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Drag prediction for the DLR-F6 Model using the EDGE code

by

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Orlando, June 21-22, 2003

Computed cases

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Contribution incomplete
– Not all grids and polars computed

Number of nodes:

Unstructured hybrid grids by DLR

Case	Coarse	Medium	Fine
WB	2.39×10^6	3.16×10^6	4.05×10^6
WBPN	3.68×10^6	4.79×10^6	6.38×10^6

Grid convergence, case 1

Case	Coarse	Medium	Fine
WB	X	X	
WBPN	X	X	X

Polars, case2

Case\Alpha	-3º	-2º	-1º	0º	1º	1.5º
WB, Medium	X	X	X	X	X	X
WBPN						

Computational tool

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EDGE – CFD flow solver for unstructured grids

- – Hybrid grids, different elements
- – Dual grids
- – Finite volume technique
- – Explicit time marching, Runge-Kutta
- – Agglomeration FAS multigrid convergence acceleration
- – Implicit residual smoothing
- – Upwind/central spatial discretisation
- – Steady state/unsteady time marching
- – Turbulence modeling
  - • Wilcox k-ω
  - • Kok k-ω
  - • BSL, SST k-ω
  - • Explicit Algebraic Reynolds Stress Model (EARSM) extensions
- – Transition prescription

Example of different element types

2D   3D

Primary and dual grids

Grid info to flow solver

N_1 S N_2

Edge and node data
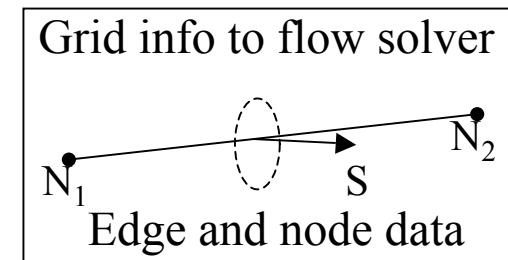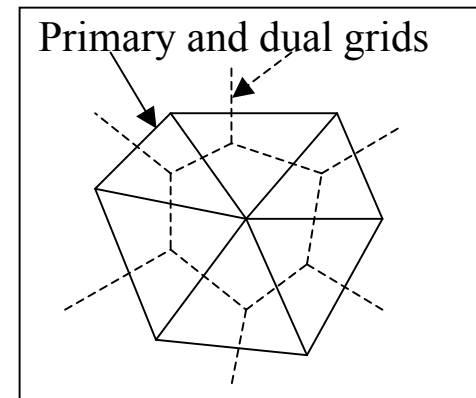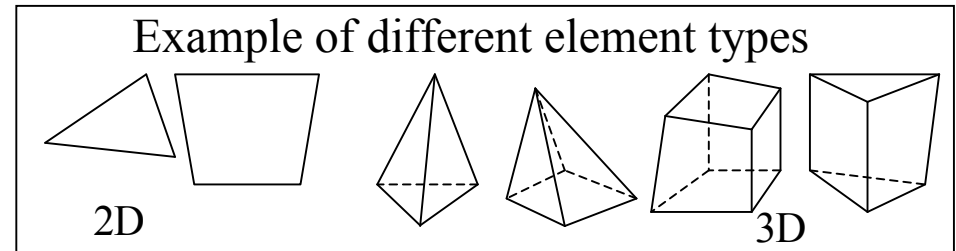
Computational information for AIAA DPW **FOI**

- – Central scheme with artificial dissipation
- – 3-stage Runge-Kutta scheme, CFL=1.25
- – 4-5 levels of multigrid, full multigrid
- – Typically 3000-4000 iterations
- – Turbulence: EARSM coupled to standard Wilcox k-ω
- – Fully turbulent calculations
- – Parallel calculations
  - Compaq cluster with Alpha processor
  - 4-10 processors used
  - Maximum 100 hours/solution
  - Maximum 10 Gbytes in total

Rate of convergence, WB

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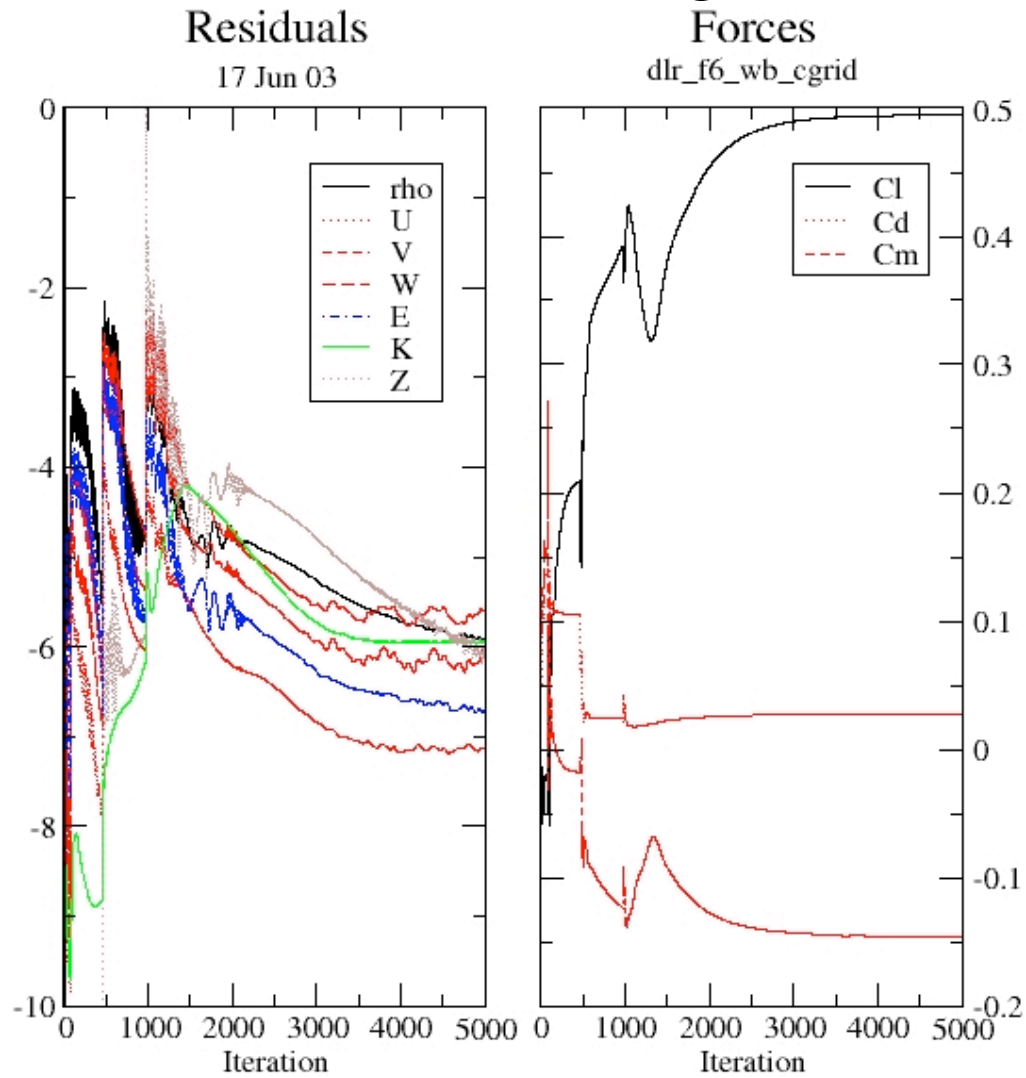
Grid refinement, Cl=0.5 match

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WB

Grid	Alpha CFD	Cl CFD	Alpha exp.	Cl exp
Coarse	0°	0.4947		
Medium	0°	0.4935	0.49°	0.4984
Fine				

WBPN

Grid	Alpha CFD	Cl CFD	Alpha exp.	Cl exp
Coarse	0.5°	0.4926		
Medium	0.5°	0.4939	1.00°	0.4981
Fine	0.5°	0.4932		

WB, Cl-α, Cl-Cd

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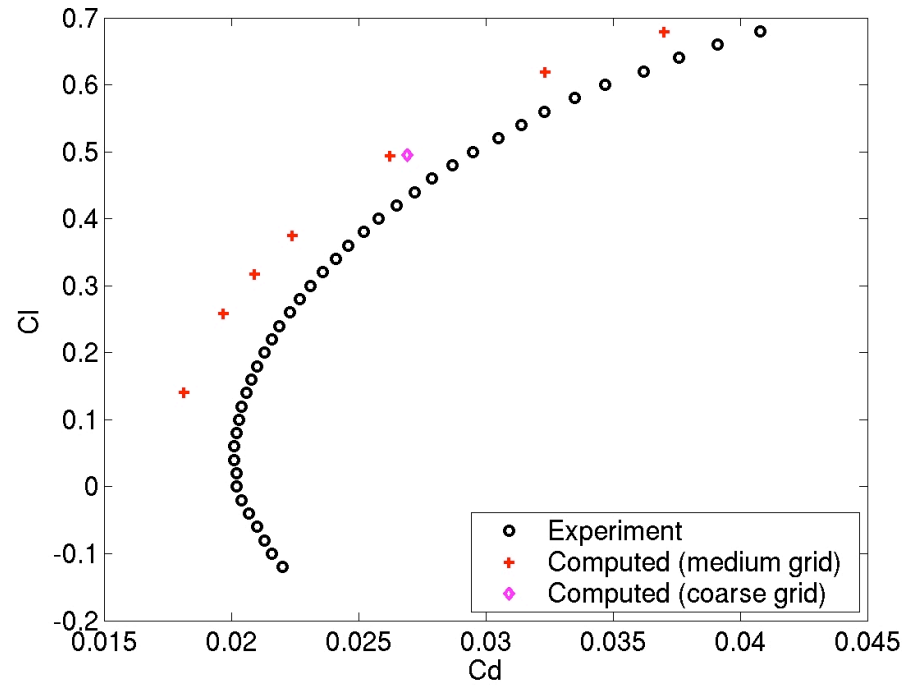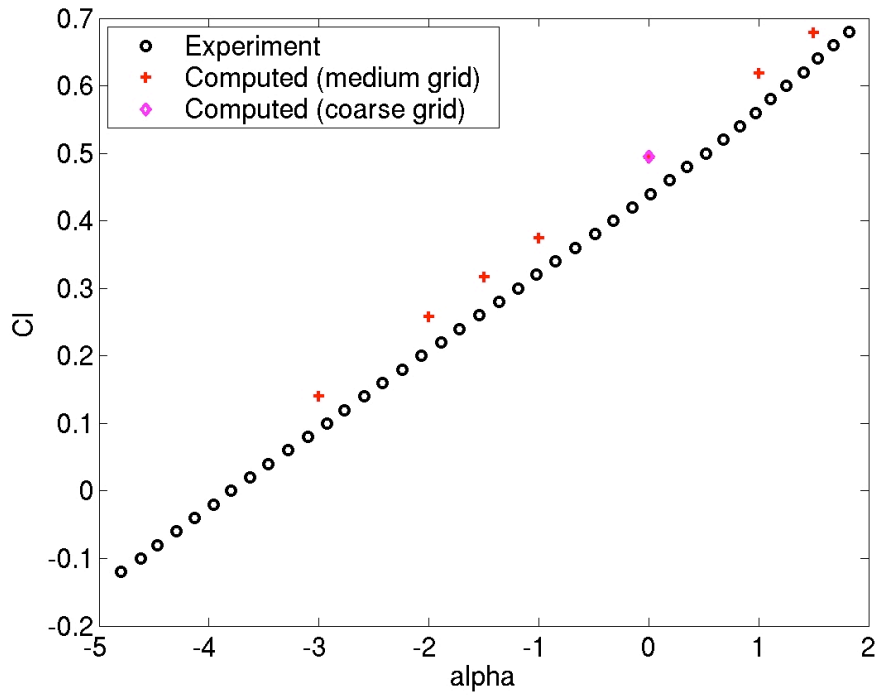
Findings

⇒Lift over-predicted

⇒Lift indicates 0.5° mismatch

⇒Small influence from the grid density
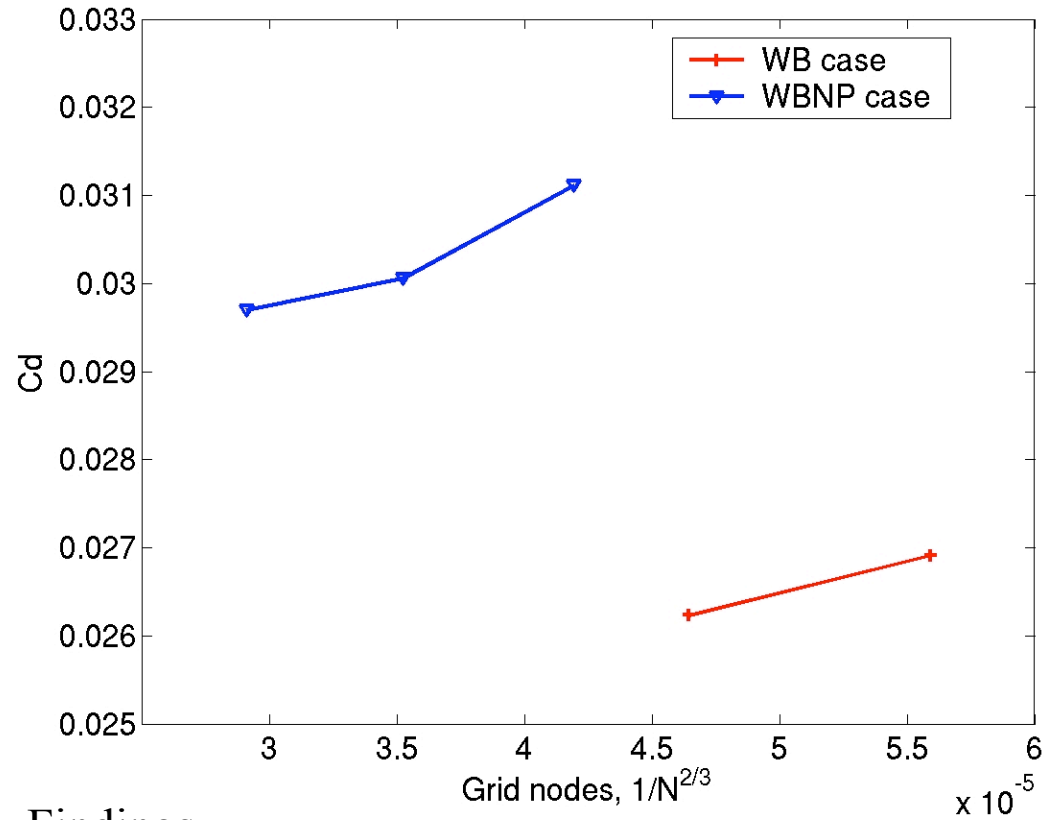
WB, Cd-α, Cd-Cl. Drag decomposition

FOI
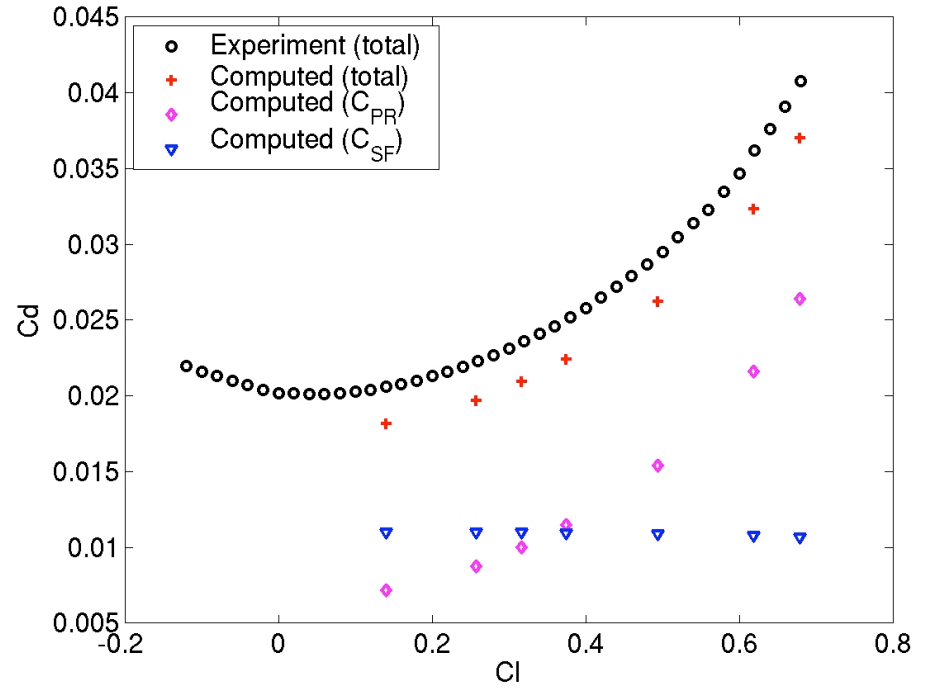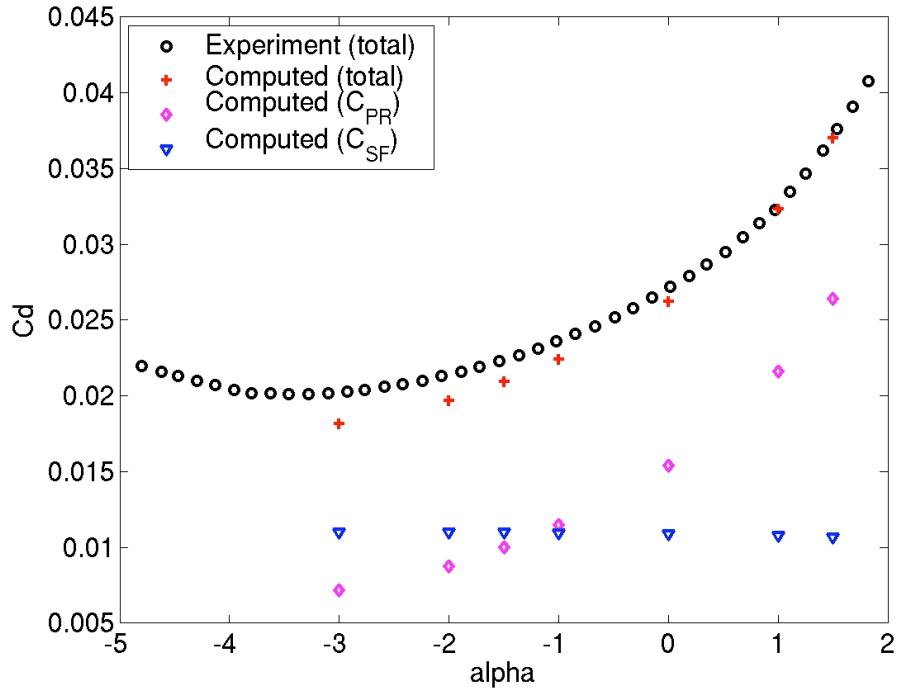
Findings

$\Rightarrow$ Good Cd prediction for the higher incidences

$\Rightarrow$ Small variation in Cd_{sf} with α

$\Rightarrow$ Shift in Cl-Cd

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WB, WBPN, Grid dependency

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Findings

⇒ WBPN gives higher drag
⇒ Still some grid dependency

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WBPN, Cl-α, Cl-Cd. Drag decomposition**FOI**
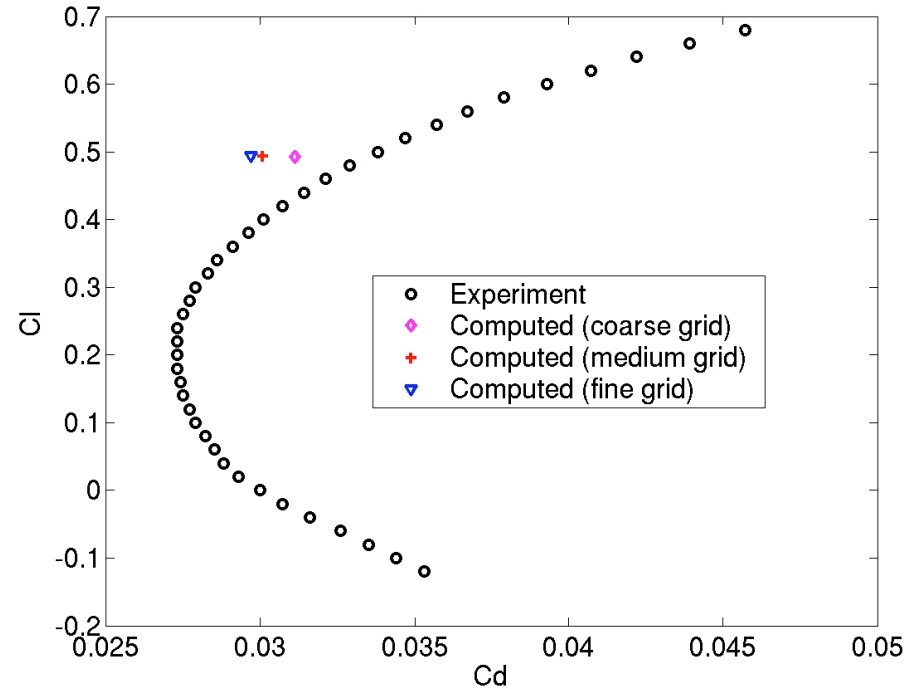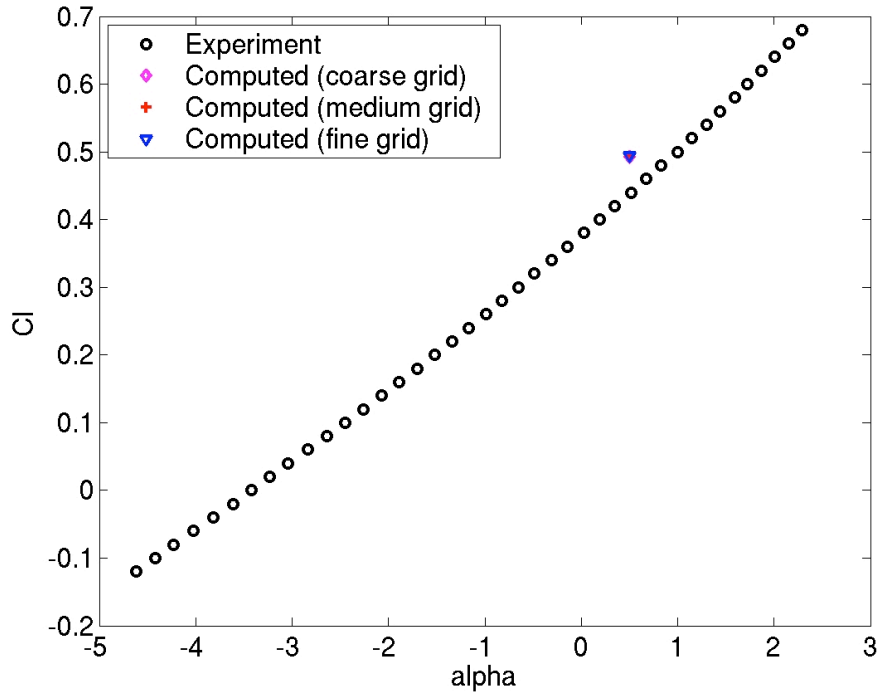
Findings
  ⇒ Lift indicate 0.5 º mismatch, similar to WB
  ⇒ Some influence from the grid density

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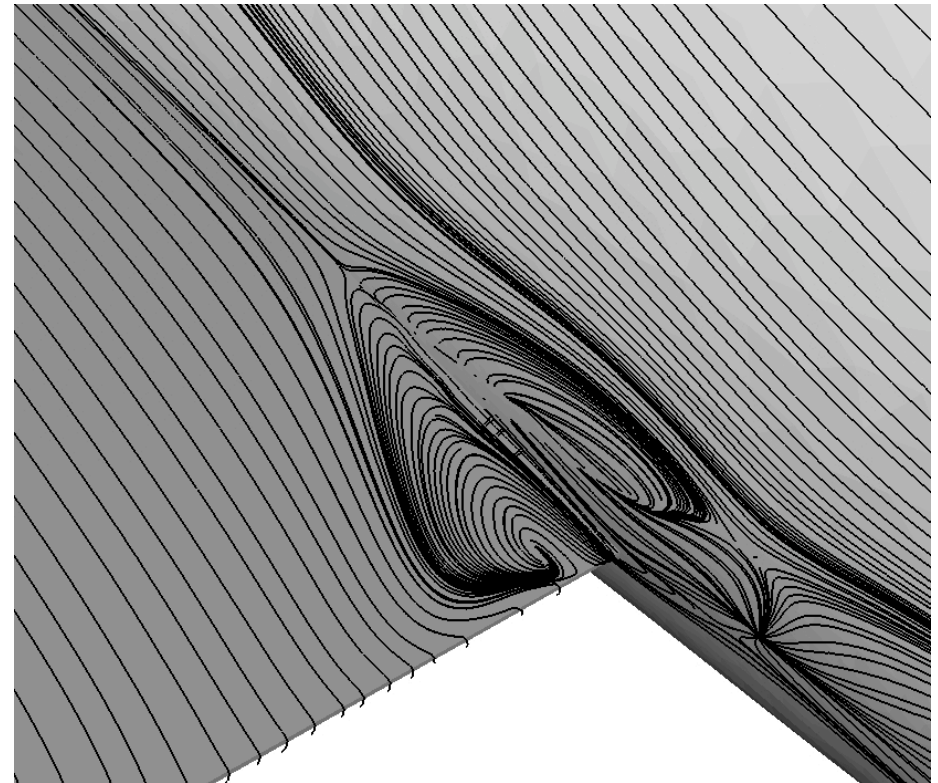
WB, Pressure distribution

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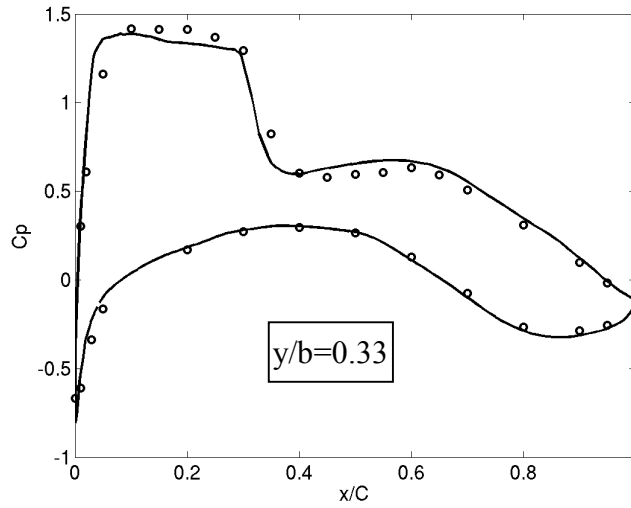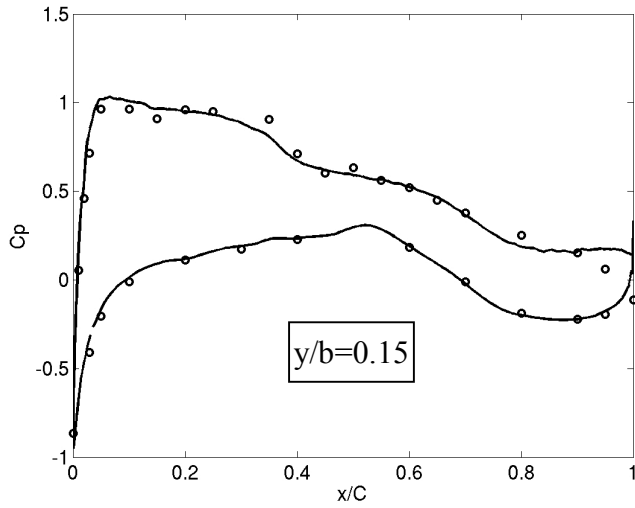
Experiments
$\alpha=1.0°$, Cl=0.618
CFD medium grid
$\alpha=1.23°$, Cl=0.598

y/b=0.15

y/b=0.33

y/b=0.51
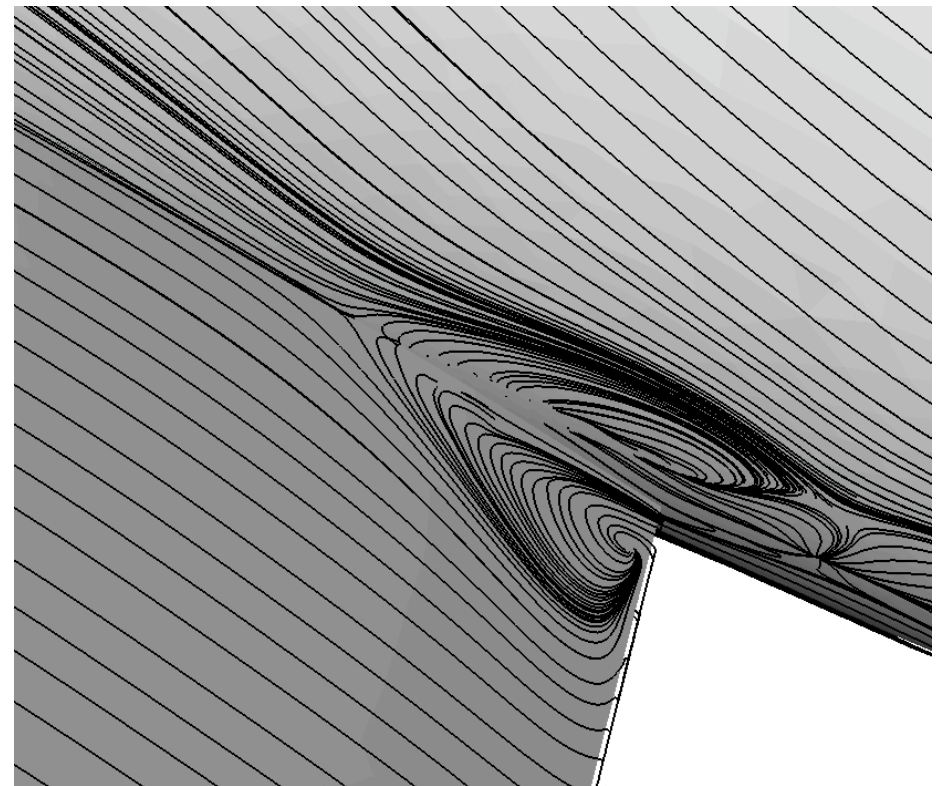
y/b=0.64
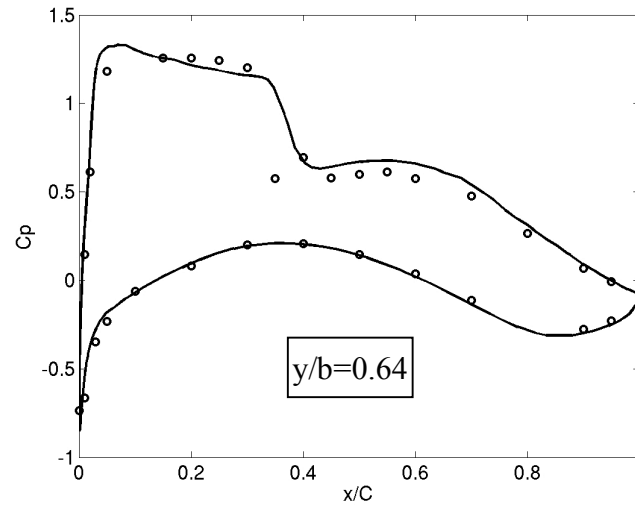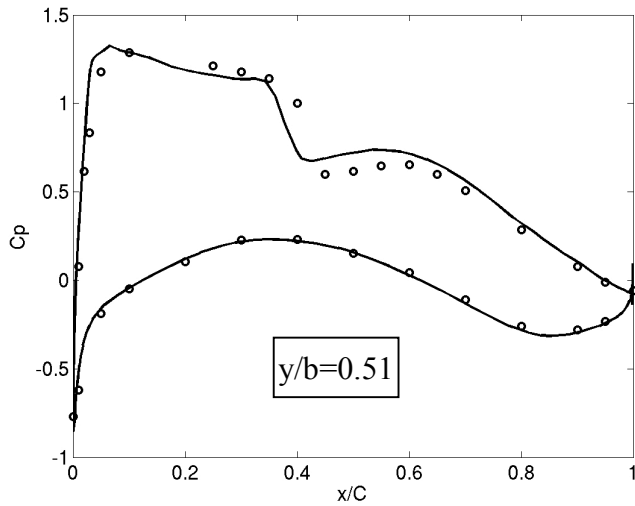
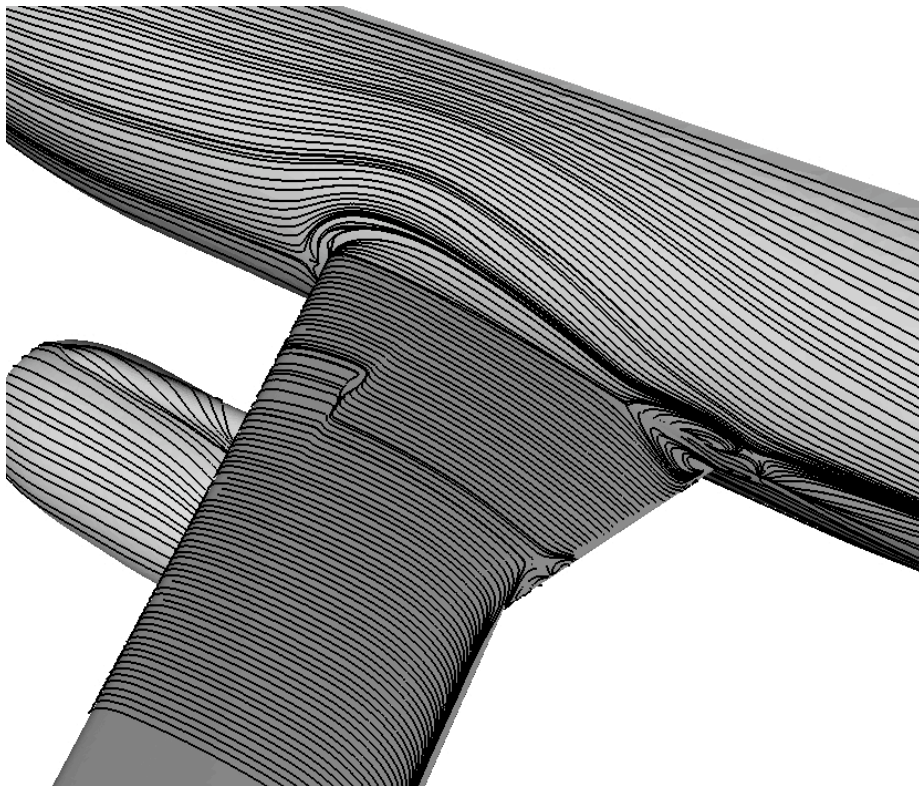# WB, skin friction traces

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Medium grid
$\alpha=0.0^\circ$, Cl=0.4947
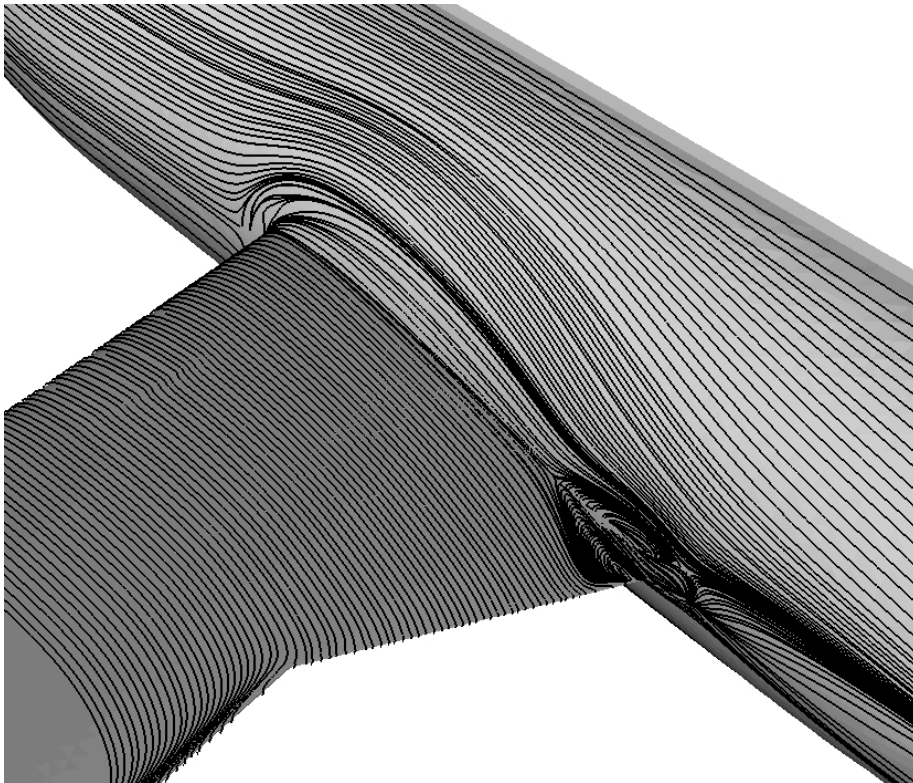
WBPN, skin friction traces

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Fine grid
$\alpha=0.5°$, Cl=0.4932

Summary

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- Overall agreement with experiments
- Over-prediction of lift
- Good Cd prediction for the higher incidences
- Qualitative agreement with pressure distribution
- Separation bubble in the wing body junction identified for both WB and WBPN