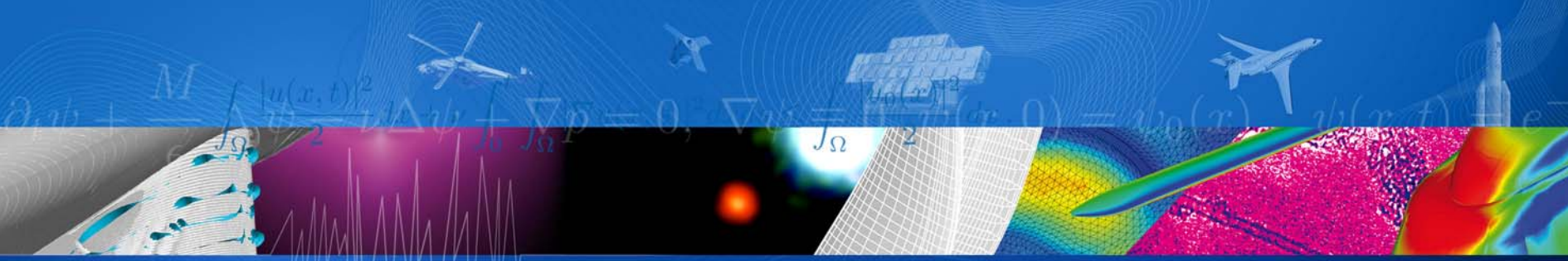
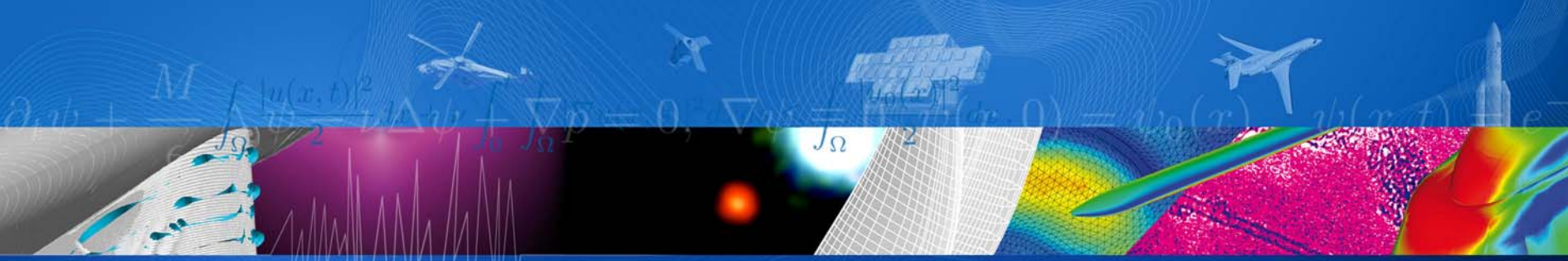


ONERA

THE FRENCH AEROSPACE LAB

return on innovation

www.onera.fr



ONERA Contribution to HiLiftPW-1

L. Wiart
Aerospace Engineer, Civil Aircraft Unit, Applied Aerodynamics Department
M. Meunier
Aerospace Engineer, Civil Aircraft Unit, Applied Aerodynamics Department

June 26th-27th 2010, Chicago, Illinois

ONERA
THE FRENCH AEROSPACE LAB

return on innovation

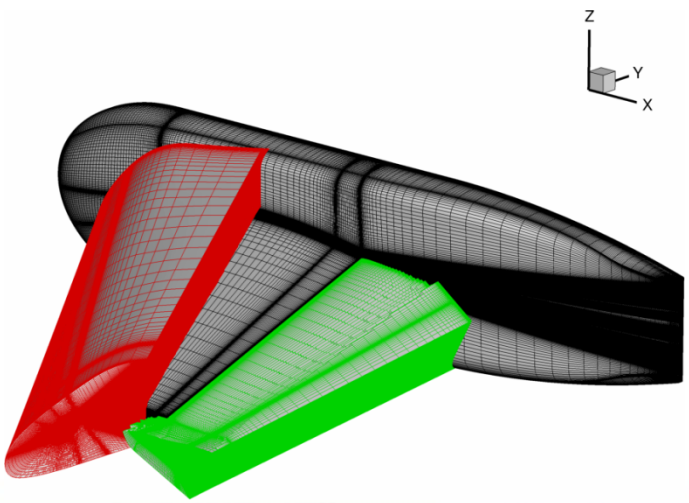
Outline

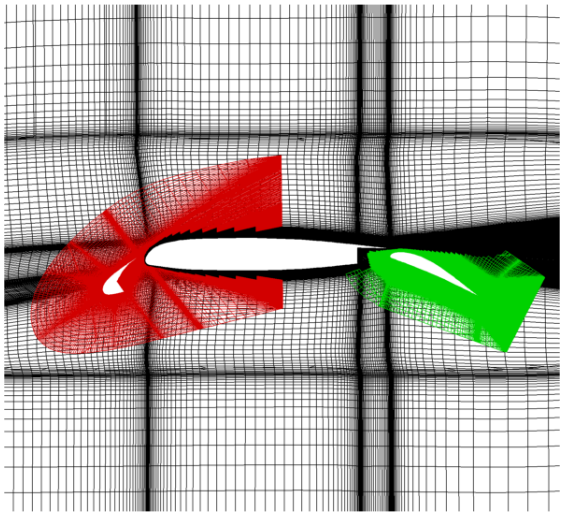
- Grids overview
- The ***elsA*** solver
- Computation strategy
- Grid convergence study
- Flap deflection prediction study
- Turbulence modeling
- Flap/SOB separation bubble investigation
- Far-Field Drag analysis
- In-house overset grid results

Grids overview

- Str-OnetoOne-A-v1 (supplied by HiLiftPW-1 committee)
  - Coarse: 22,606,727 points
  - Medium: 52,061,907 points
  - Fine: 170,661,635 points

- Structured overset created in-house using Icem-CFD
  - Equivalent to CONF1 medium grid: 32,389,554 points





Masking detail

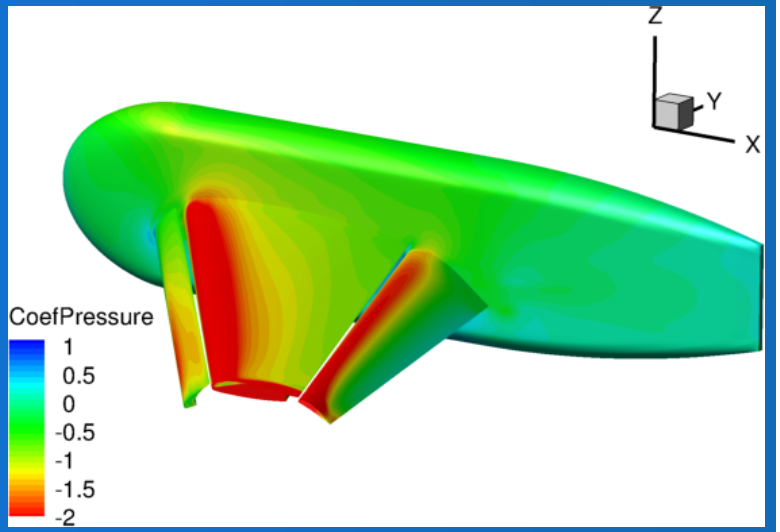
The *elsA* solver

RANS computations

- Cell-centered finite volume on structured multi-block meshes
- Time integration: Backward-Euler scheme with LU-SSOR relaxation
- Spatial discretization: Jameson's second-order centered scheme
- V-cycle multigrid technique
- Low-speed preconditioning

CGNS input and output format

Parallel mode (SGI Altix ICE 8200 EX)

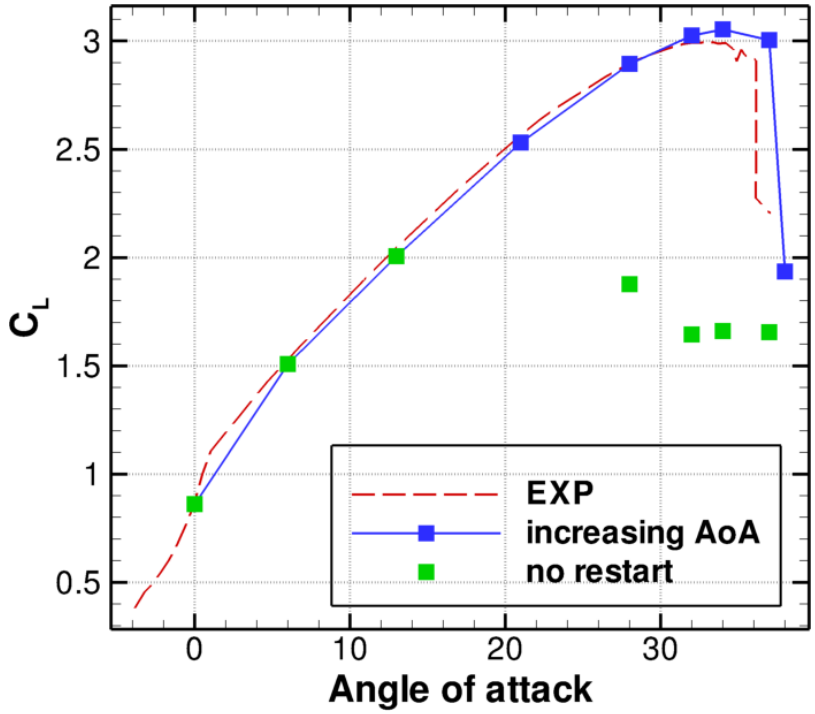


Computation strategy

- Polars obtained with increasing AoA
- Non-unique solutions
  - if no initialization from previous AoA
  - hysteresis indication

M = 0.2

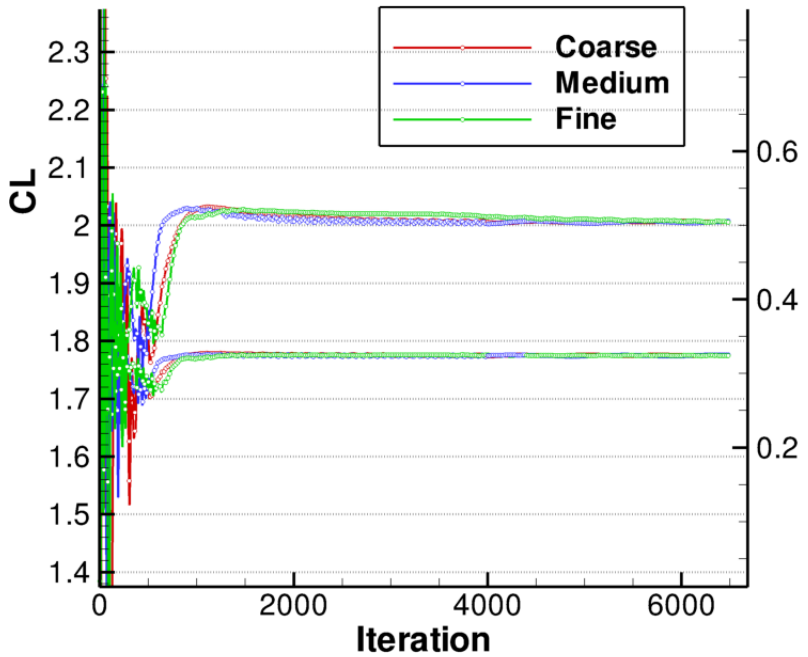
Re = 4.3 M

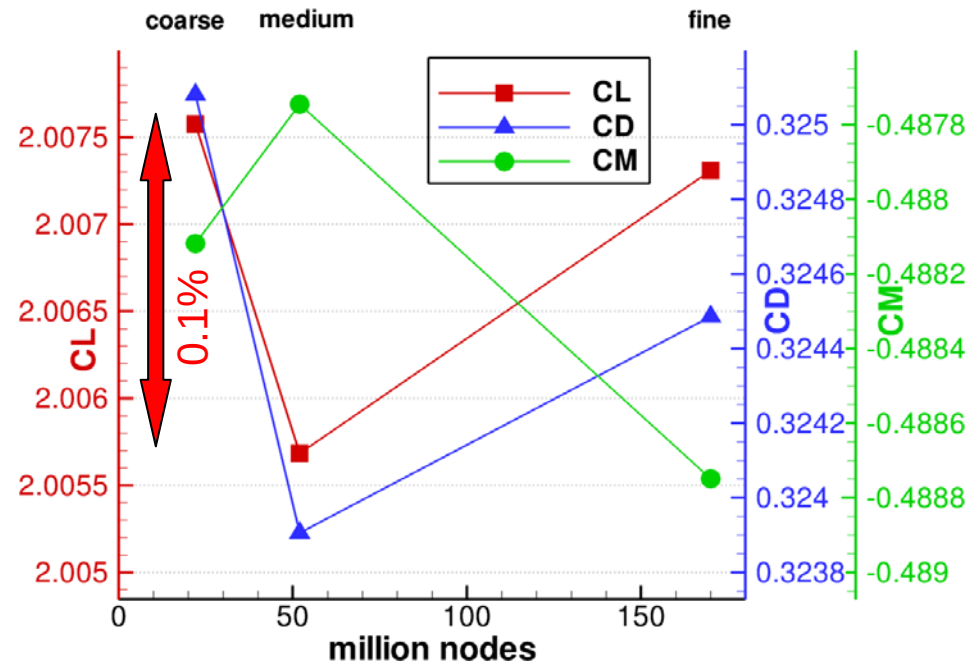


CONF1, SA

Grid convergence study

- No asymptotic convergence reached as such
- But fairly small variations between different grid levels





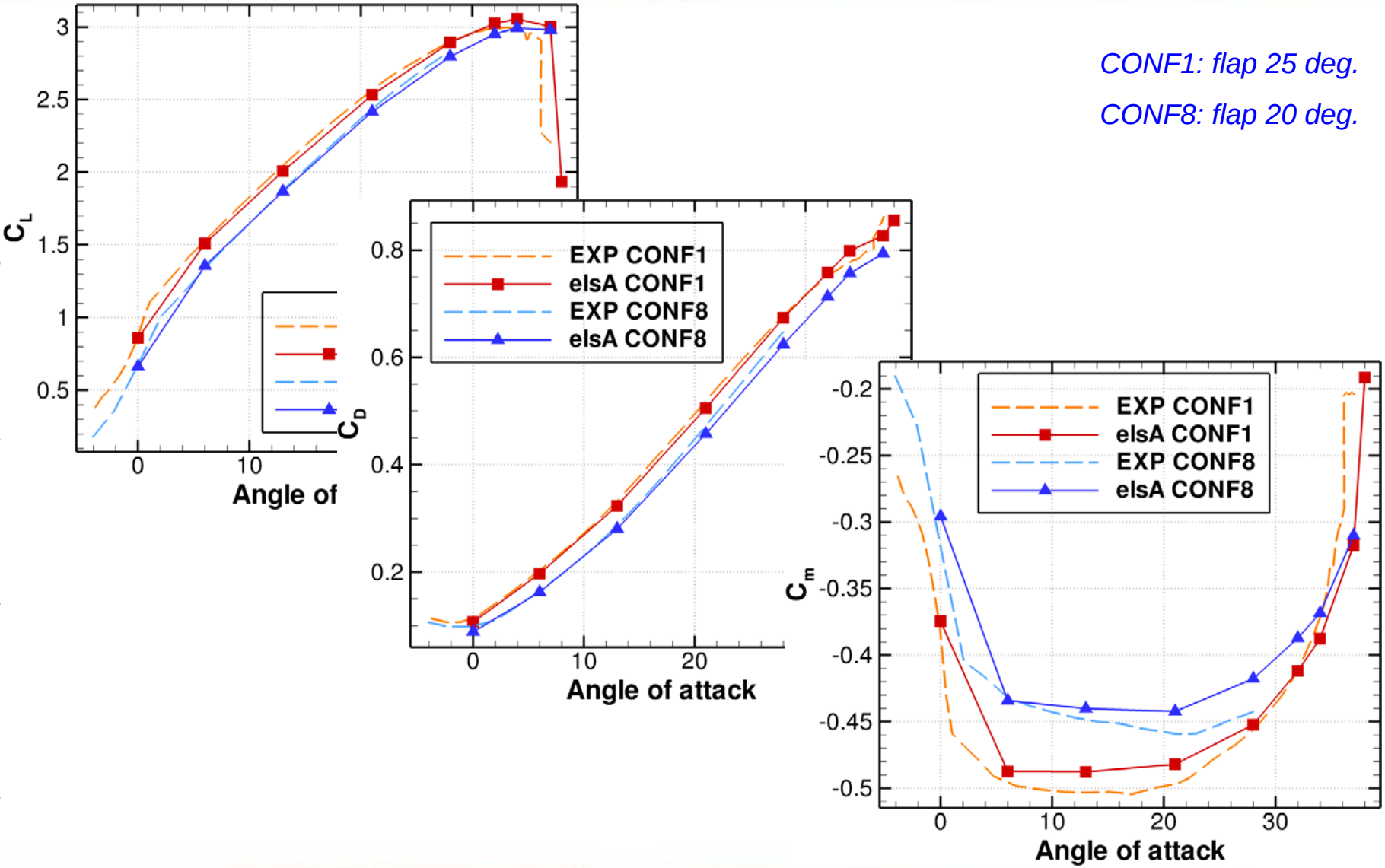
Influence of grid refinement on aerodynamic coefficients

CONF1, SA, α=13 deg.

Flap deflection prediction study

CONF1: flap 25 deg.

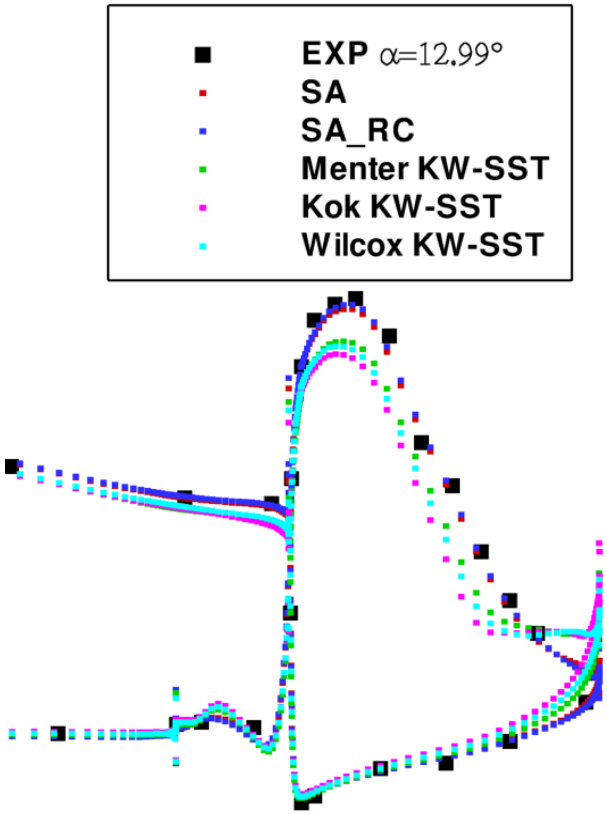
CONF8: flap 20 deg.



Turbulence modeling (1/2)

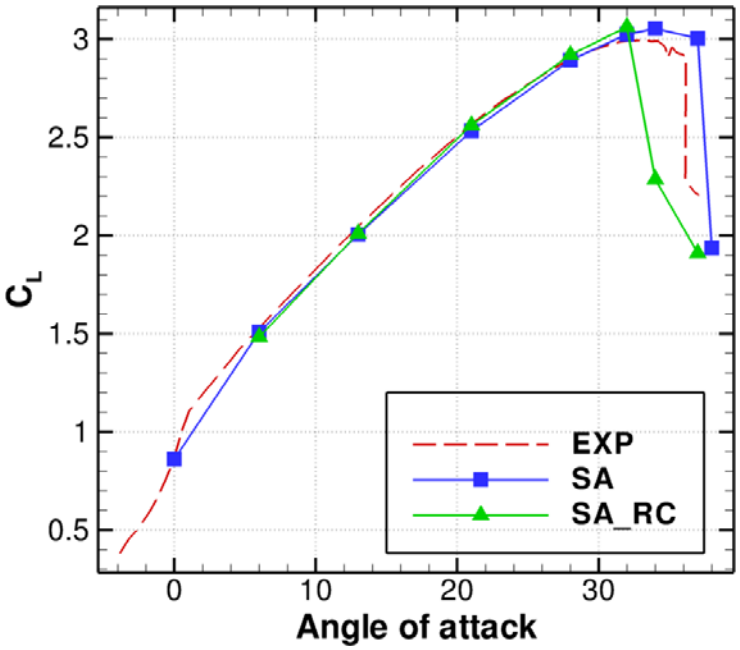
- All KW-SST models over-predict flap TE separation

→ not suited for this configuration



CONF1, α =13 deg.

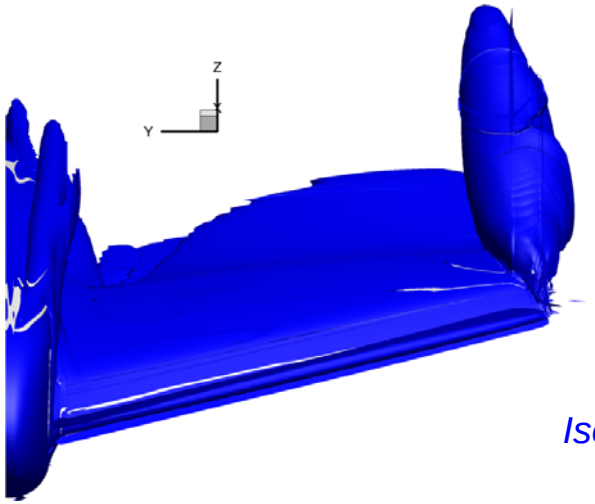
- Rotation correction in SA changes stall behavior

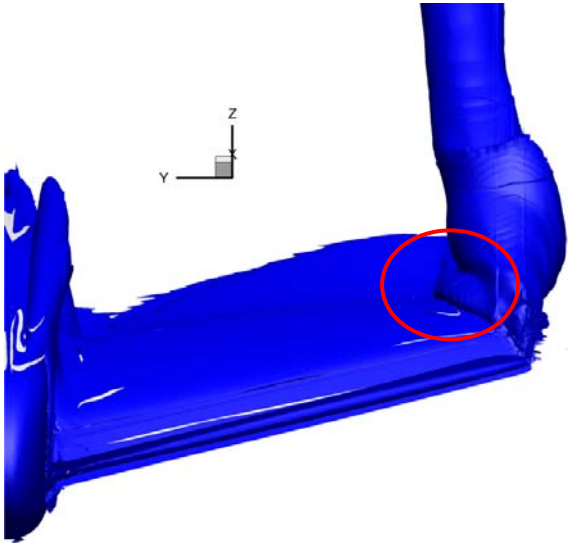


CONF1	EXP	SA	SA_RC
C_{Lmax}	2.995	3.054	3.063
Error	X	1.9%	2.3%
α_{max}	33	~34°	~32°

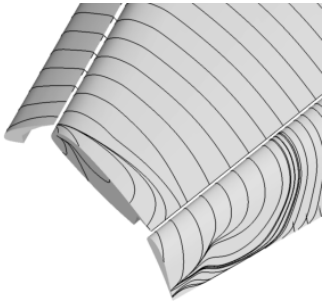
Turbulence modeling (2/2)

- Major impact of slat-tip vortex resolution on stall

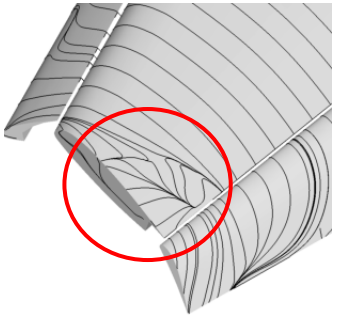




Isosurfaces of vorticity



Friction lines

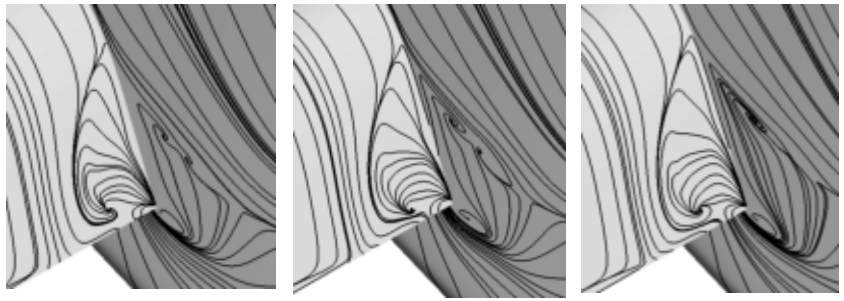


CONF1, SA, α=32 deg.

CONF1, SA_RC, α=32 deg.

Flap/SOB separation bubble investigation *(SA)*

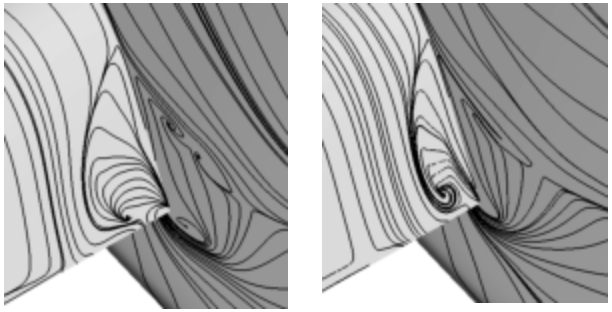
- Grid refinement impact (α =13 deg.)
  - little influence on separation bubble topology
  - → indication of good grid convergence



Coarse *Medium* *Fine*

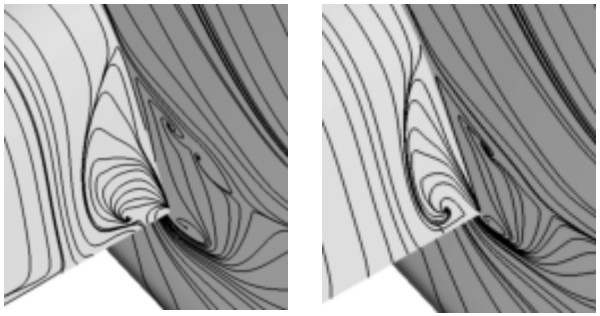
CONF1

- Influence of AoA



α =13 deg. *α =28 deg.*

- Flap deflection effect (α =13 deg.)
  - similar to an increase of AoA

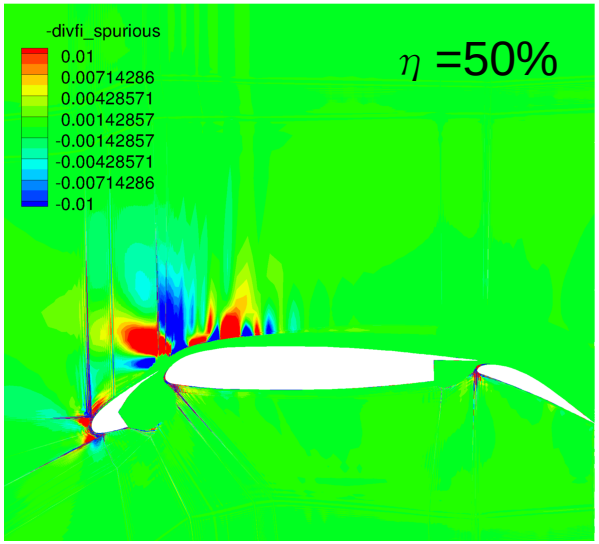


Flap 25 deg. *Flap 20 deg.*

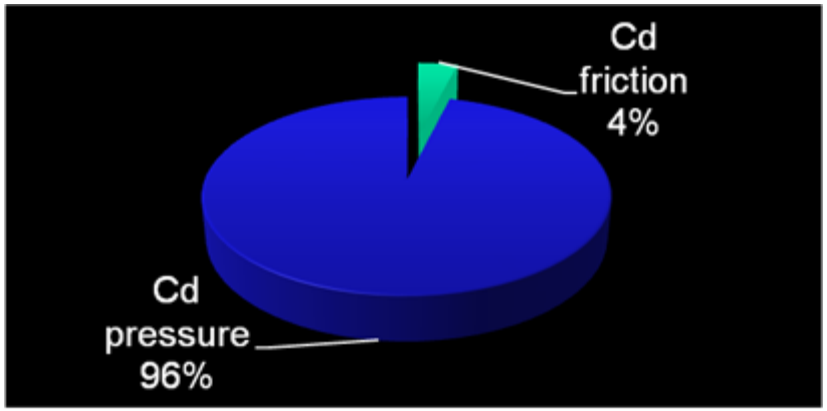
Far-Field Drag analysis

- Spurious drag mainly created in high curvature areas
  - drops from 4.66 to 0.35 drag counts from coarse to medium grid
- Drag mostly dominated by induced component

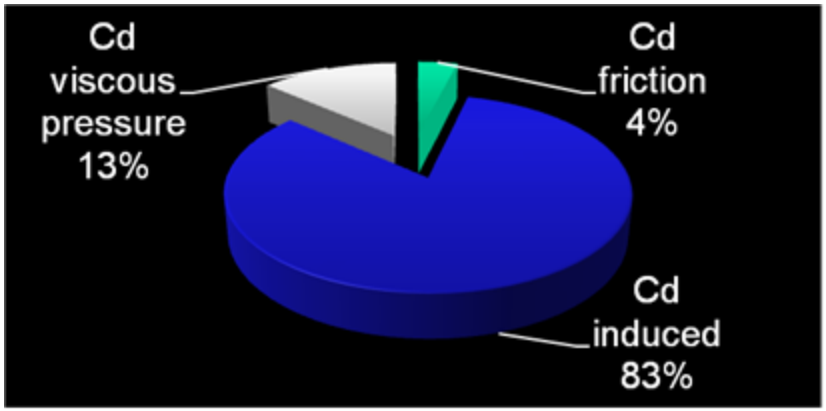
CONF1, SA, α=13 deg.



Spurious drag creation areas



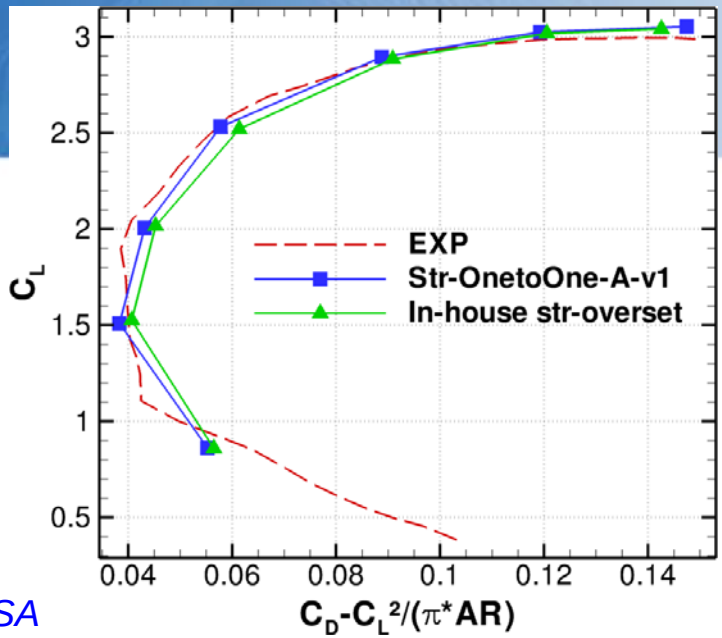
Near-field drag breakdown



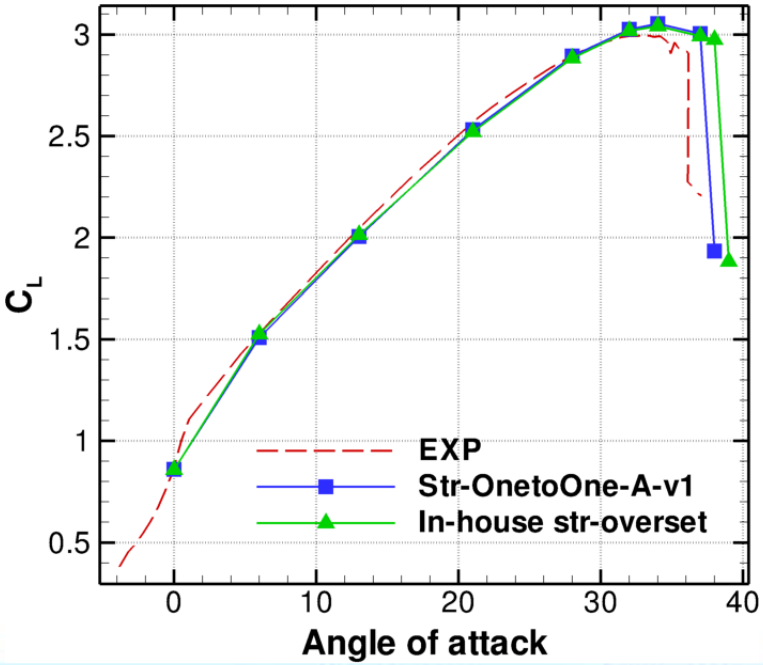
Far-field drag breakdown

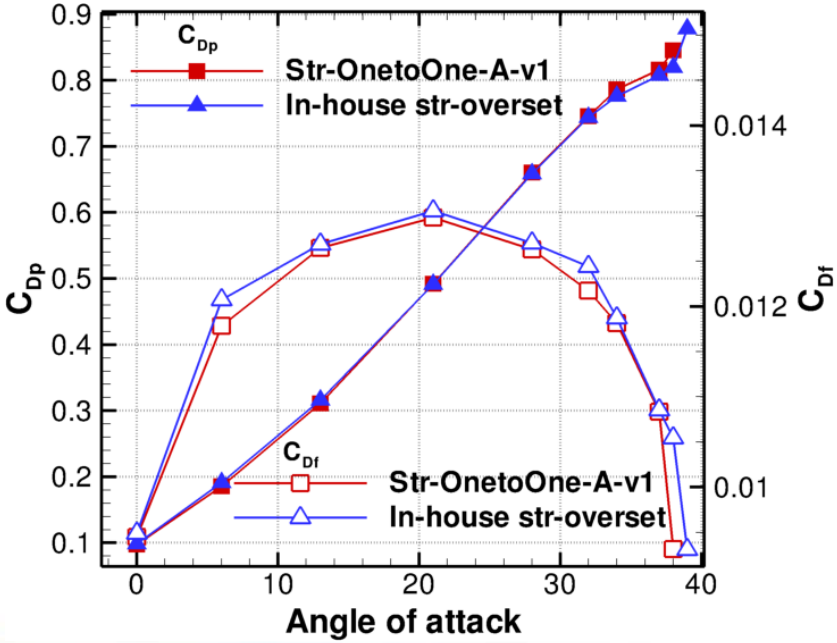
Overset grid results (1/2)

- Excellent agreement with coincident grid results
- Lesser meshing effort !!

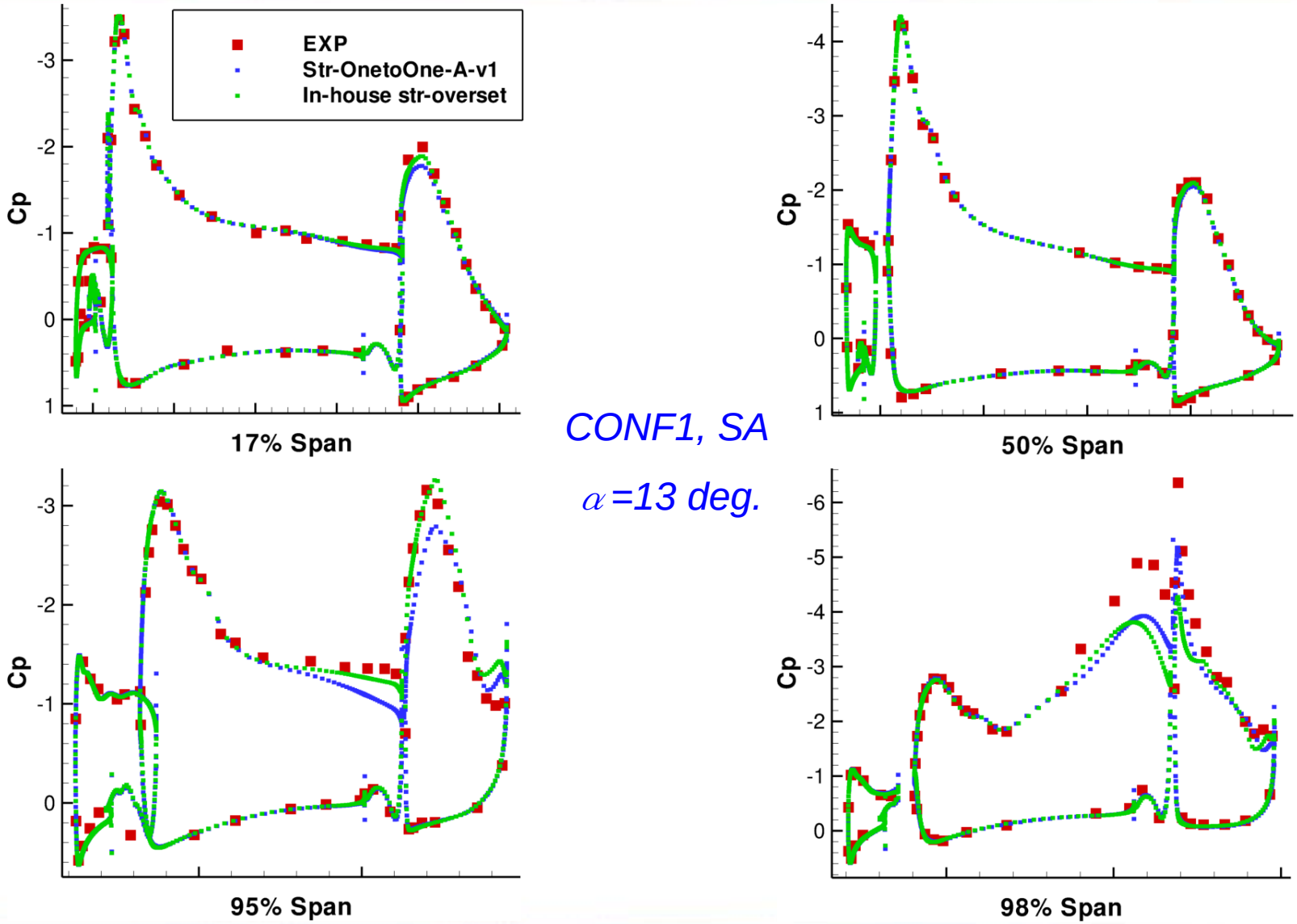


CONF1, SA





Overset grid results (2/2)



CONF1, SA

α=13 deg.

Conclusion

- Grid convergence study
  - no asymptotic convergence as such reached with Spalart-Allmaras but fairly small differences between different grid levels
  - major impact of slat-tip vortex resolution
  - grid refinement did not solve flap TE separation issue; the efforts should rather focus on turbulence models
- Flap deflection prediction study
  - good overall agreement with experimental data
  - complicated by the approximate prediction of flap TE flow separation
- Good validation case for ***elsA*** overset technique on 3D high lift configurations
- Suggestions: HiLiftPW-2 should focus on C_{Lmax} area (viscous dominated flow) with extended experimental measurements and visualization (oil flow, PIV/5-hole probe, model deformation, wake rakes…)