DLR Contribution to the 2nd High Lift Prediction Workshop

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CFD High Lift Prediction Workshop

DLR Contribution and Objectives for HiLiftPW-2 Computations

- **Hybrid unstructured grids for all Configurations based on SOLAR grid generation System**
  - **Assessment of present SOLAR features taking into account grid family requirement and gridding guidelines (a.f.a.p.)**
  - **Grid refinement study for moderately complex 3D configuration**
  - **Reynolds number adapted gridding approach (cross-check still open)**
  - **Assessment of normal to wall resolution improvements**

- **TAU computations**
  - **Assessment of geometry simplifications for low and high Re-No. conditions**
  - **Assessment of TAU capability to simulate OoM Reynolds-number effects**
  - **Validation of to simulate and predict transitional effects (yet to be done)**
  - **Turbulence model performance (RSM simulations ongoing)**

Grid Generation - SOLAR

- Hybrid unstructured grids, hex-based near surfaces, individual grids for all configurations and Reynolds number conditions
- Grid generation and adaptation approach
  - y^+ -manual adaptation, const. first cell height
  - grid family approach according to DPW IV, HiLiftPW-1 (SOLAR)
  - special treatment of sources

- Grid family for Stage II, (high Re) with 3 levels

  Grid level characteristics

Grid Level	Pts.	Hexas	Surf. Elem.	Tot. Elem.	Struct.layers
C	9,168,002	6,526,338	552,377	21,356,048	17
M	25,574,796	18,589,894	1,143,776	59,066,549	23
F	73,421,980	54,851,776	2,377,309	165,246,813	32

Grid Generation - SOLAR

- Grids characteristics for low Re-No. conditions

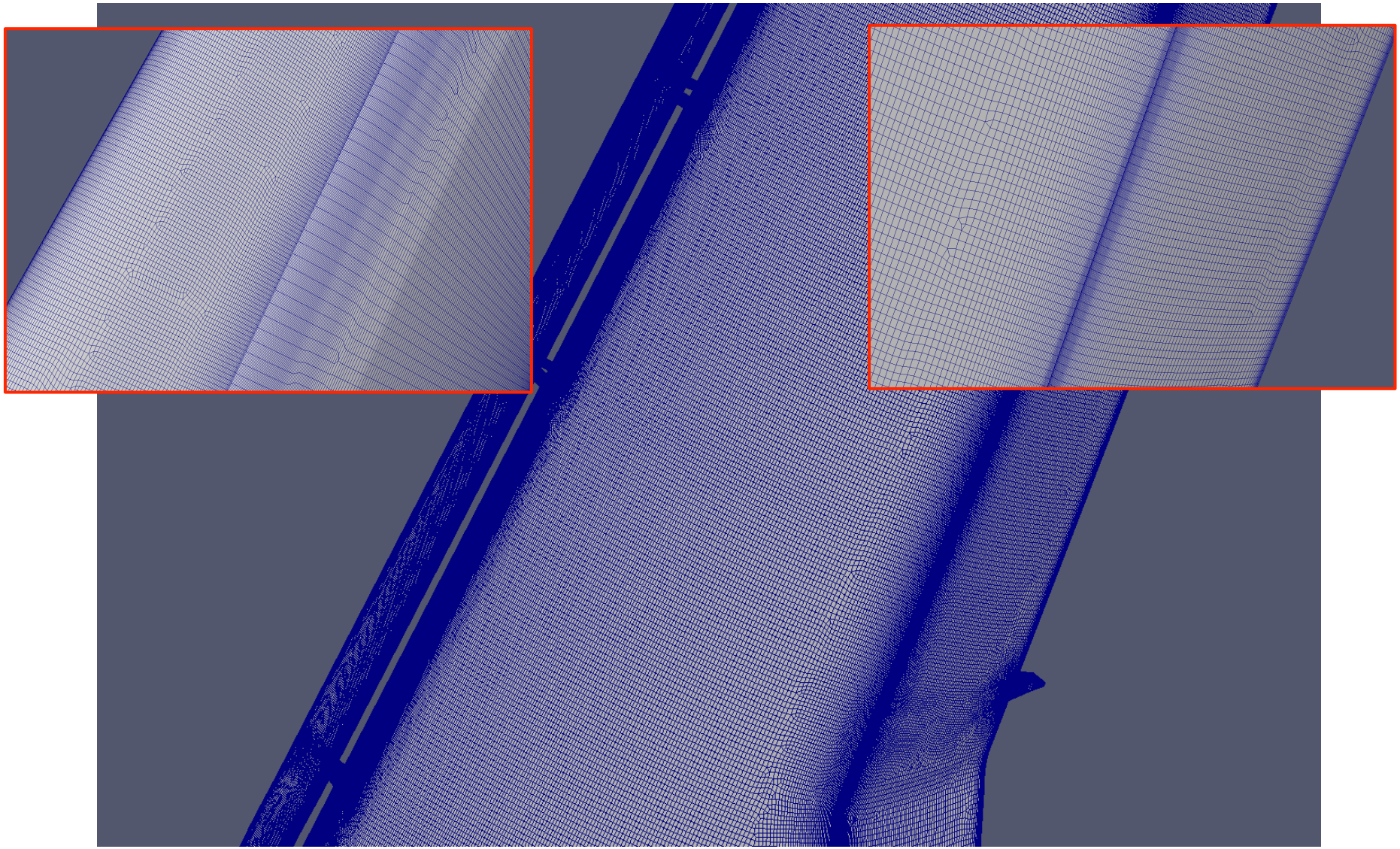
Configurat.	Pts.	Hexas	Surf. Elem.	Tot. Elem.	Struct.layers
Stage II	29,777,019	22,862,572	1,147,071	62,814,015	28
Stage IV	37,346,449	28,970,720	1,380,824	76,972,998	28
Stage V	37,692,411	29,626,850	1,365,861	75,547,314	28

- Grids characteristics for high Re-No. conditions

Configurat.	Pts.	Hexas	Surf. Elem.	Tot. Elem.	Struct.layers
Stage II	25,574,796	18,589,894	1,143,776	59,066,549	23
Stage IV	32,392,356	23,727,289	1,378,773	73,740,331	23
Stage V	34,183,985	24,382,376	1,408,577	81,603,665	23

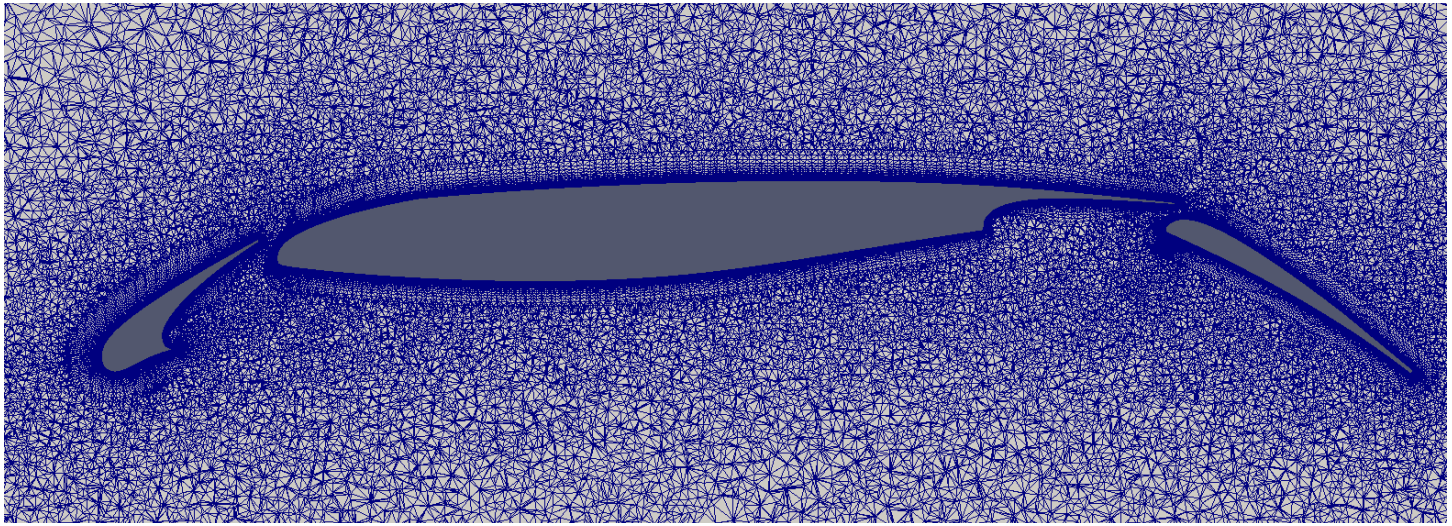
Grid Generation - SOLAR

- **SOLAR grid: Surface mesh resolution**

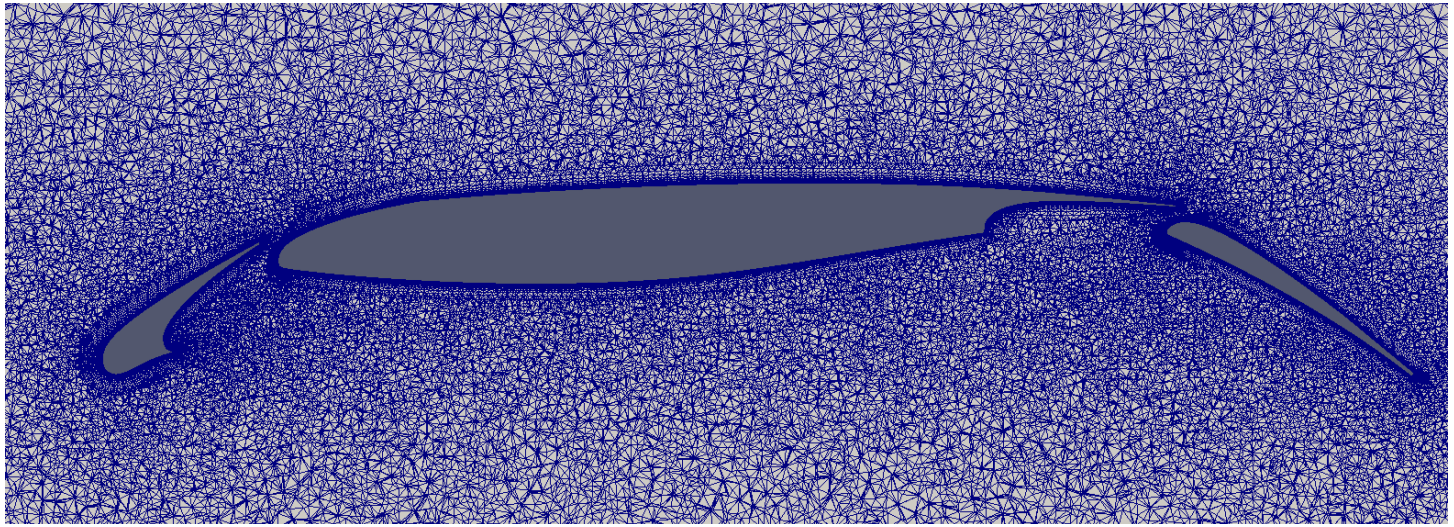


Grid Generation - SOLAR

- **Grid section for low Re conditions (Stage II)**



- **Grid section for high Re conditions (Stage II)**



CASE 3a

TAU-SAO / SOLAR

Baseline Validation, Low Re No.

TAU Computations – Parameter-Settings

- **Code Version:** DLR TAU code 2012.1.0

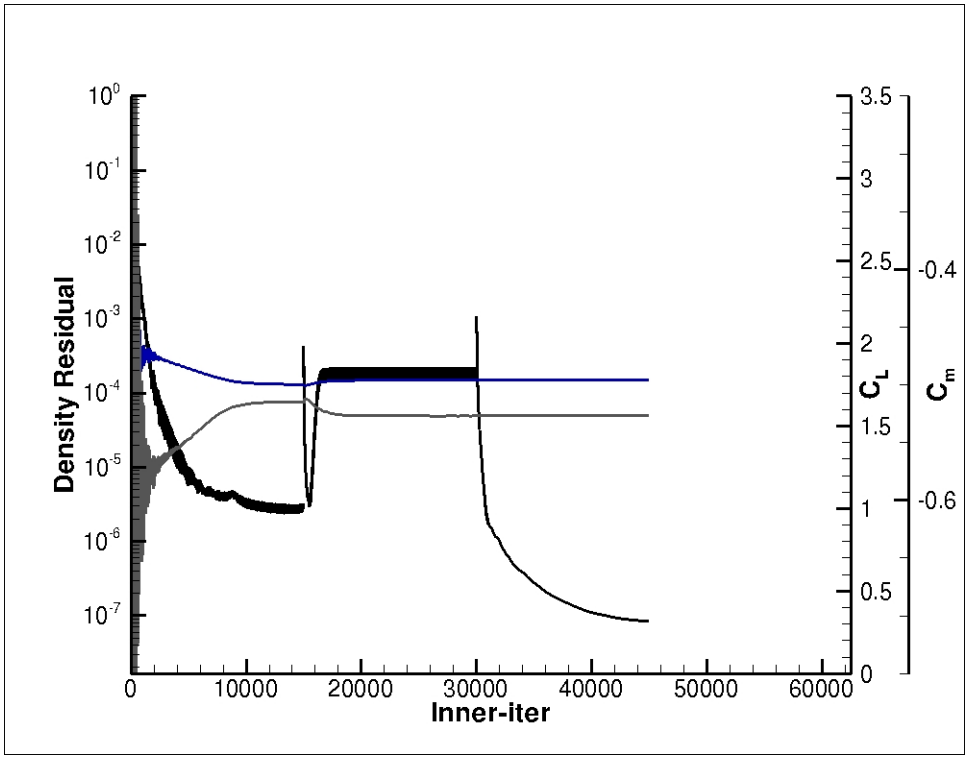
- **Spatial Discretization:**
  - **Main equations:** Jameson central, 2nd order;
    Blend scalar (20%) – matrix (80%) dissipation
  - **Turbulent equations:** AUSMDV upwind, 2nd order
  - **Full NS Discretization**

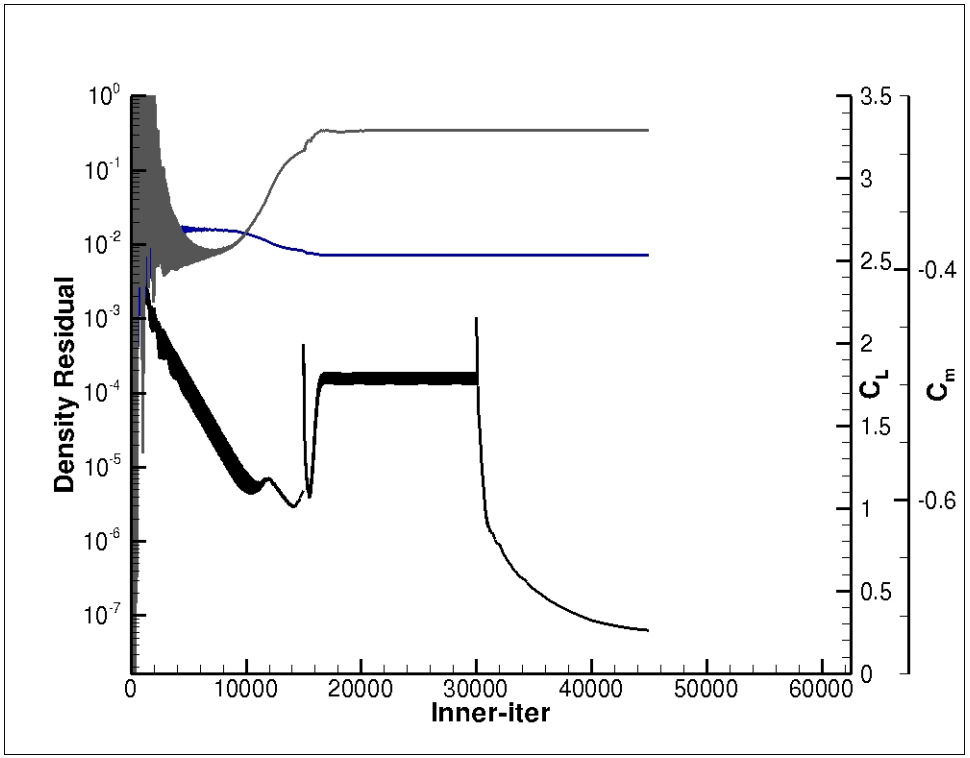
- **Turbulence Models:** - Spalart-Allmaras, original 1992 formul. (SAO)

- **Temp. Integration:** - LU-SGS Backward Euler
  - Multigrid, 3V cycle, main and turb. equations
  - final set of iterations approaching global time step

TAU Computations – Convergence behavior

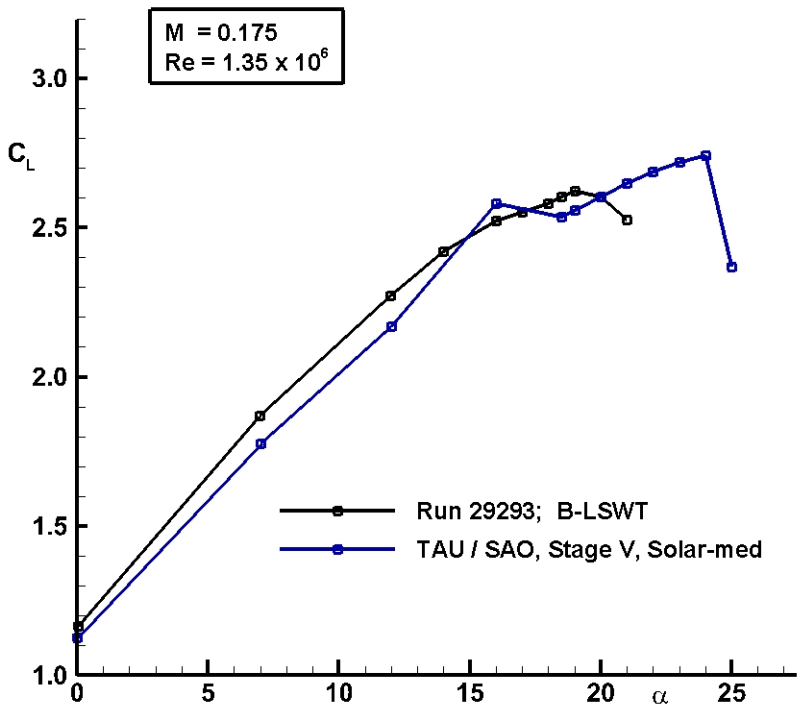
- **Convergence of main flow residual, density, lift, and moment for α = 7° and α = 18.5°**

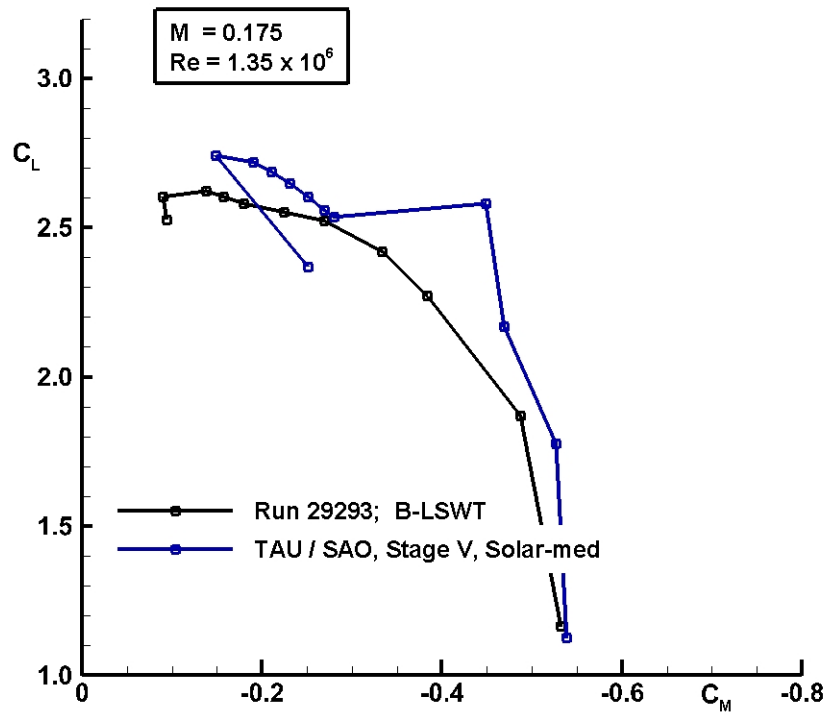




TAU/SAO, Solar Grid - Case 3a (low Re-No.)

- **Lift curve and pitching moment**





TAU/SAO, Solar Grid - Case 3a (low Re-No.)

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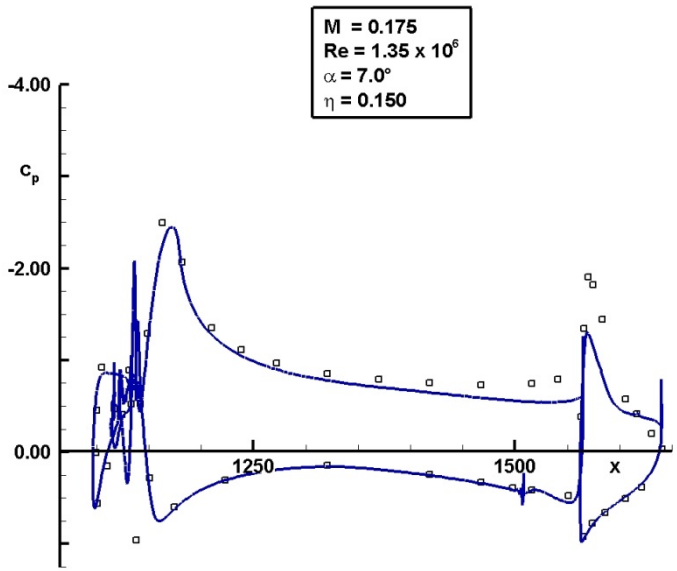
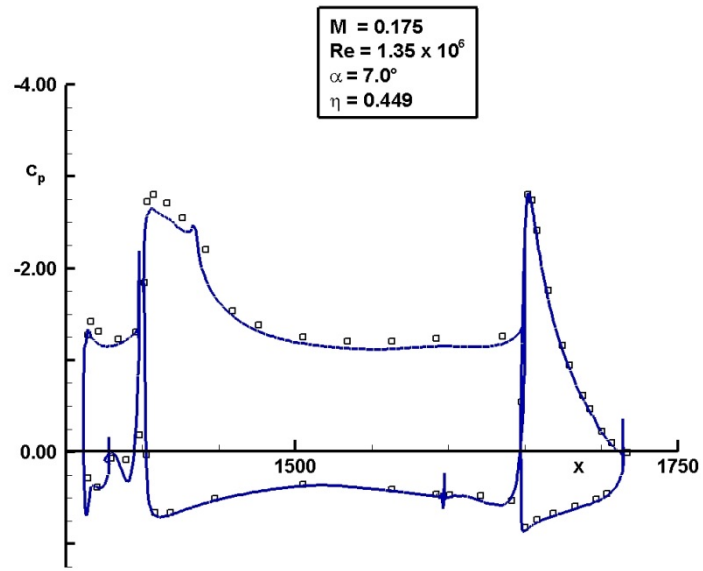
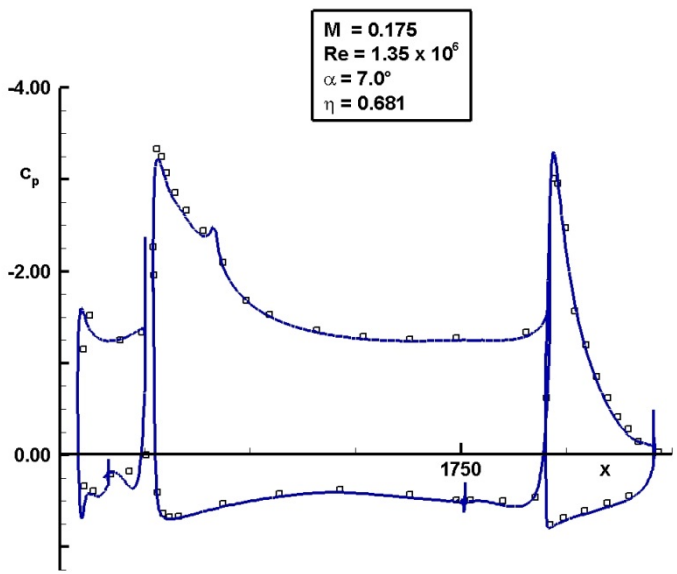
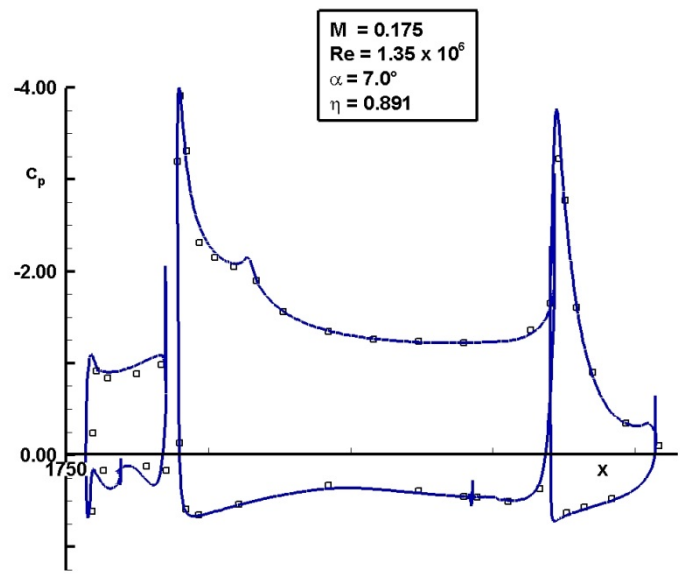






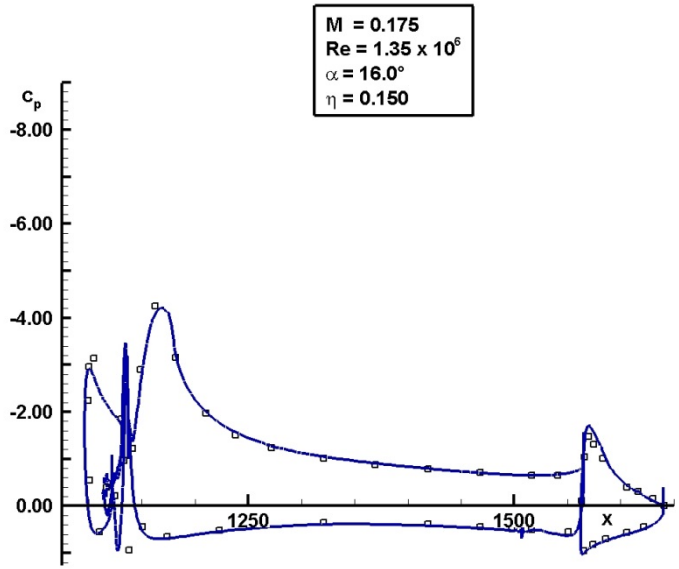


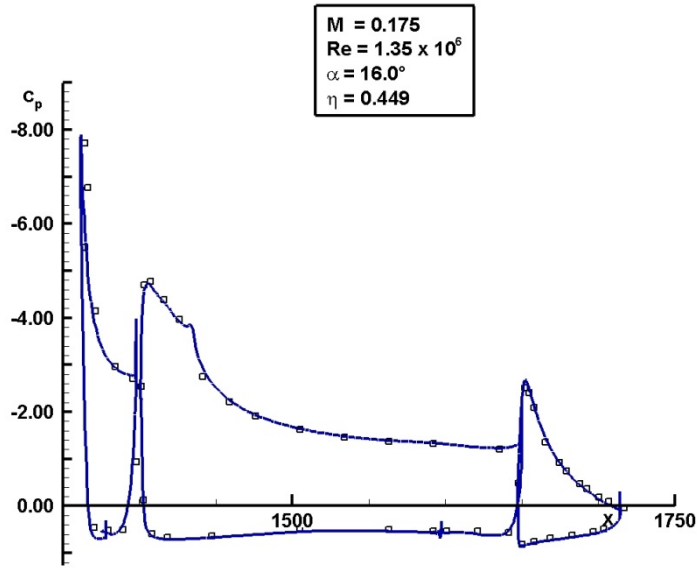
α = 7°

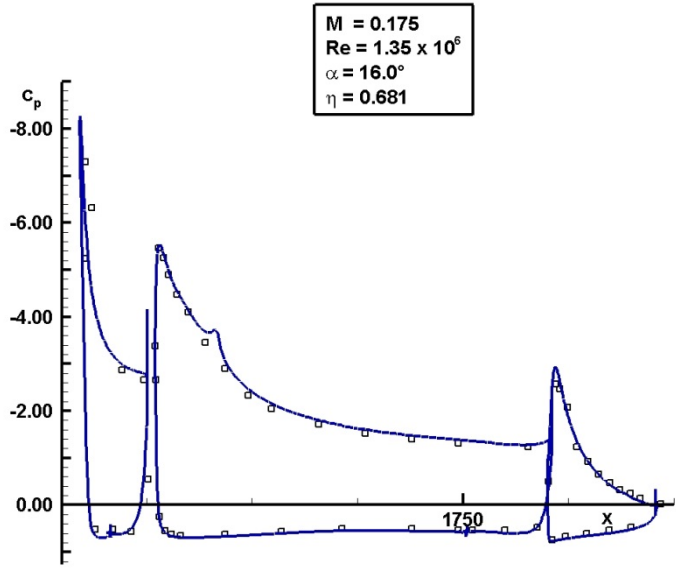
PS1, PS4, PS6, PS1

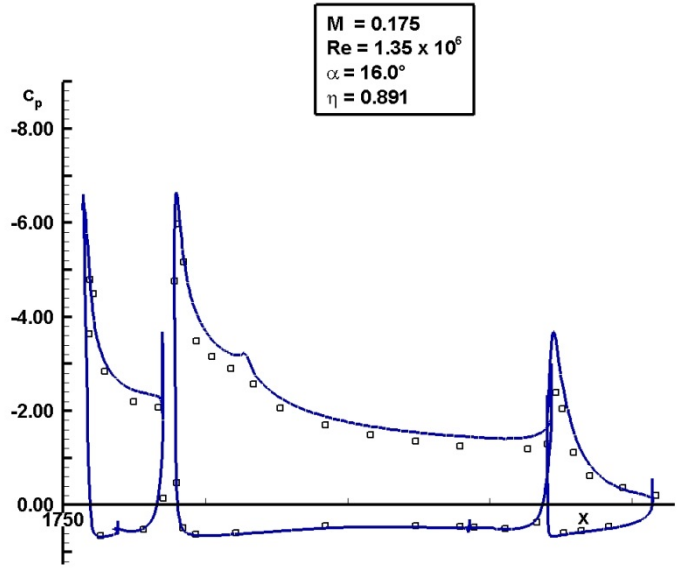
TAU/SAO, Solar Grid - Case 3a (low Re-No.)

CFD High Lift Prediction Workshop









α = 16°

PS1, PS4, PS6, PS1

TAU/SAO, Solar Grid - Case 3a (low Re-No.)

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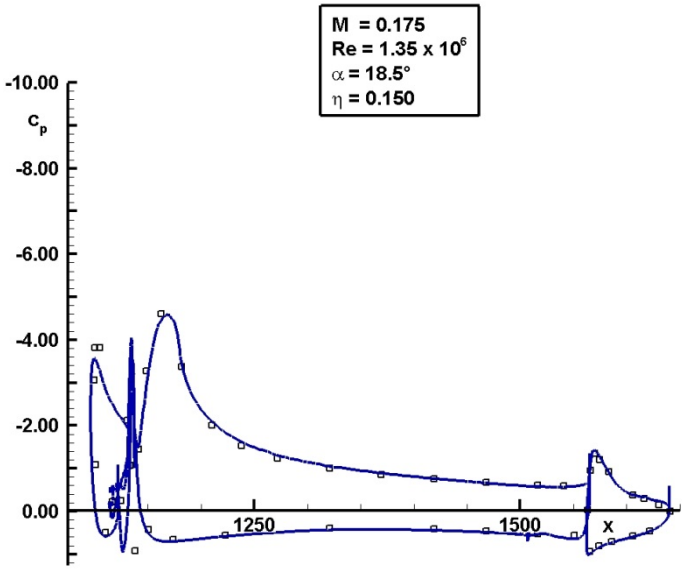

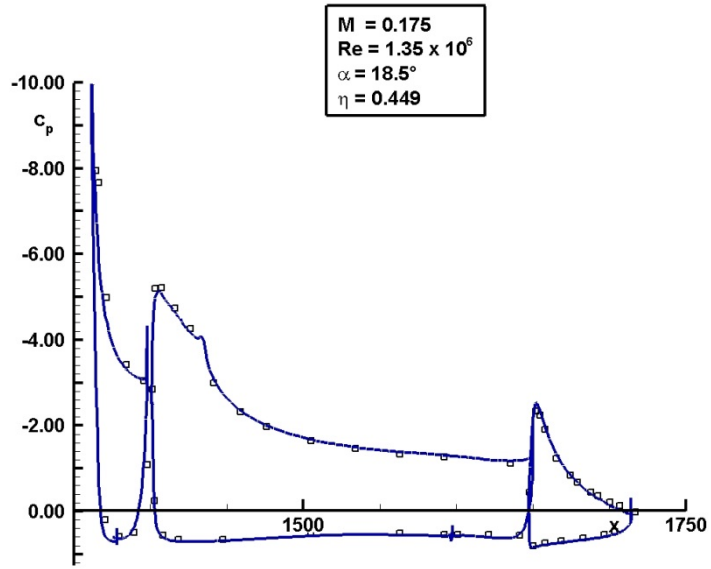

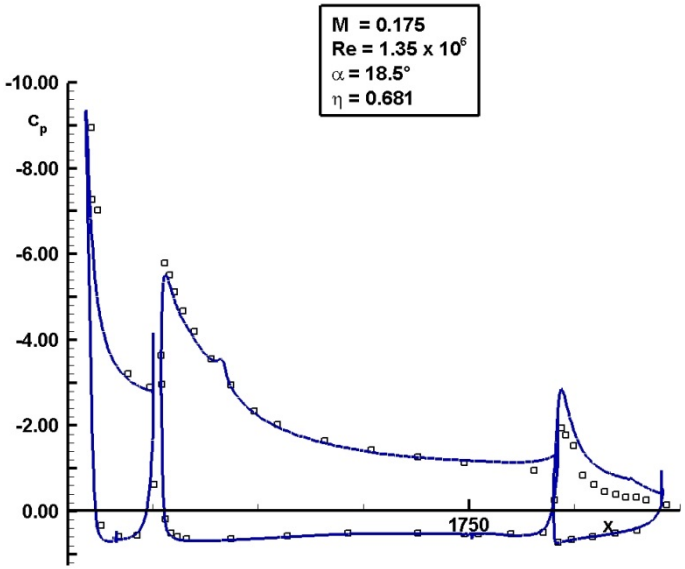

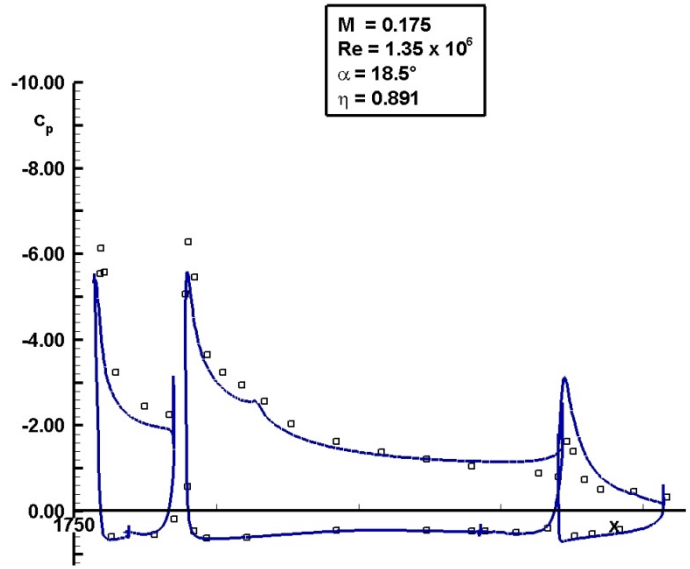

α = 18.5°

PS1, PS4, PS6, PS1

TAU/SAO, Solar Grid - Case 3a (low Re-No.)

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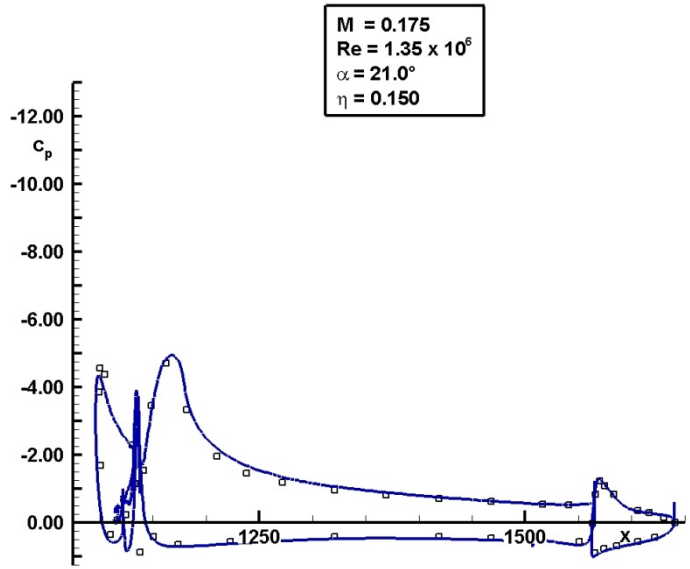
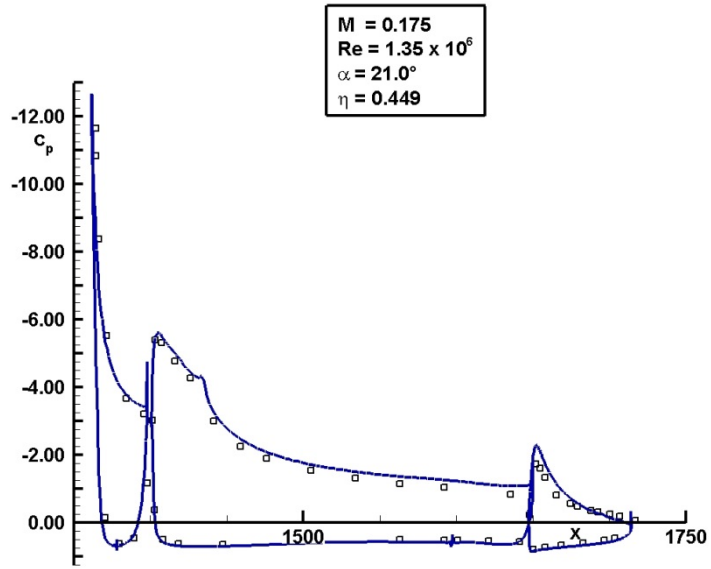
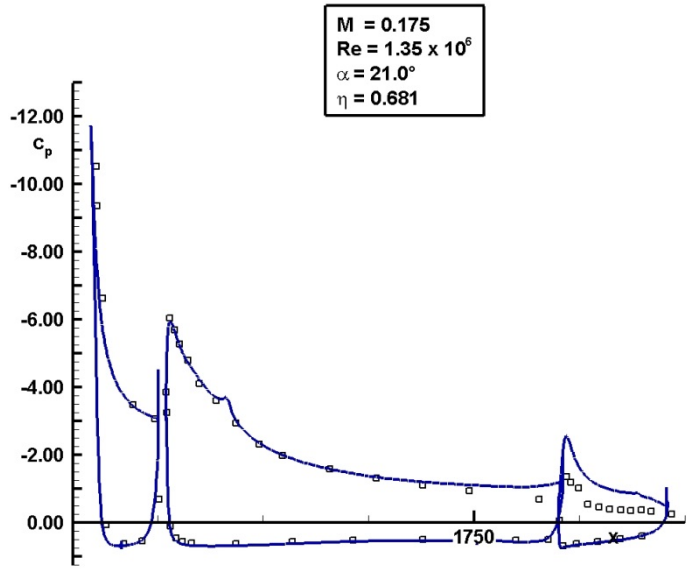
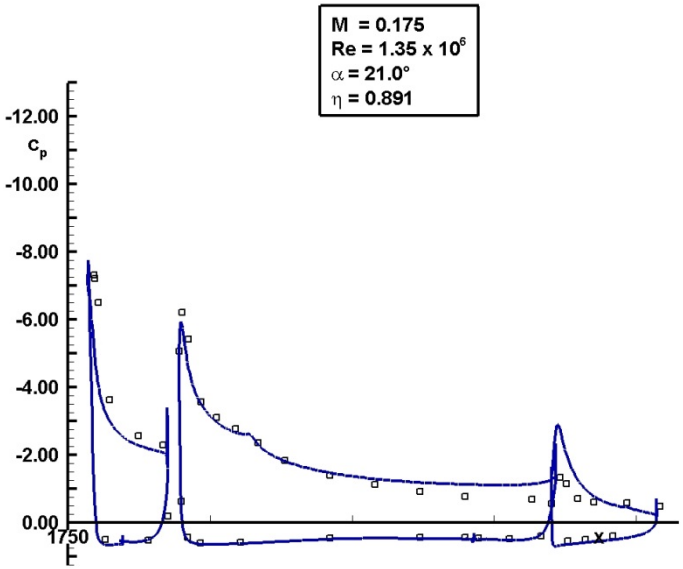






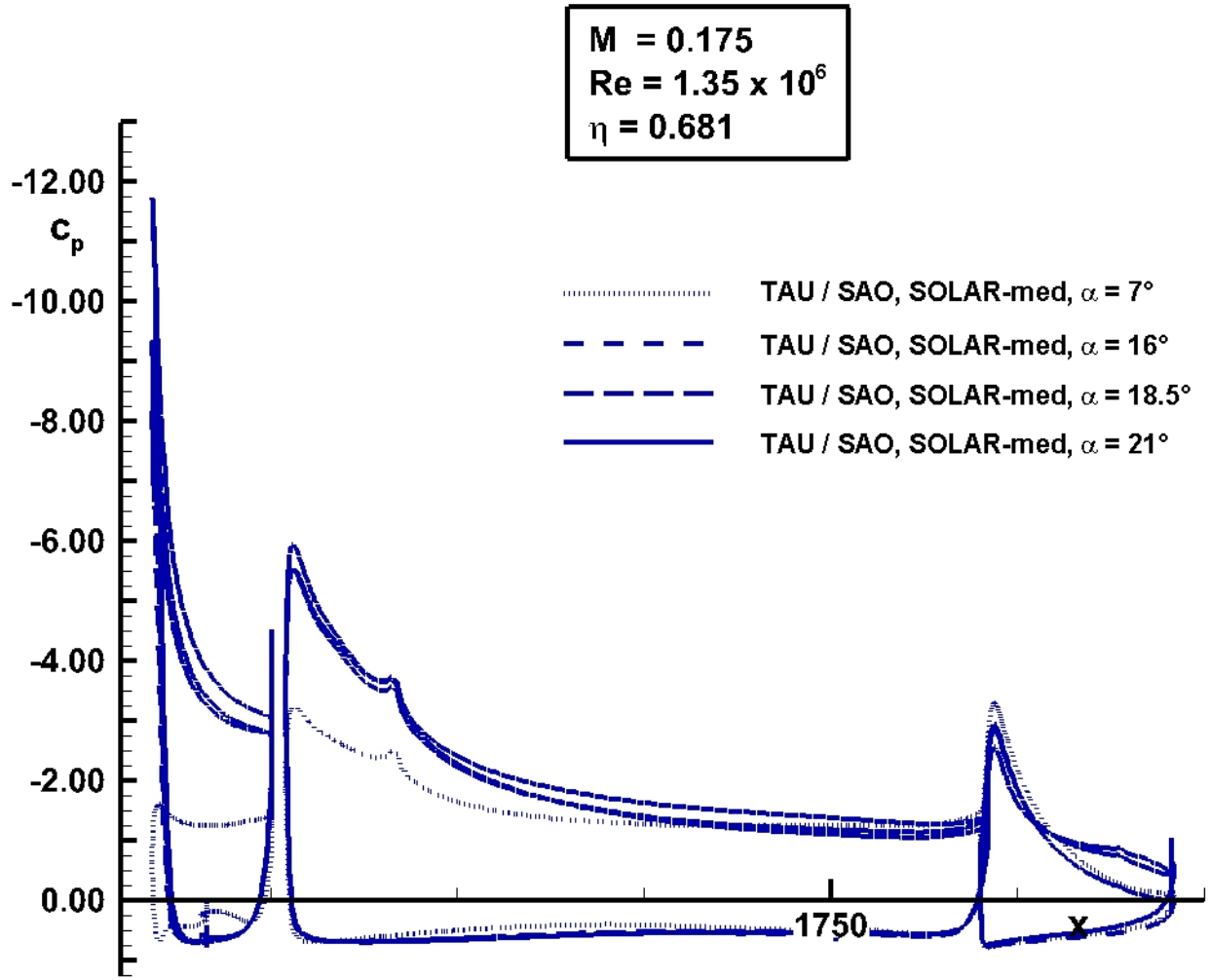


α = 21°

PS1, PS4, PS6, PS1

TAU/SAO, Solar Grid - Case 3a (low Re-No.)

CFD High Lift Prediction Workshop

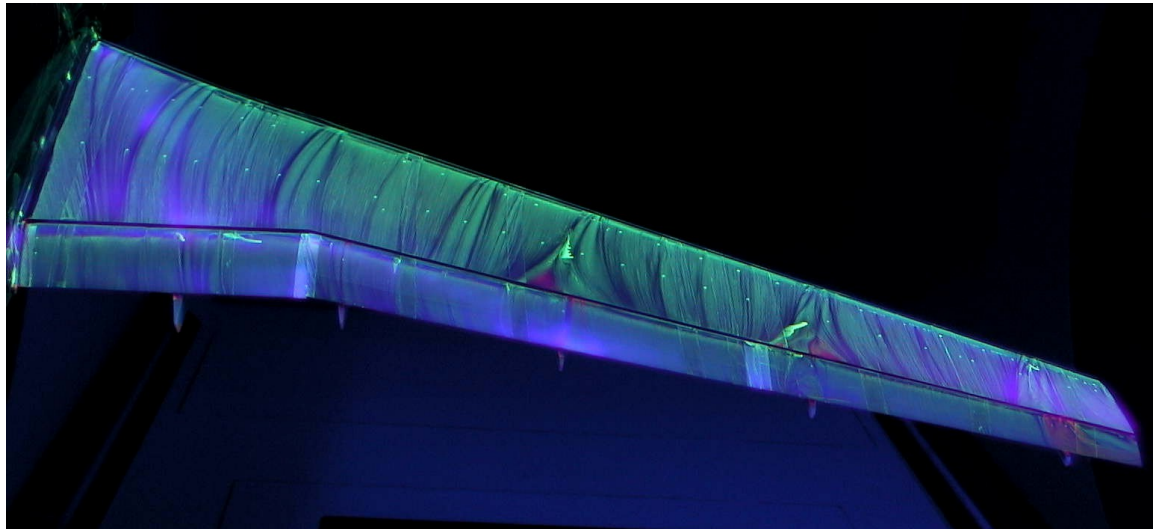


α = var.

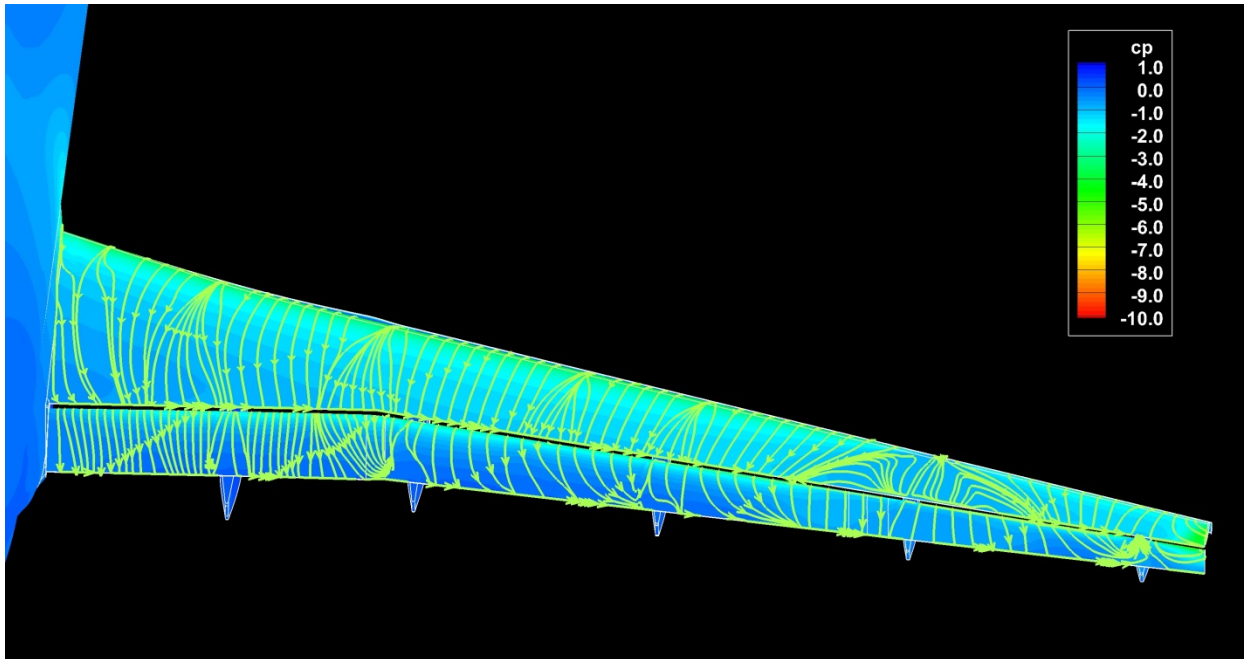
PS6

TAU/SAO, Solar Grid - Case 3a (low Re-No.)

CFD High Lift Prediction Workshop



α = 18.5°



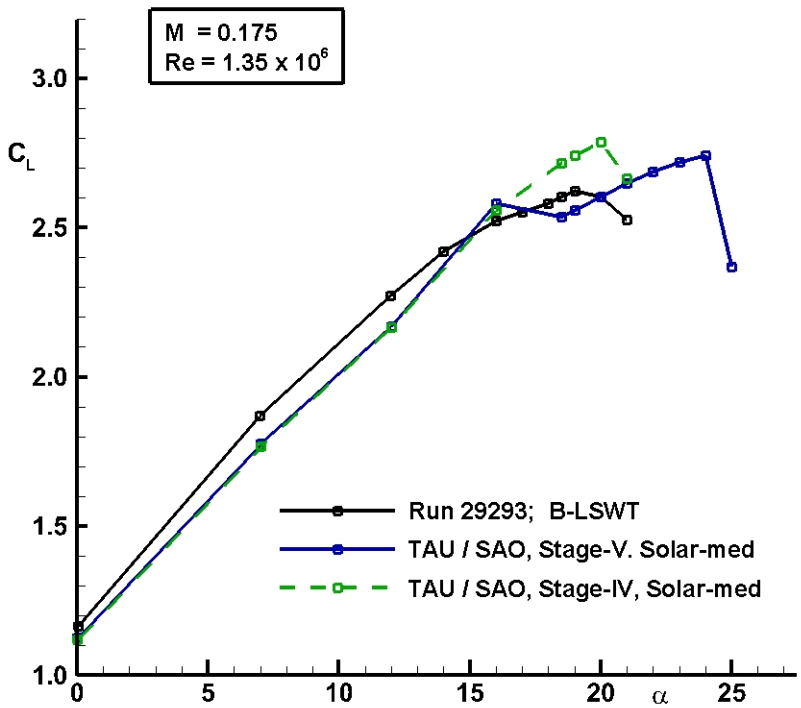
CASE 3a vs. Case 2a

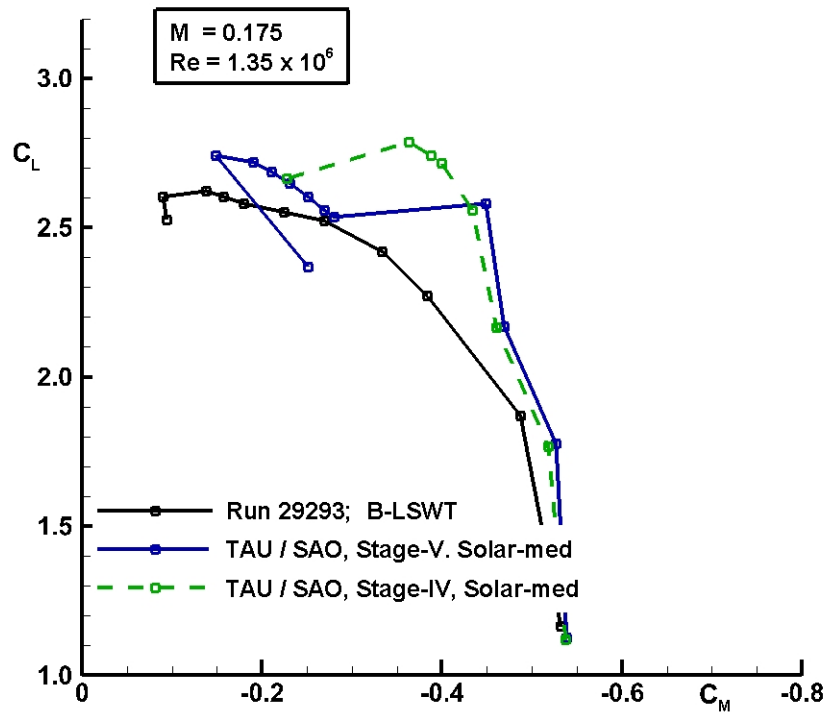
TAU-SAO / SOLAR

Pressure Tube Bundle Influence, Low Re No.

TAU/SAO, Solar Grid - Case 3a vs. Case 2a (low Re-No.)

- **Lift curve and pitching moment**





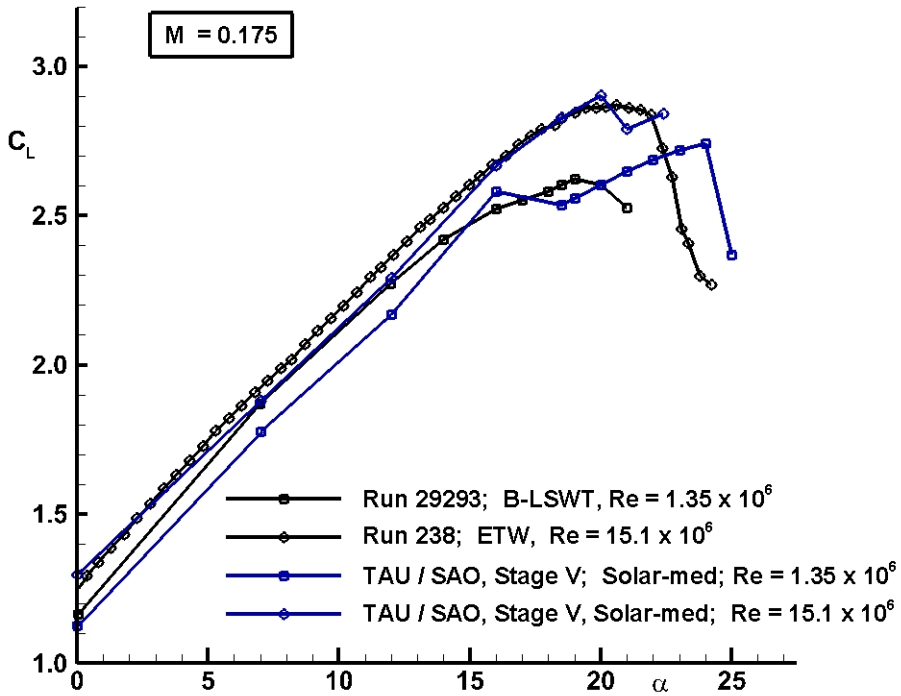
CASE 3b (vs. Case3 a)

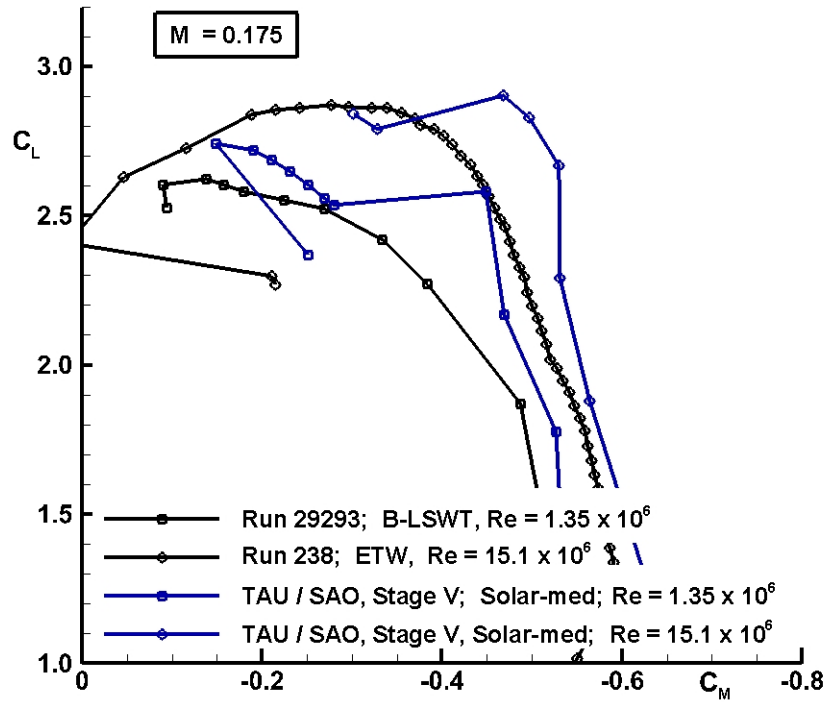
TAU-SAO / SOLAR

Baseline Validation, High Re No.

TAU/SAO-Computations, Solar Grid - Case 3b (high Re-No.)

- **Lift curve and pitching moments 3a vs. Case 3b**





TAU/SAO, Solar Grid - Case 3b (high Re-No.)

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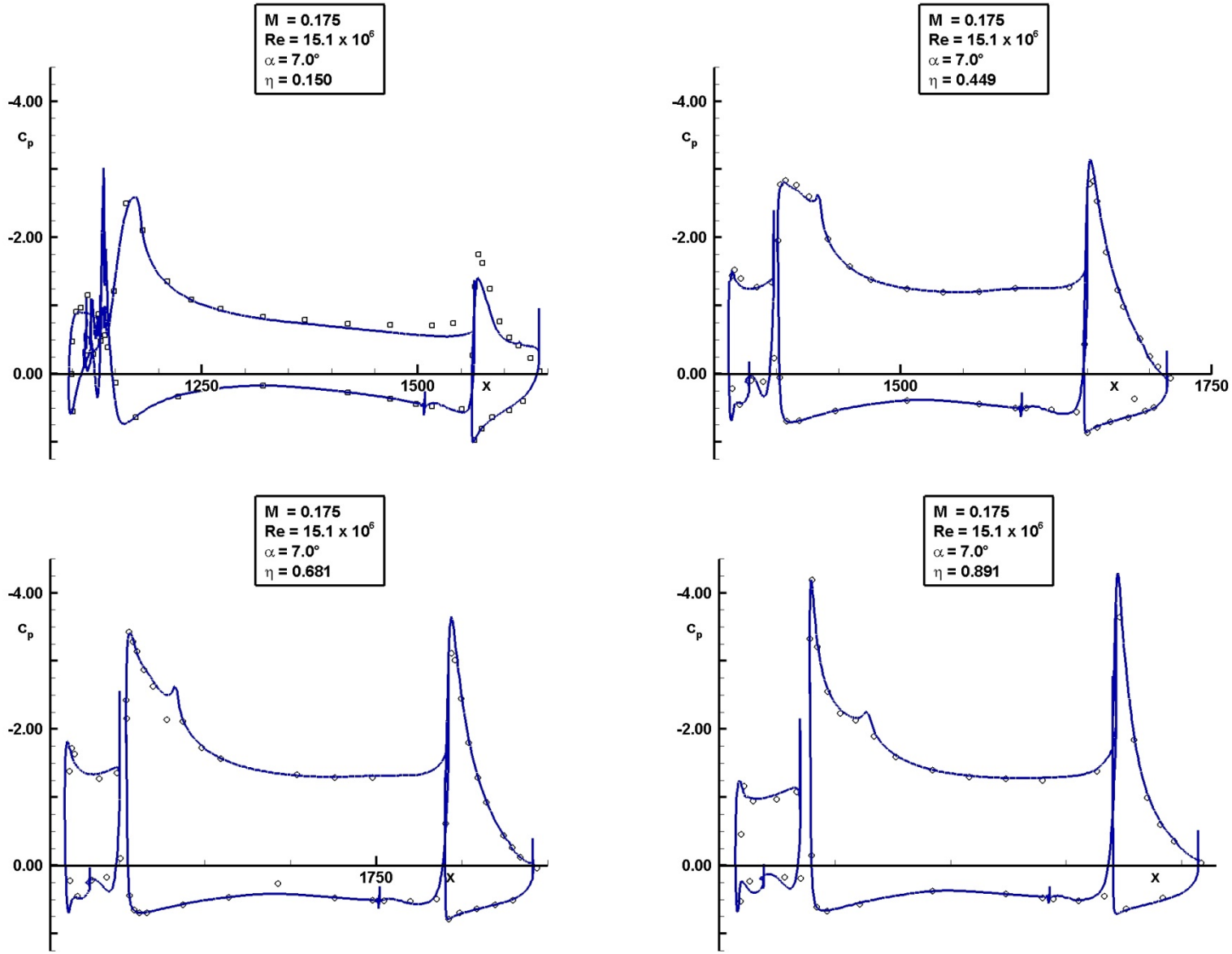
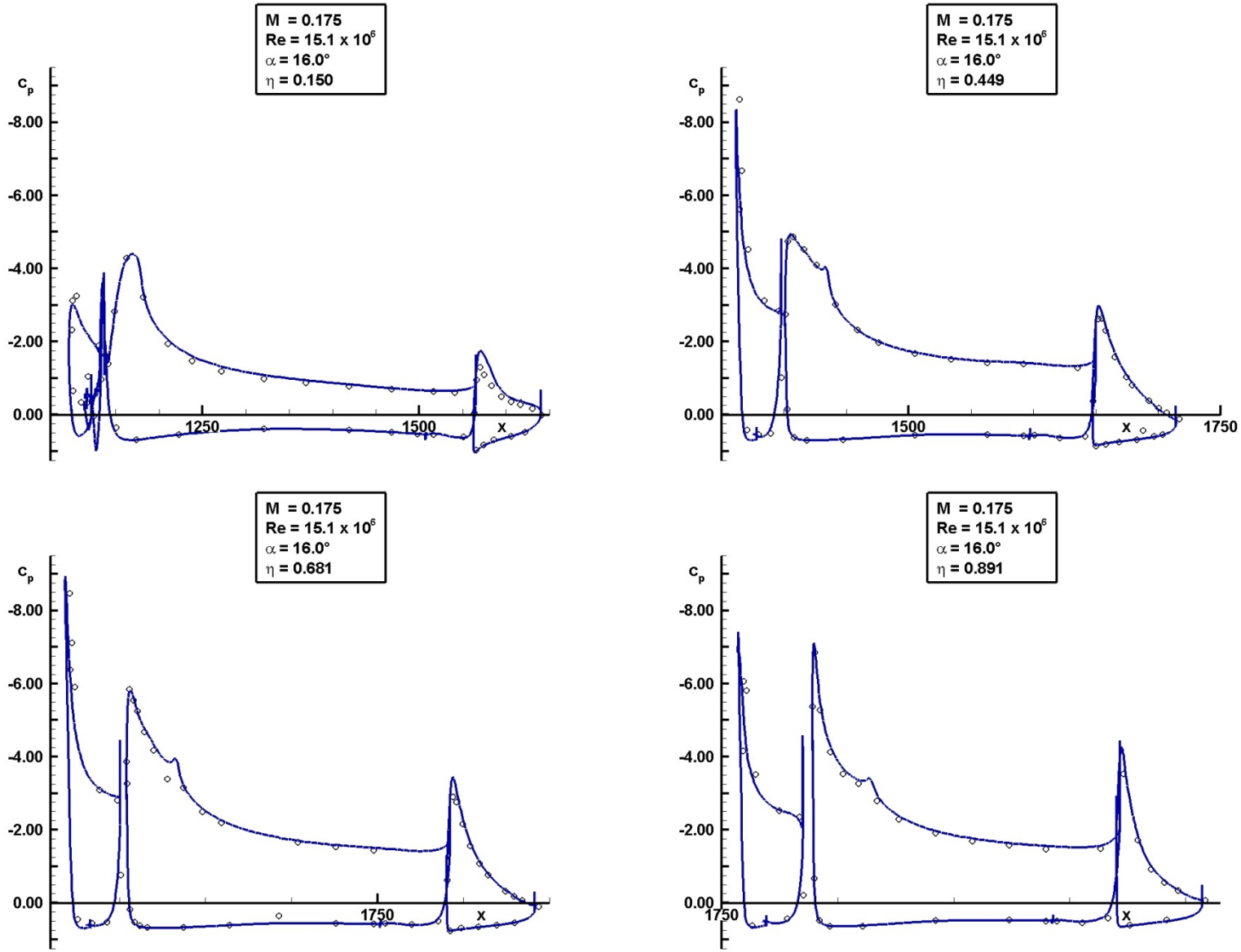


α = 7°

PS1, PS4, PS6, PS1

TAU/SAO, Solar Grid - Case 3b (high Re-No.)

CFD High Lift Prediction Workshop

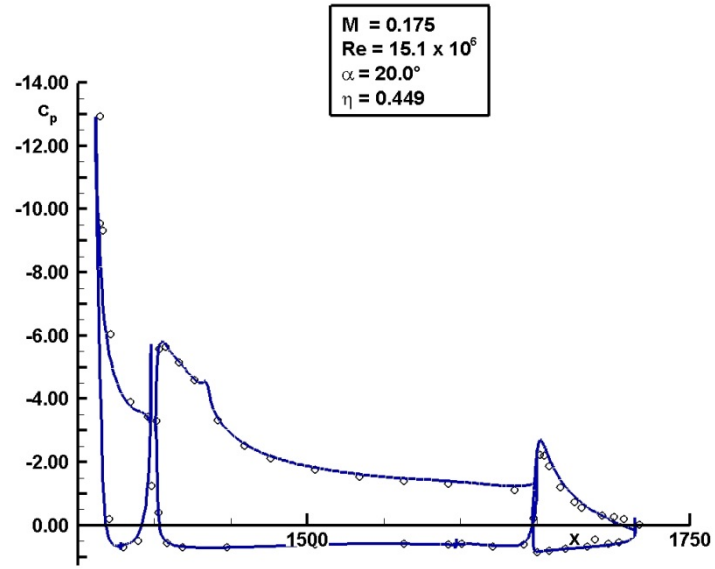


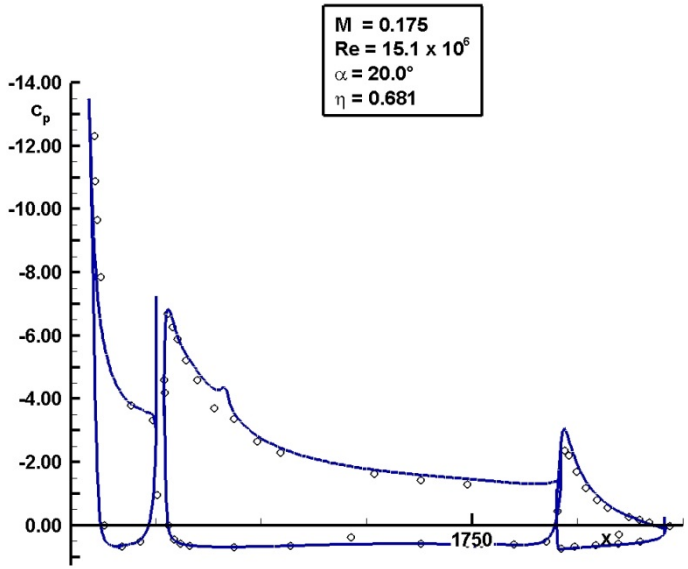
α = 16°

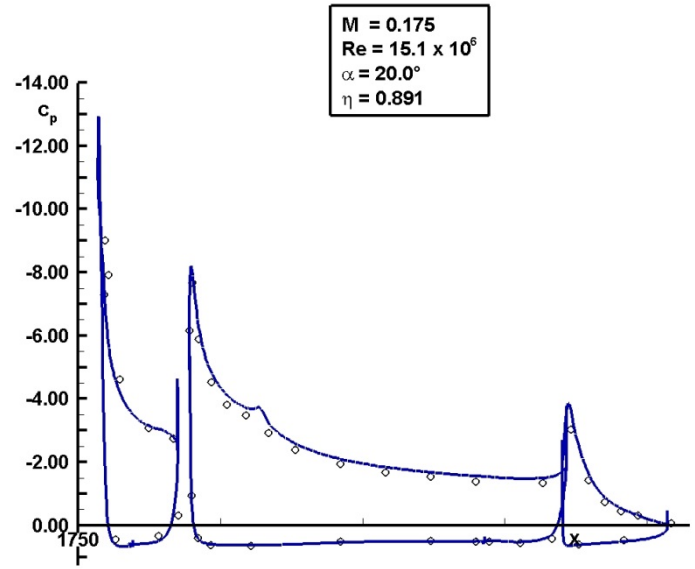
PS1, PS4, PS6, PS1

TAU/SAO, Solar Grid - Case 3b (high Re-No.)

CFD High Lift Prediction Workshop





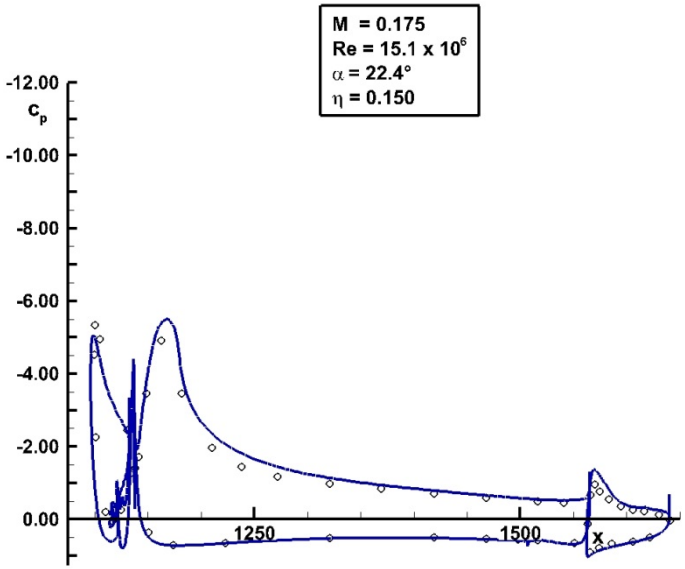


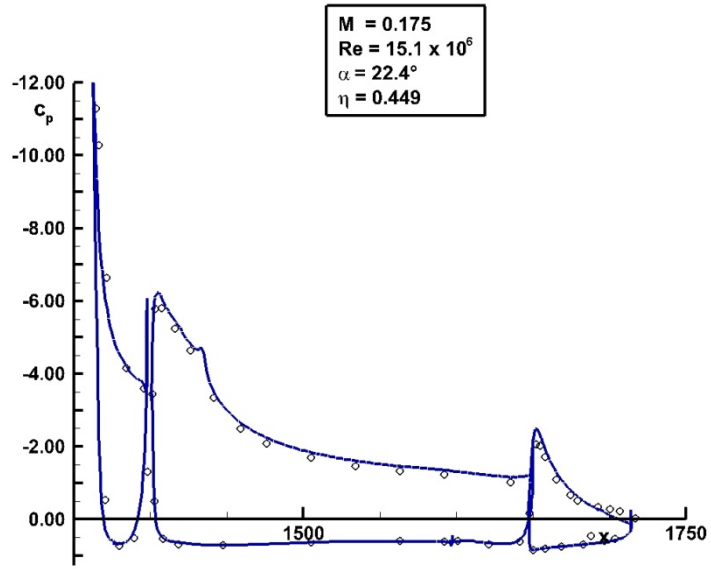
α = 20°

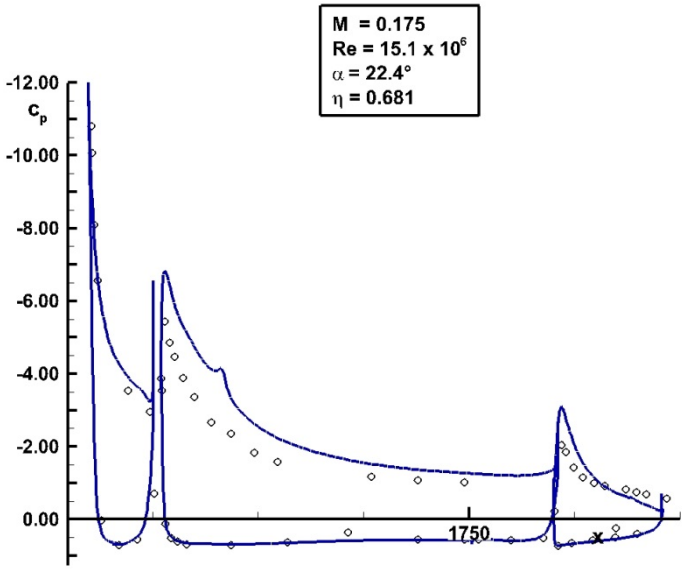
PS1, PS4, PS6, PS1

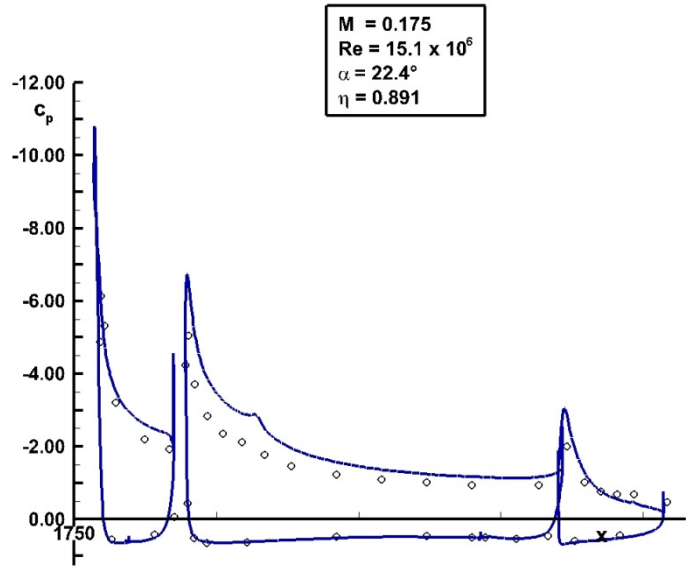
TAU/SAO, Solar Grid - Case 3b (high Re-No.)

CFD High Lift Prediction Workshop





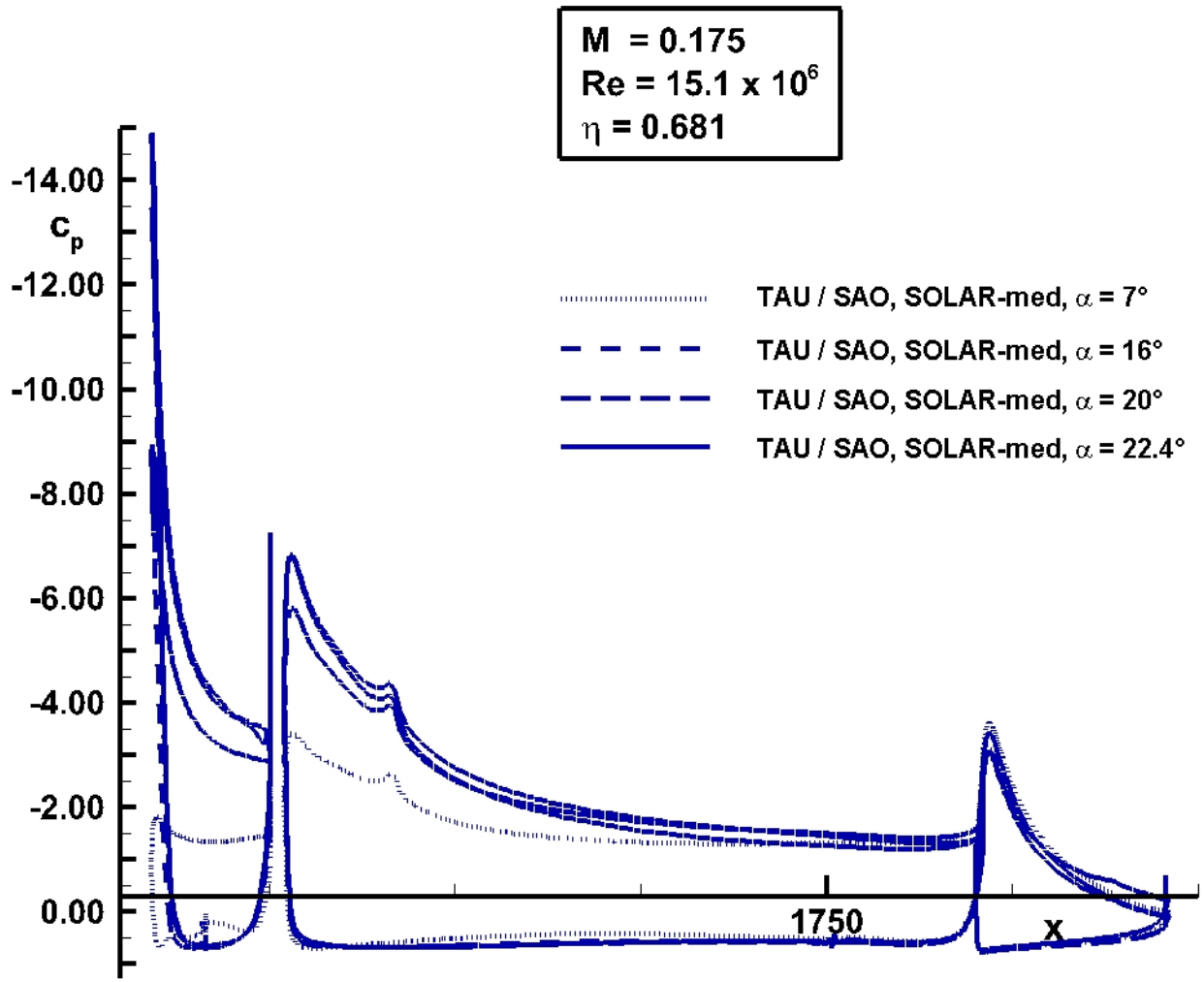




α = 22.4°

PS1, PS4, PS6, PS1

TAU/SAO, Solar Grid - Case 3b (high Re-No.)



α = var.

PS6

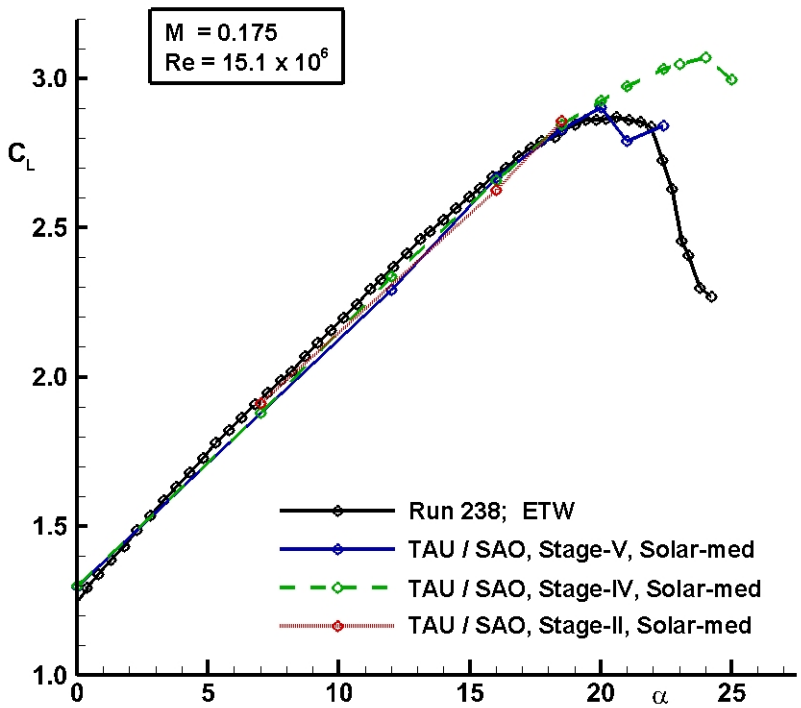
Case 1 vs. Case 2b vs. Case 3b

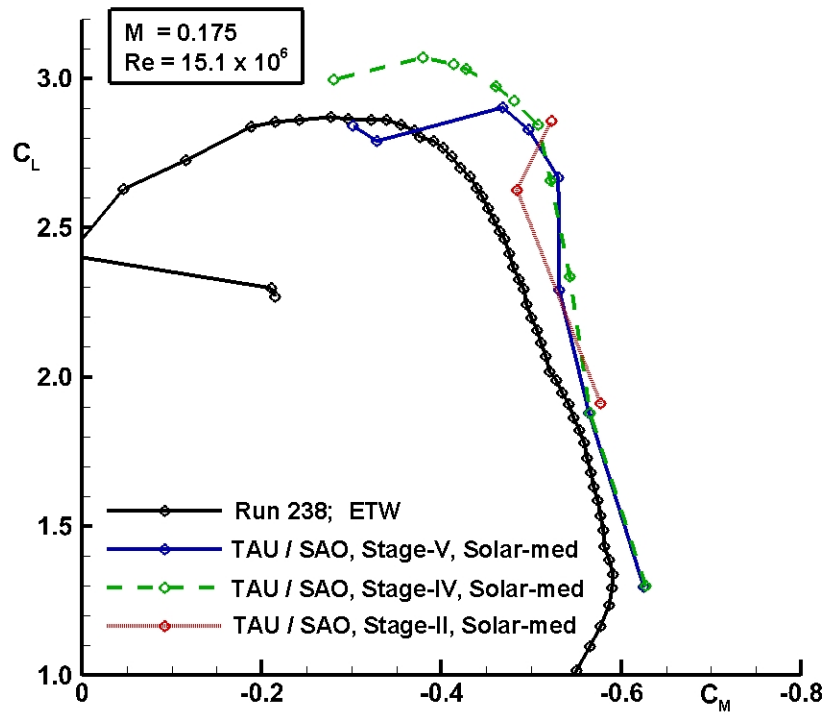
TAU-SAO / SOLAR

Simplification Influence & Grid Refinement, High Re No.

TAU/SAO, Solar Grid - Case 1 vs. Case 2b vs. Case 3b (high Re-No.)

- **Lift curve and pitching moment**



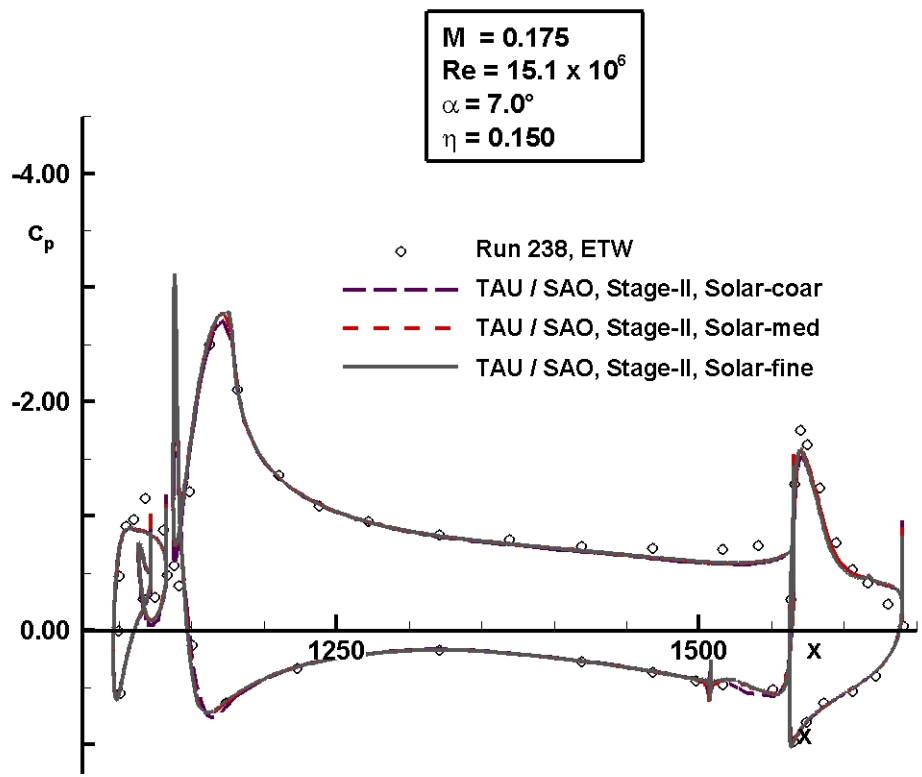


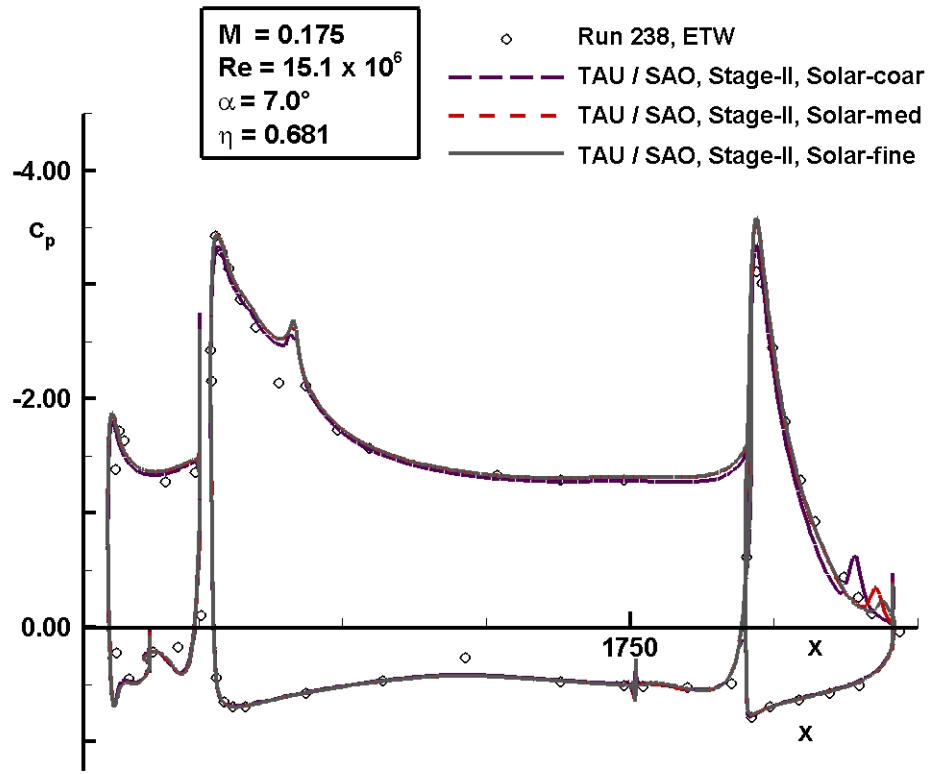
TAU/SAO, Solar Grid - Case 1 (high Re-No.)

CFD High Lift Prediction Workshop

α = 7°

PS1, PS6



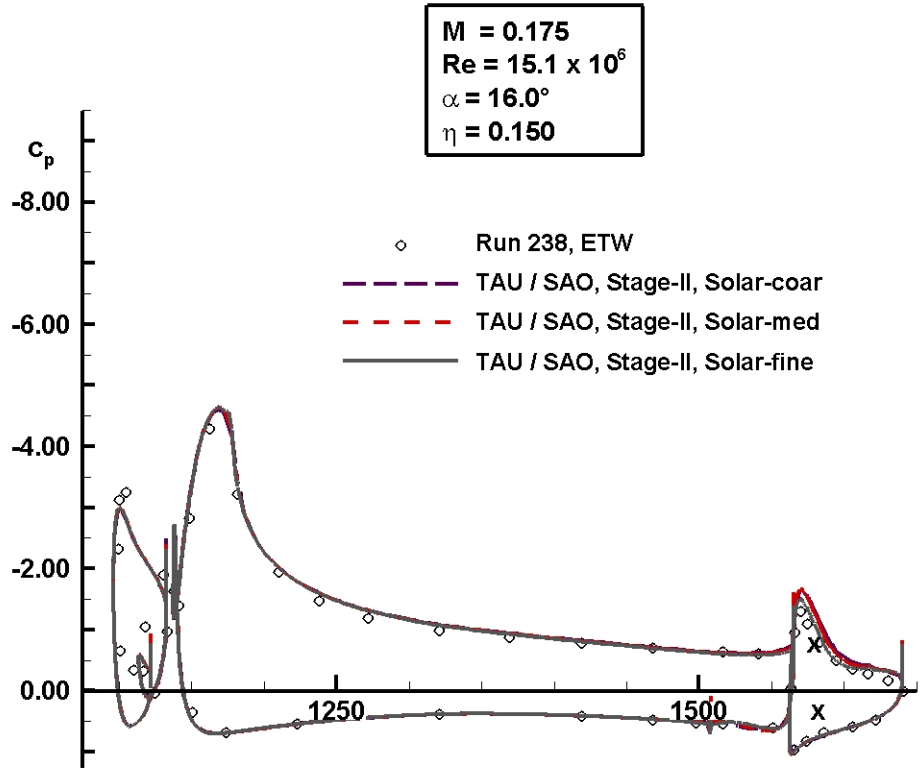


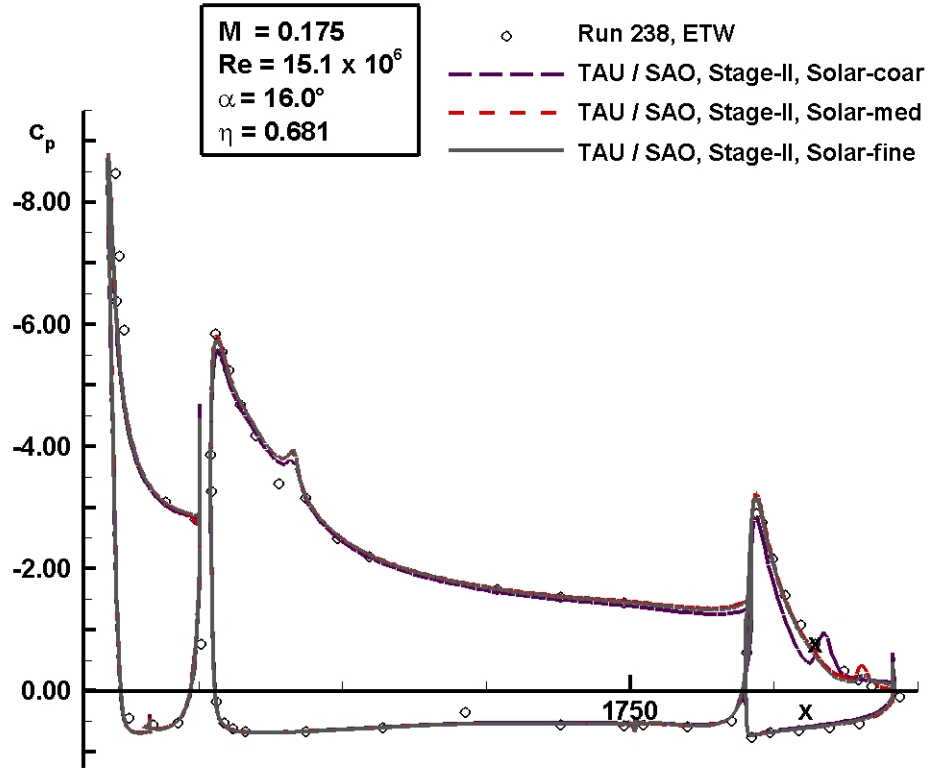
TAU/SAO, Solar Grid - Case 1 (high Re-No.)

CFD High Lift Prediction Workshop

α = 16°

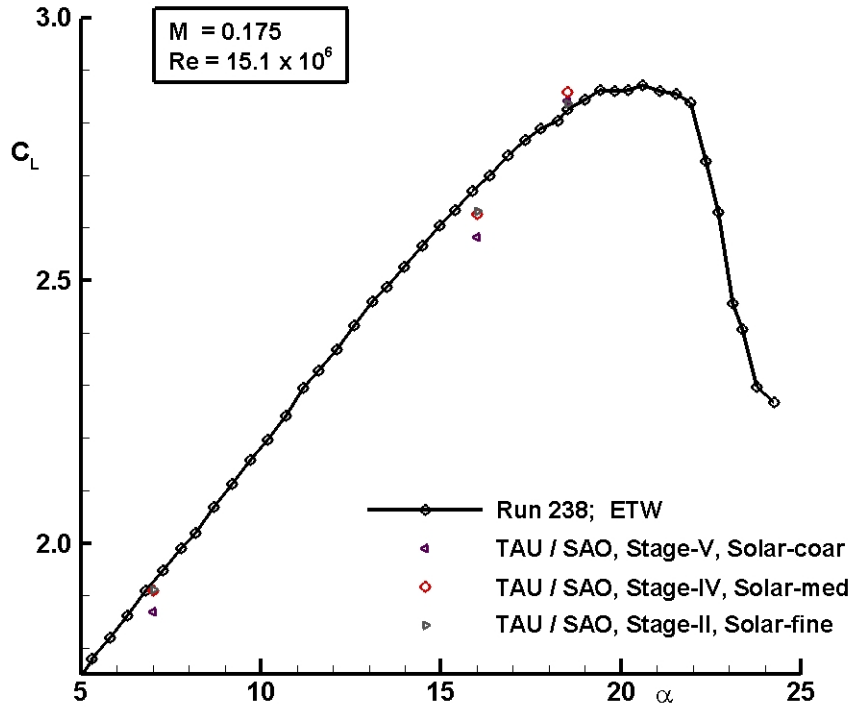
PS1, PS6

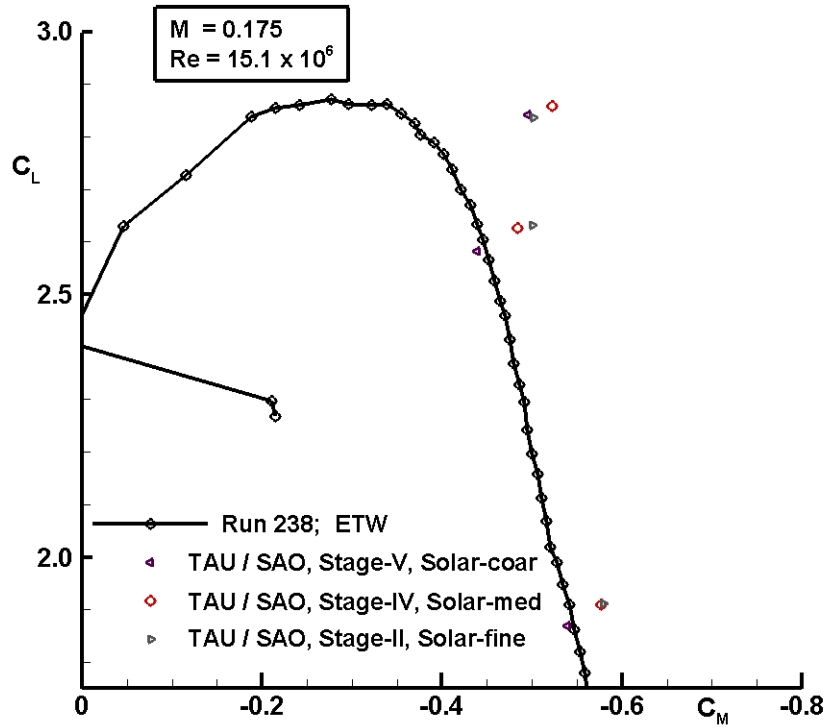


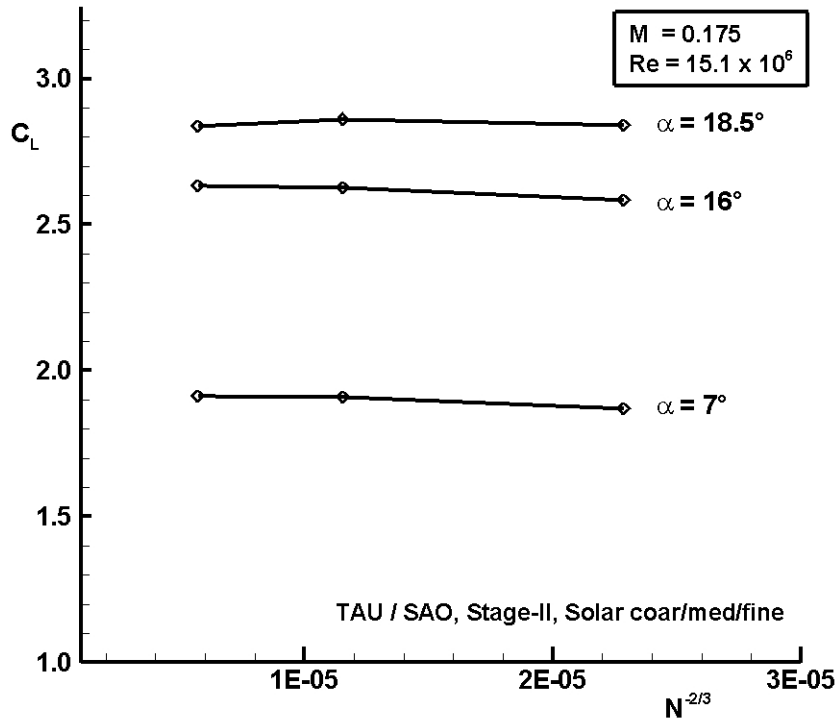
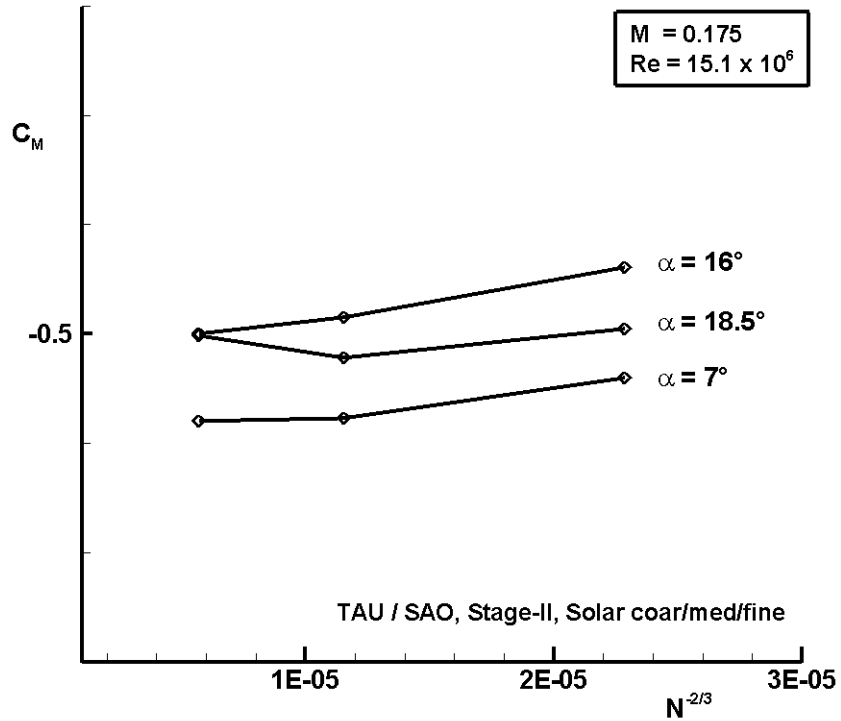


TAU/SAO, Solar Grid - Case 1 (high Re-No.)

- **Lift curve and pitching moment**





TAU/SAO, Solar Grid - Case 1 (high Re-No.)

- **Lift and pitching moment vs. grid point no.**