models in linear range of CL-α