DPW-8: ONERA contributions to Working Group #1 *“Sources of Scatter”*

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AIAA DPW-8/AePW-4 – San Diego, USA & Virtual

Saturday June 6th, 2026

Outline

- Overview of ONERA participation
- Numerical approach
- Results on Scatter group cases
  - 1b Joukowski airfoil
  - 1c OAT15A airfoil
  - 2a NASA CRM WB grid convergence
  - 2b NASA CRM WB drag polar
- Conclusions & perspectives

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Overview of ONERA participation

- ONERA has been participating in DPWs over many years[1]
- DPW-8:
  - Participation in group meetings since the beginning of DPW-8
  - Most results presented here are recent, computed in early 2026
- Test cases of the Scatter group:
  - 1a OAT15A airfoil (workshop-wide)
  - 1b Joukowski airfoil
  - 1c OAT15A airfoil (refined specifications)
  - 1d/1e DPW-III Wing1 and Wing2
  - 2a/2b NASA Common Research Model Wing-Body

[1] *[…]*
D. Hue, "Fifth Drag Prediction Workshop: ONERA Investigations with Experimental Wing Twist and Laminarity, J. Aircraft, 2014.
D. Hue, Q. Chanzy, S. Landier, "DPW-6: Drag analyses and Increments Using Different Geometries of the Common Research Model Airliner", J. Aircraft, 2018.
D. Hue, F. Sartor, I. Petropoulos, C. Fournis, "DPW-7: Steady and Unsteady Computations of the Common Research Model at Different Reynolds Numbers", J. Aircraft, 2023.

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- Test cases of the Scatter group:
  - ~~1a OAT15A airfoil (workshop-wide)~~ → ran by colleagues as part of the “Buffet” group
  - 1b Joukowski airfoil
  - 1c OAT15A airfoil (refined specifications)
  - ~~1d/1e DPW-III Wing1 and Wing2~~ → not computed (unstructured grids only)
  - 2a/2b NASA Common Research Model Wing-Body

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Numerical approach

- Reference simulation approach for cruise performance prediction
- *elsA* CFD solver[1]
  - Compressible Finite-Volume Navier-Stokes solver
  - Property of ONERA – Safran
  - Use of the structured-grid solver
  - Convective flux discretization using a Jameson-type scheme
  - Multigrid techniques applied when possible
  - Turbulence modeling
    - Fully-turbulent computations
    - Submitted results computed using SA variants
    - Computations in progress with other turbulence models
  - Pursuit of fine iterative convergence

[1] L. Cambier, S. Heib, S. Plot, "The ONERA elsA CFD Software: Input from Research and Feedback from Industry" Mechanics and Industry, 2013.

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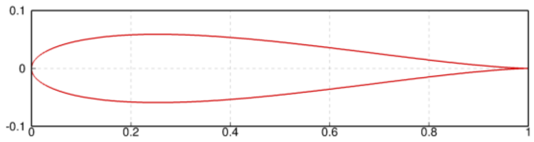
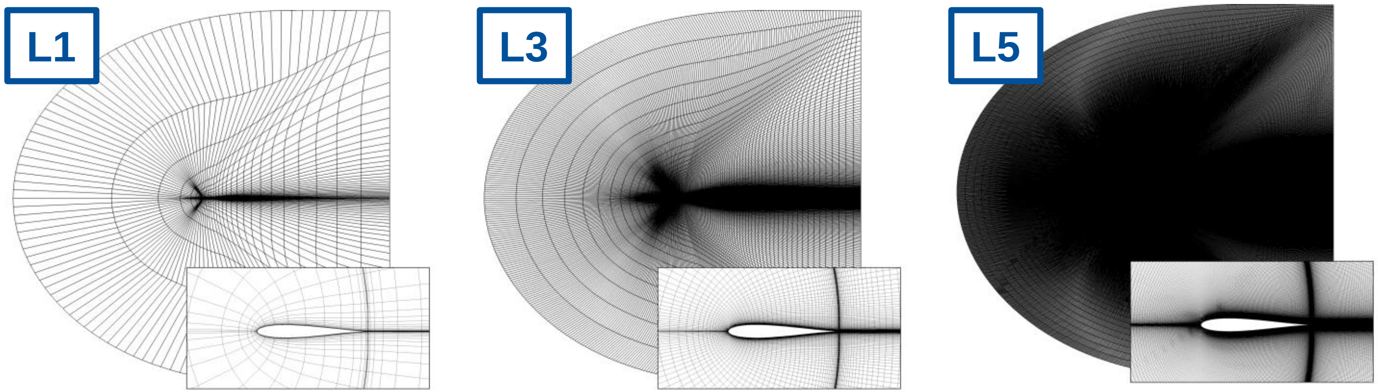
TestCase1b – Joukowski airfoil

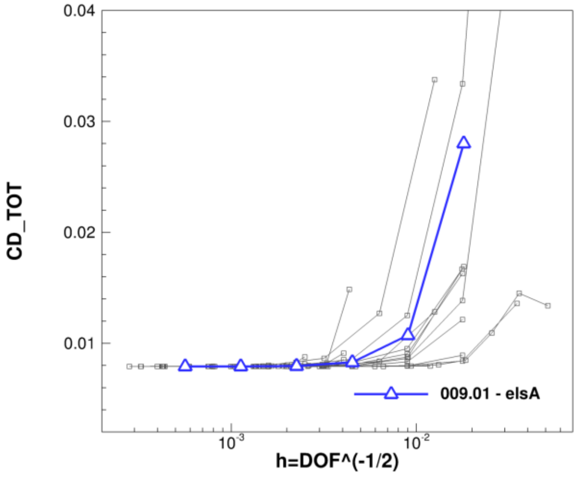
Joukowski airfoil

- Verification case expected to eliminate sources of discrepancy and lead to a “universal” agreement between solvers
- Mach = 0.15, Re = 6 M, α=0°
- SA with farfield $\tilde{\nu}/\nu$ = 3
- Analytical high-quality grids in “classic” and “challenge” variants
  - Case computed on classic linear grids (6 levels)





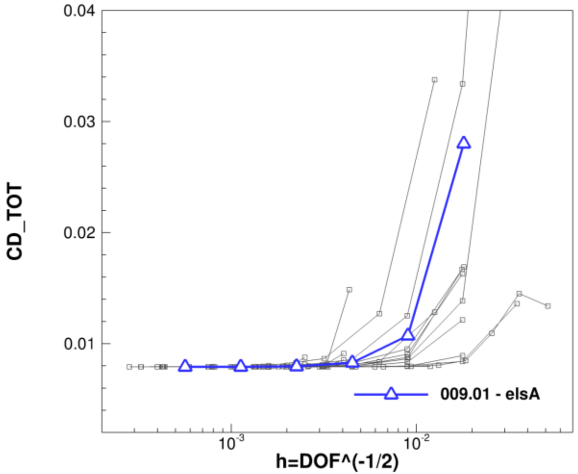
TestCase1b – Joukowski airfoil

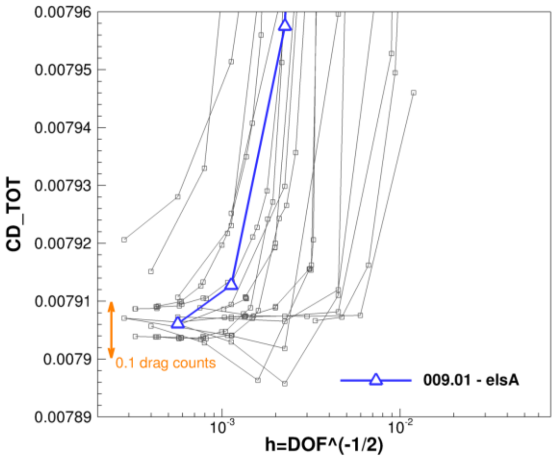


<u>Grid convergence & order of accuracy</u>

- Good agreement between submissions on the overall CD value

TestCase1b – Joukowski airfoil





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- Most submissions agree within ~0.05 drag counts

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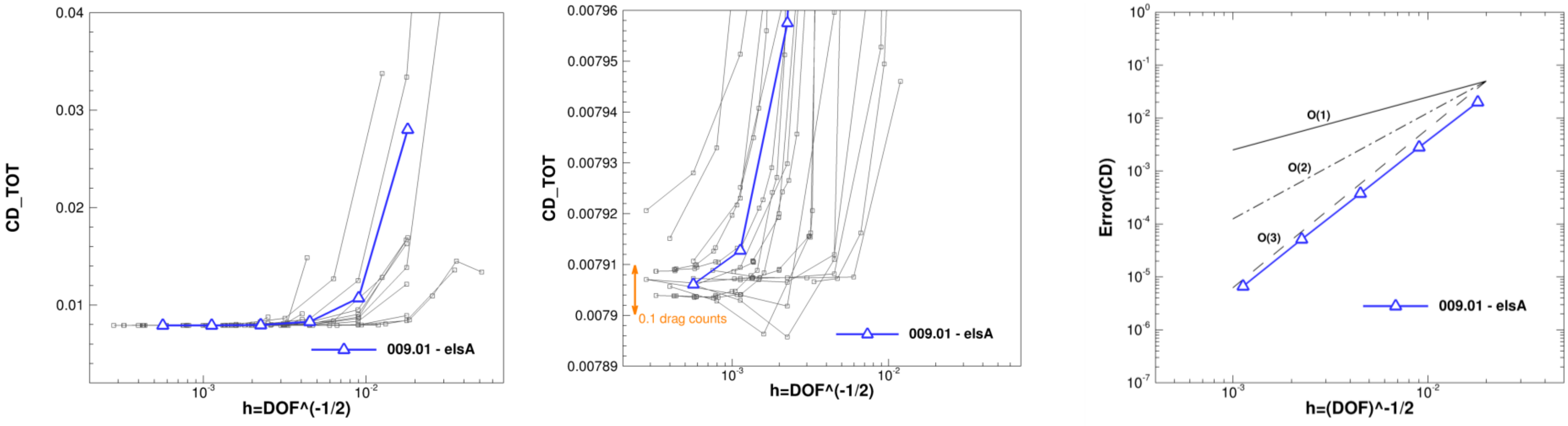


(note: error computed with respect to the elsA solution on the L6 mesh)

<u>Grid convergence & order of accuracy</u>

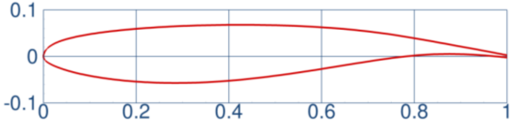
- Good agreement between submissions on the overall CD value
- Most submissions agree within ~0.05 drag counts
- Higher than 2nd effective order of accuracy

TestCase1c – OAT15A airfoil

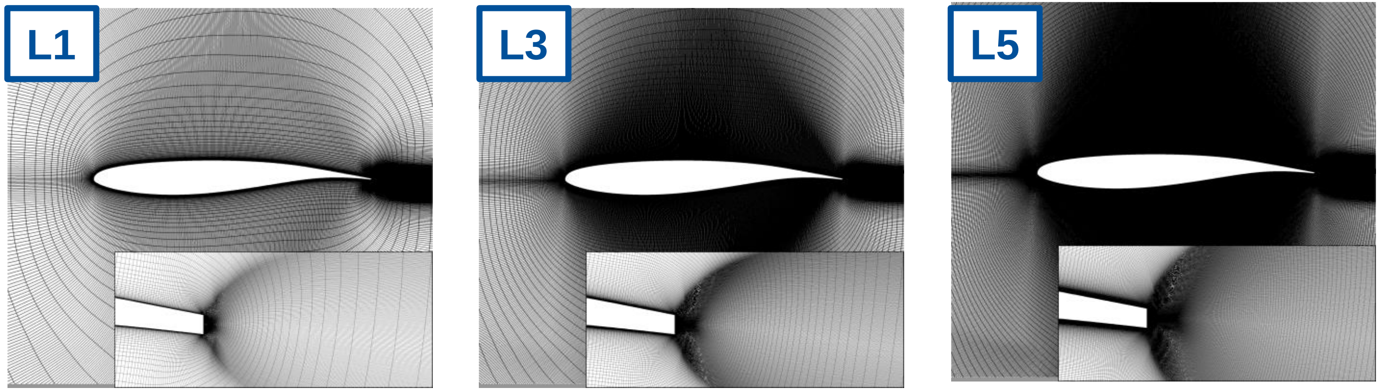
OAT15A airfoil

- ONERA supercritical airfoil, focus of many transonic buffet studies
- Mach = 0.73, Re = 3M, α=1.50°
- SA with farfield $\tilde{\nu}/\nu = 3$
- Updated version of TestCase1a aimed at reducing scatter
- Cadence structured grids REV02 (6 levels)

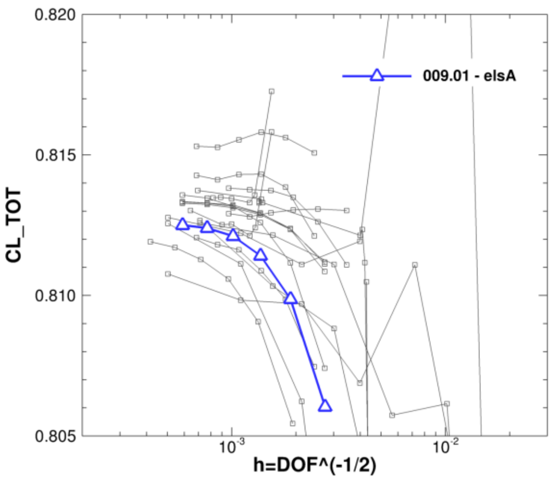
Jaquin, et al. "Experimental Study of Shock Oscillation over a Transonic Supercritical Profiles." AIAA Journal, Vol. 47, No. 9, 2009. Pages 1985-1994.

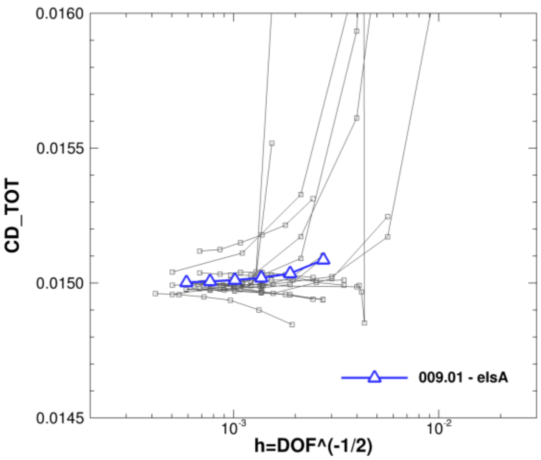


ONERA OAT15A Transonic Airfoil



TestCase1c – OAT15A airfoil

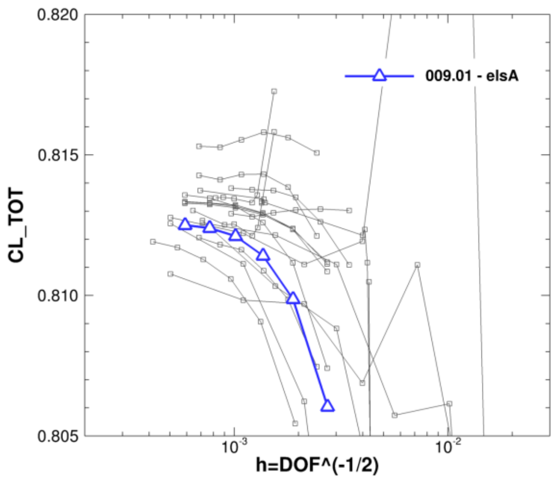


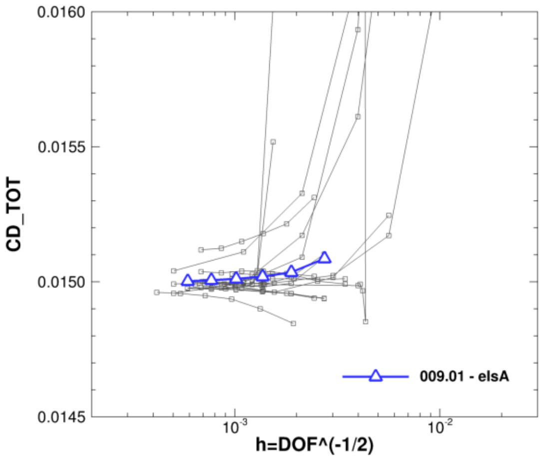


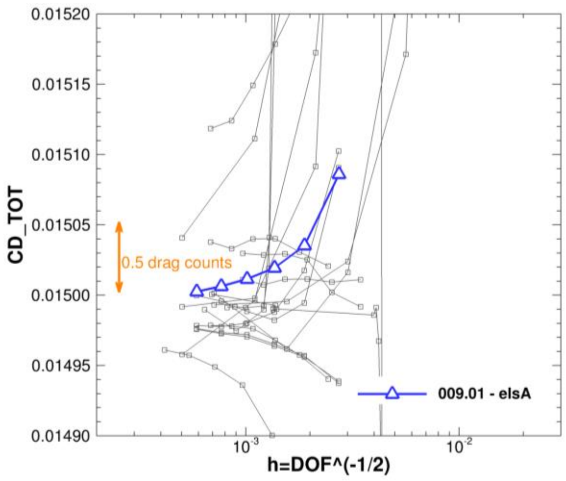
Grid convergence

- Good agreement between solvers in drag value

TestCase1c – OAT15A airfoil







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- Good agreement between solvers in drag value
- Almost all submissions agree within ~1 dc on the finest grid level

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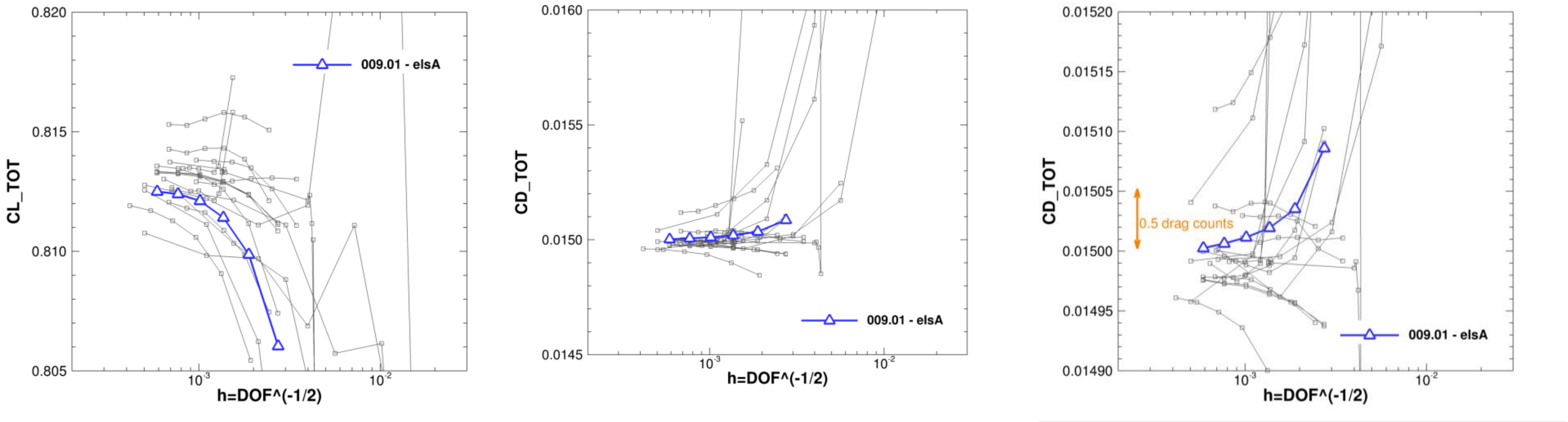


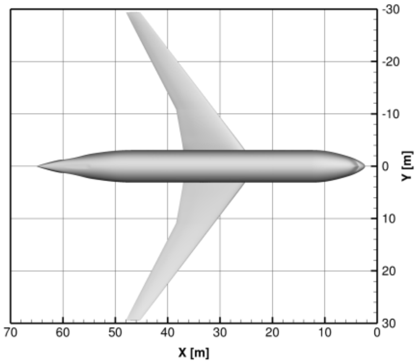
<u>Grid convergence</u>

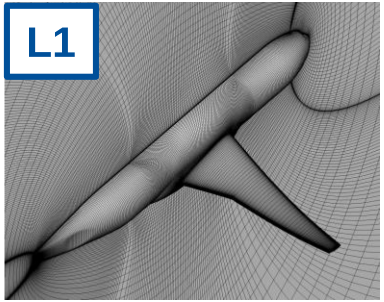
- Good agreement between solvers in drag value
- Almost all submissions agree within ~1 dc on the finest grid level
- Part of the discrepancy likely associated to differences in lift, more sensitive at a fixed AoA in transonic conditions

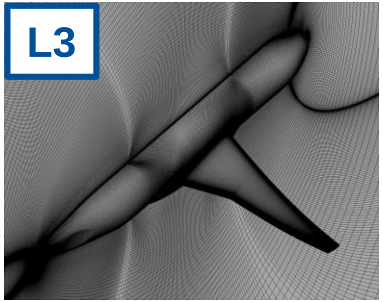
TestCase2a/2b – NASA CRM

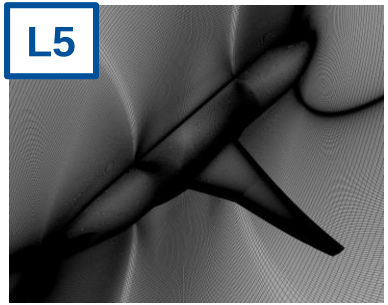
NASA CRM WB

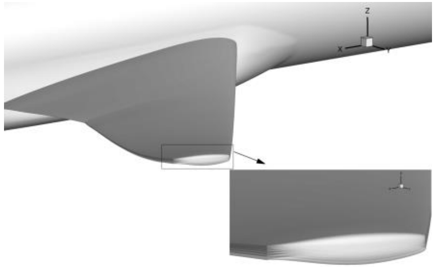
- Mach=0.85, Re_c=5 M
- Multi-block structured Vassberg grids from DPW-7
  - **TestCase2a (grid convergence at cruise point)**
    Rigid wing with measured shape at α=2.5°
    Computed 5 levels from L1 (Tiny, ~5 MPts) to L5 (Extra-fine, ~140 MPts)
  - **TestCase2b (alpha sweep: 2.50° - 4.25° with Δα=0.25°)**
    Rigid wing with measured shape at each α
    L3 grid (Medium, ~40MPts)
- Turbulence model effect: SA vs. SA+QCR2000





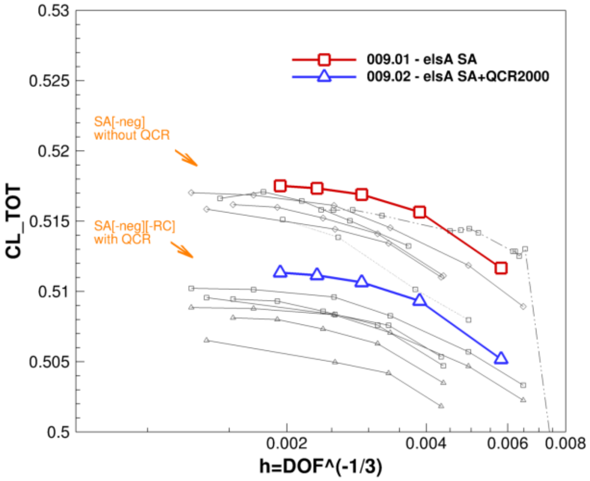






View of the wing deformation along the alpha sweep study

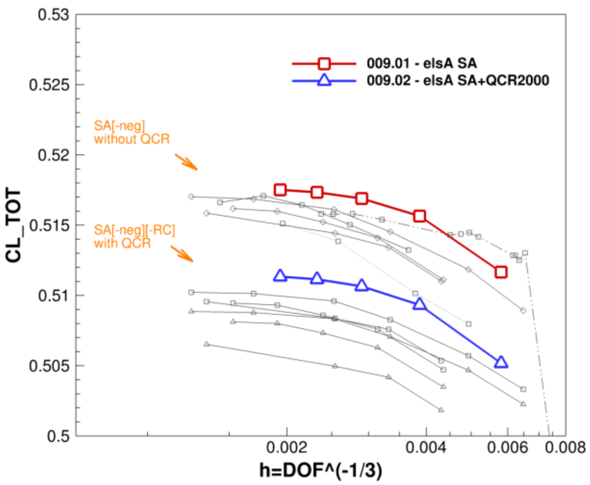
TestCase2a – NASA CRM grid convergence

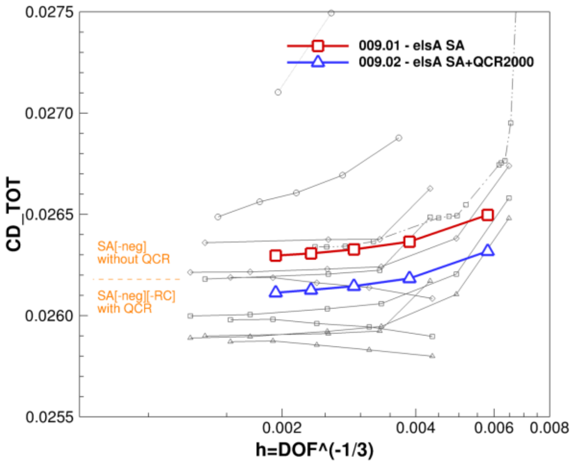


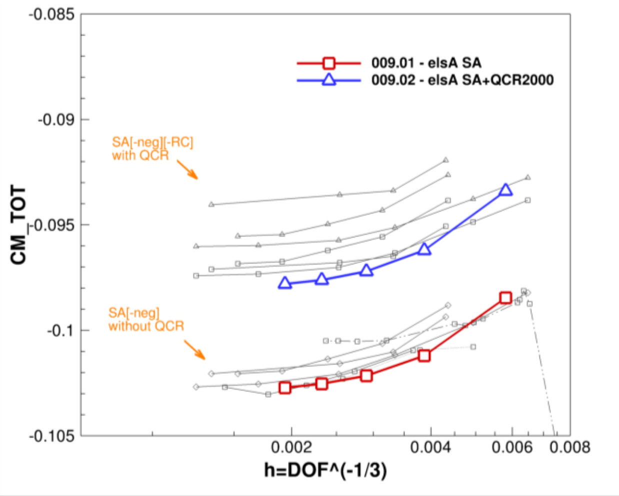
Grid convergence

- QCR and RC corrections yield lower lift and pitching moment

TestCase2a – NASA CRM grid convergence



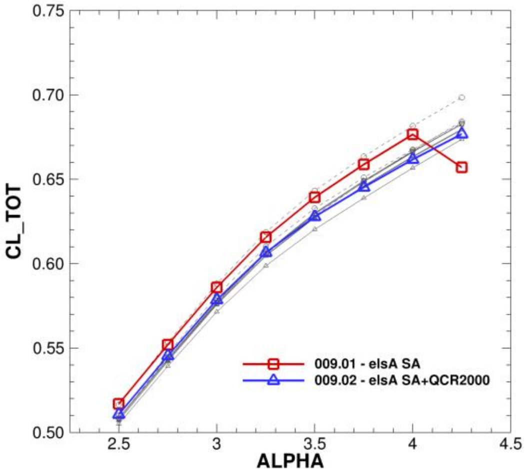




<u>Grid convergence</u>

- QCR and RC corrections yield lower lift and pitching moment
- CD increment across 5 grids ~2 dc for ONERA solutions (with and without QCR)
- Less submitting participants (all SA*): results overall consistent, but larger scatter than previous cases

TestCase2b – NASA CRM drag polar



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- Generally QCR yields lower CL at fixed alpha, adding RC further slightly lowers CL

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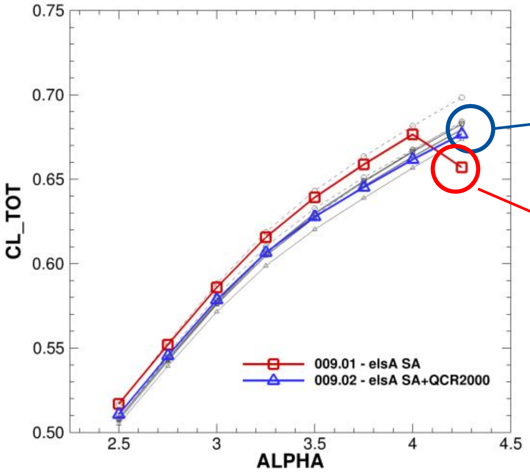

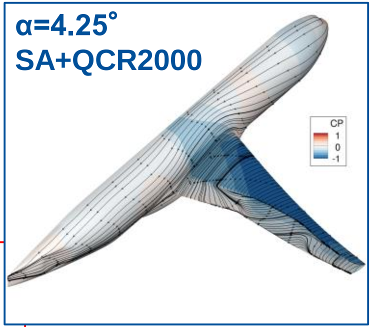

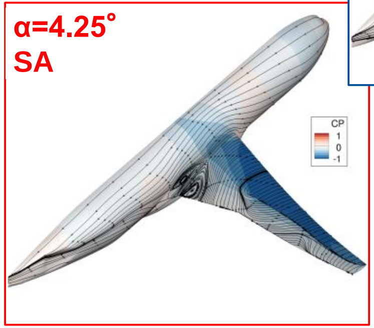

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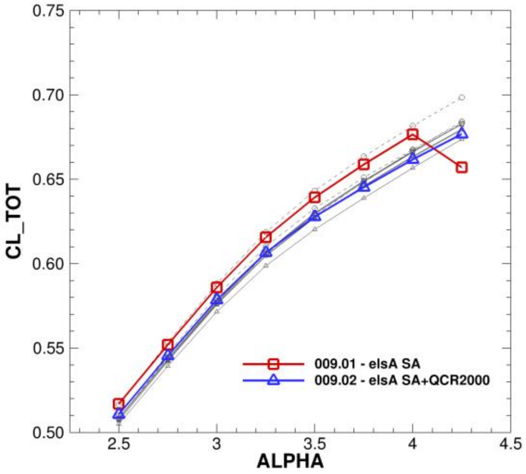

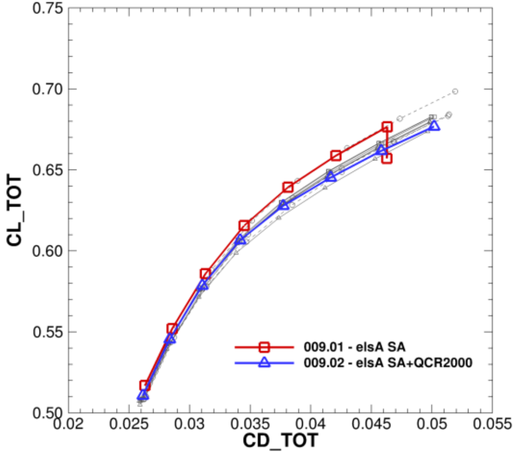

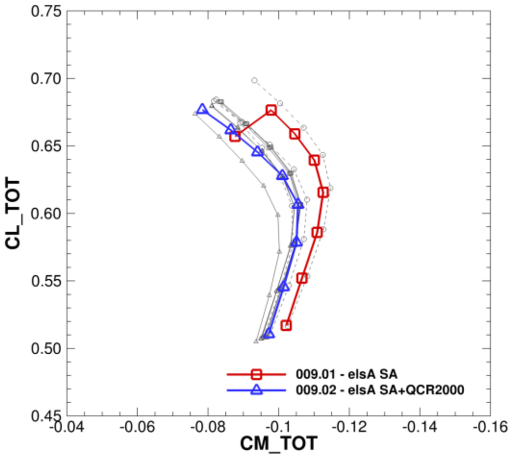

<u>Alpha sweep</u>

- Generally QCR yields lower CL at fixed alpha, adding RC further slightly lowers CL
- As established in previous DPWs, QCR remedies the lift loss (not observed in experiments) due to separation at the wing-body junction
- Scatter in CMy prediction remains notable (important turbulence model effects in DPW-7)

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- Main conclusions
  - No significant difficulties encountered with a reference CFD approach
  - Very good convergence behavior on good-quality structured grids
  - Comparisons at fixed AoA between solvers is subtler than at fixed CL
    > mixed effects of numerical scheme and turbulence modeling

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Thank you for your attention!