

FUN3D and NSU3D Comparisons for the HiLiftPW-1

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Outline

- Grids
- Flow solvers
- Case1 – Grid convergence
 - Force & moment convergence
 - Component lift
- Case2 – Flap deflection study
 - Lift & moment comparison
 - Component lift
- Flow field images
 - Wingtip – wing C_L
 - Stall
 - Side of body
- Conclusions

Grids

- Generated by Mike Long of Scientific Simulations using VGrid ver. 4.1
- Unst-Mixed-FromTet-Nodecentered-A-v1
 - Coarse, Medium, Fine
 - Config 1 and Config 8
 - No brackets
- Viscous layers merged using tools related to solvers

Flow solvers

NSU3D

- Node based
- Mixed elements (prisms in BL)
- Matrix artificial dissipation (upwind)
- Runge-Kutta with preconditioning
- Thin layer
- Spalart-Allmaras
- Agglomeration Multigrid

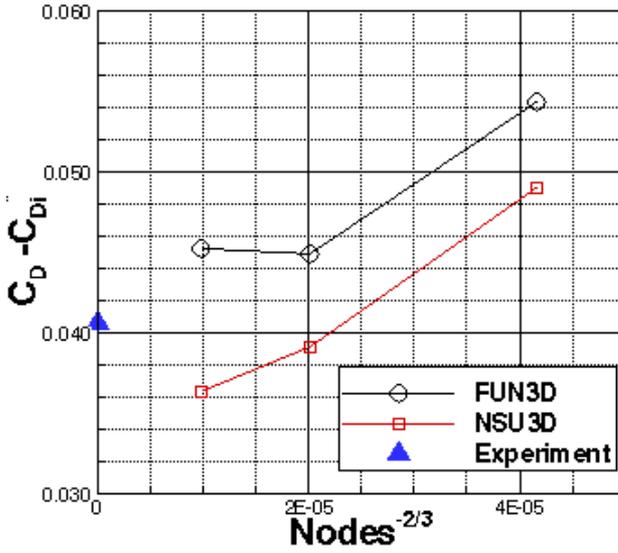
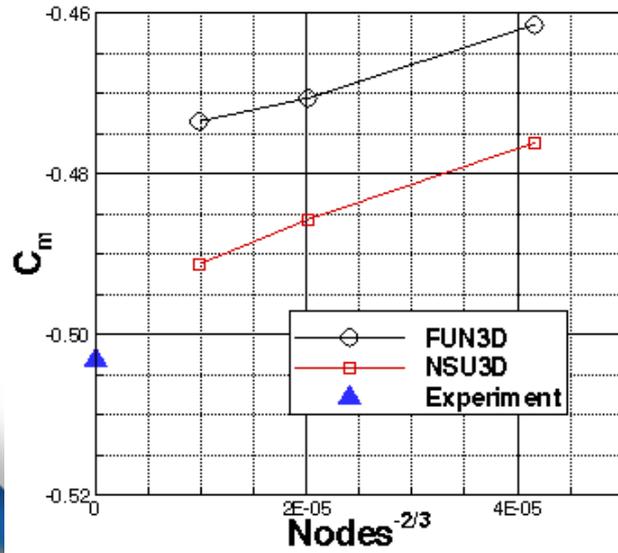
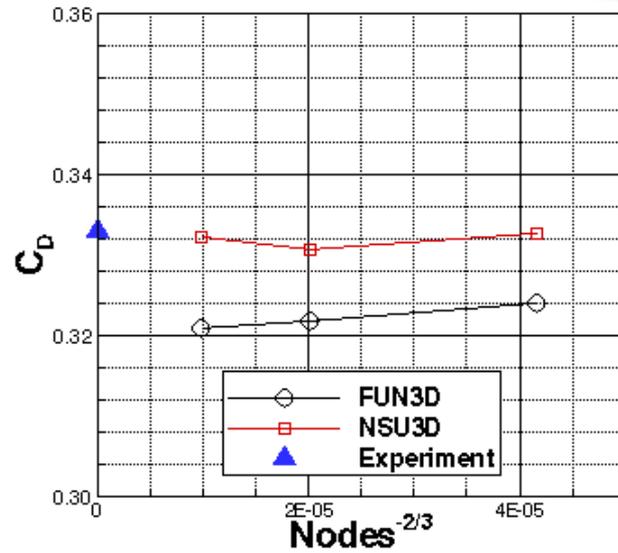
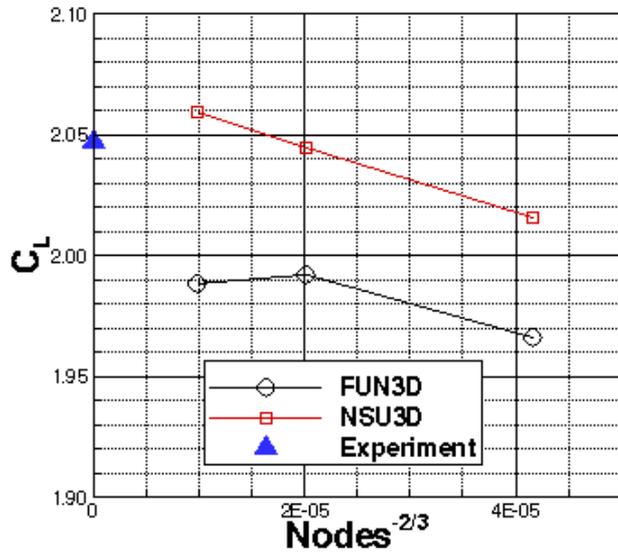
FUN3D

- Node based
- Mixed elements (prisms in BL)
- UMUSCL (CD + Roe), no limiter
- Implicit time-stepping with Gauss-Seidel relax.
- Full N-S
- Spalart-Allmaras

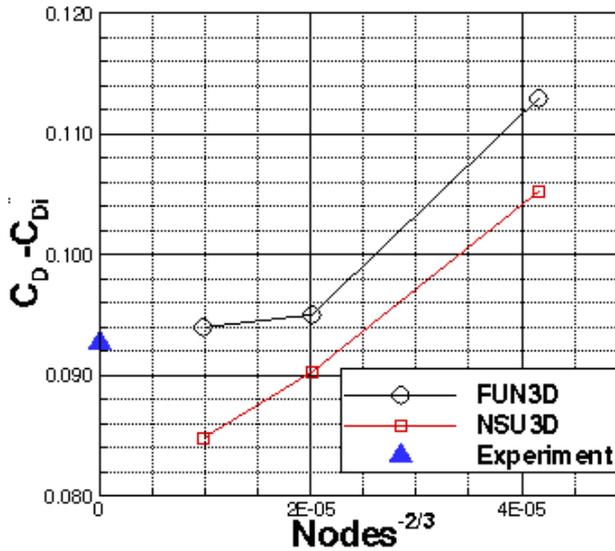
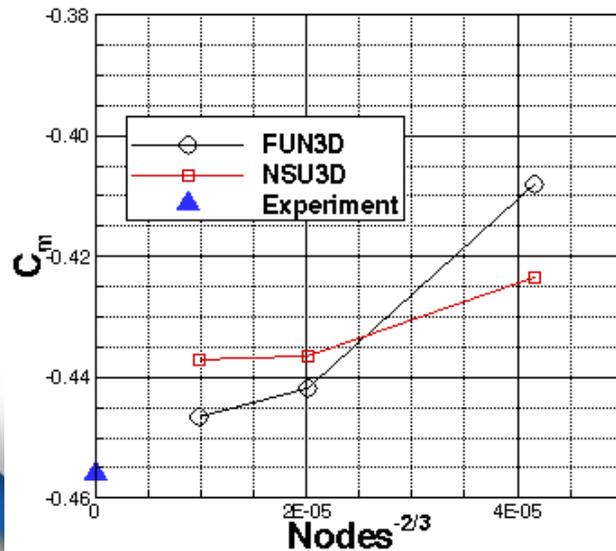
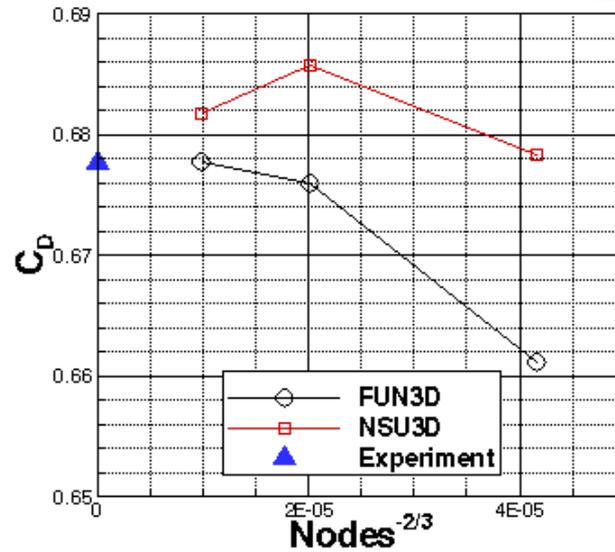
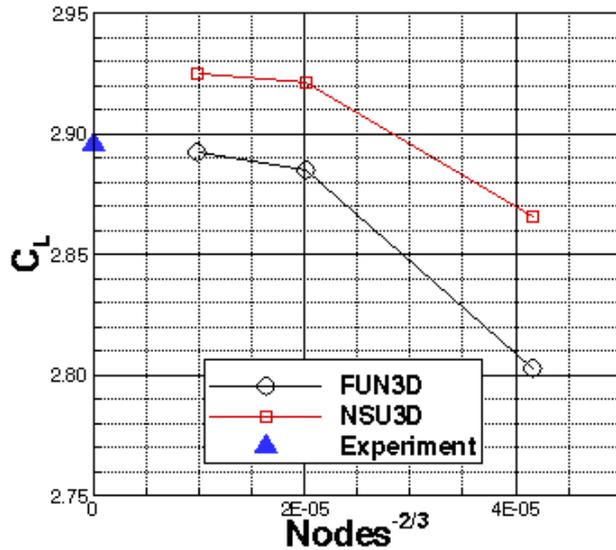
Case 1 – Grid Convergence Study

- Conditions:
 - Mach = 0.20
 - Angle of attack = 13, 28 degrees
 - Re = 4.3 M based on MAC

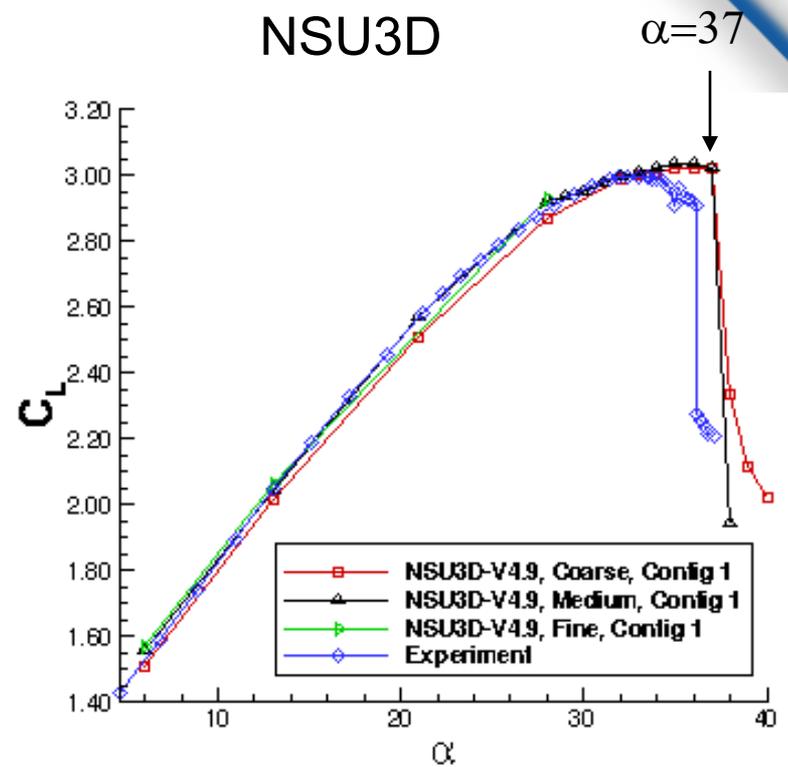
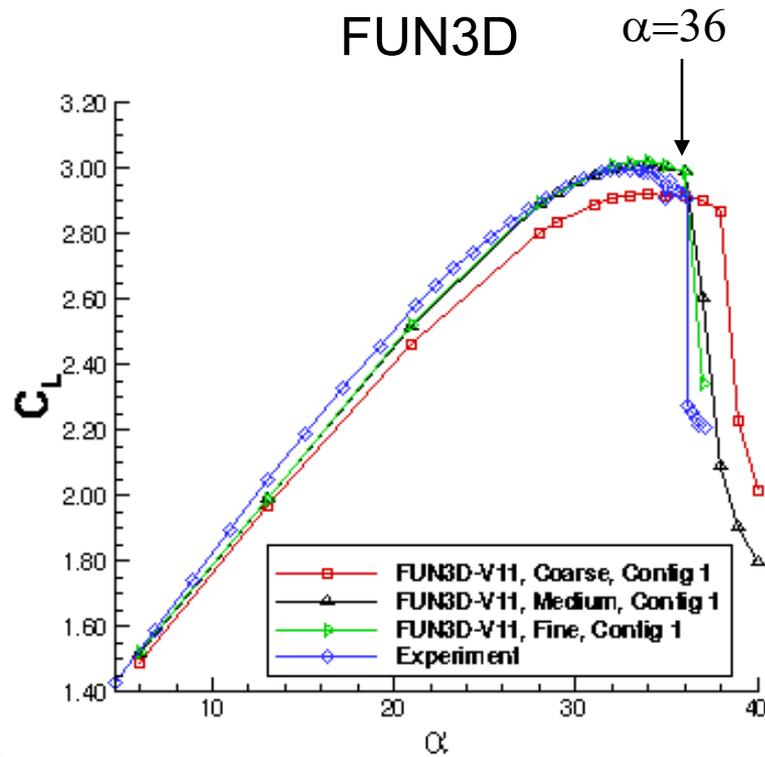
Case 1 – Grid convergence $\alpha=13$



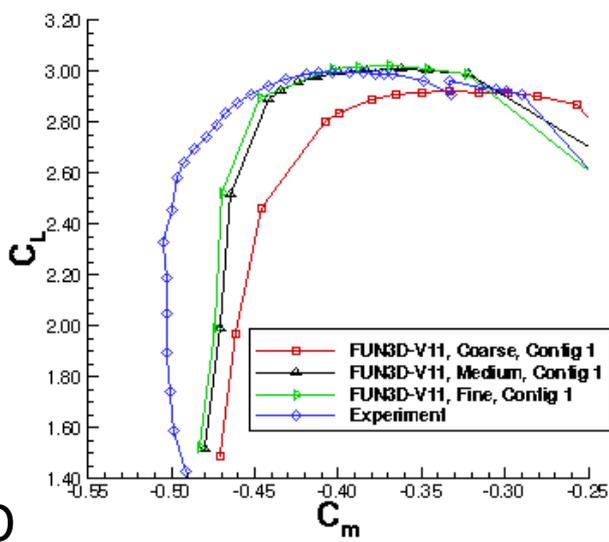
Case 1 – Grid convergence, $\alpha=28$



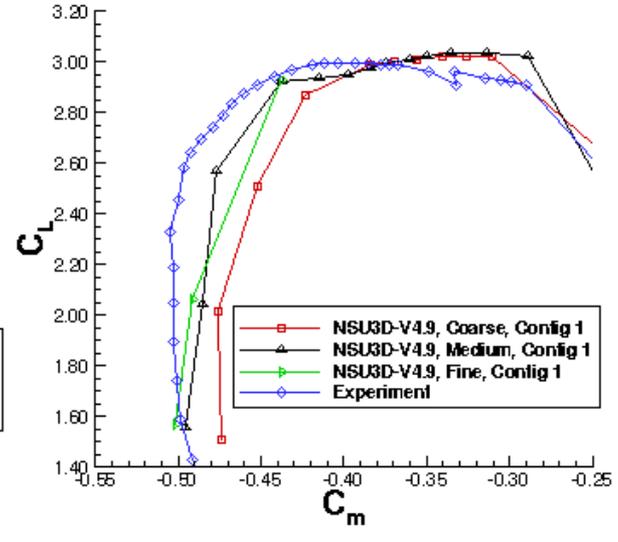
Case 1 – Grid comparison, C_L



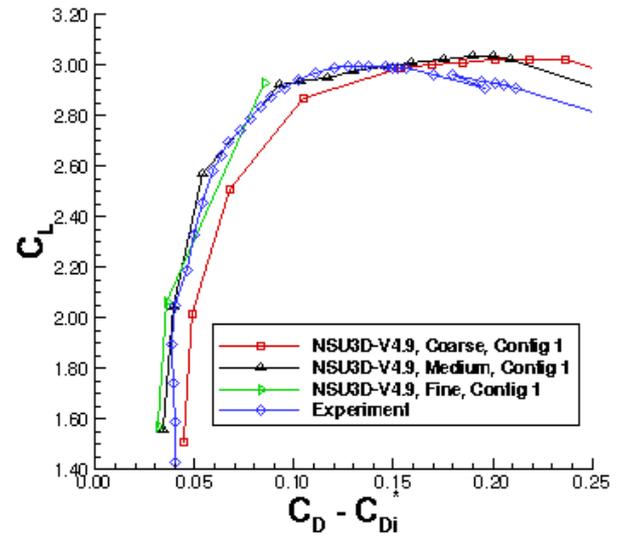
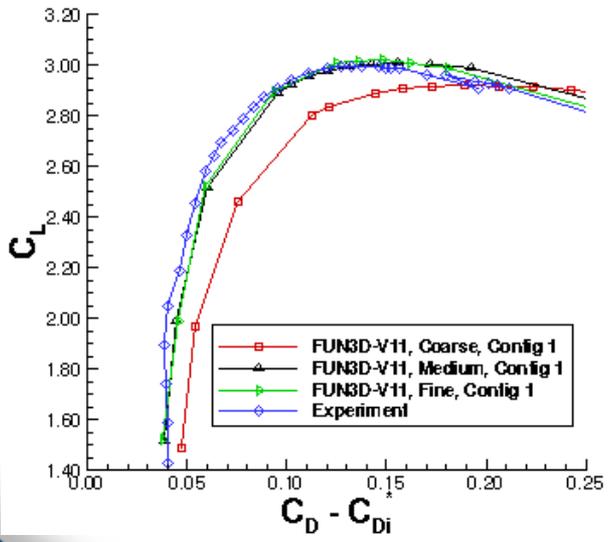
Case 1 – Grid comparison, C_m , C_{DP}



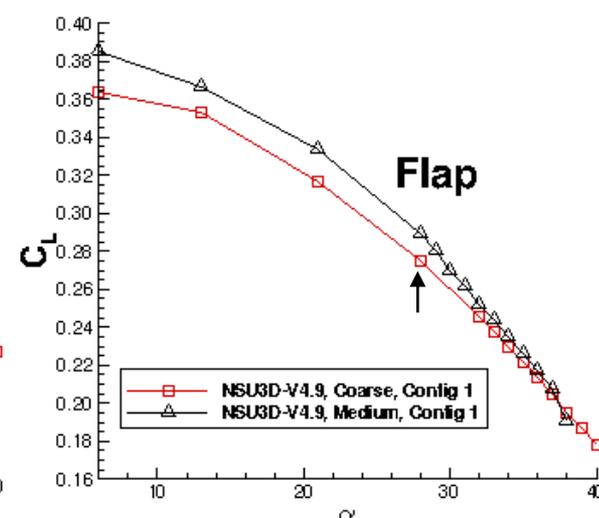
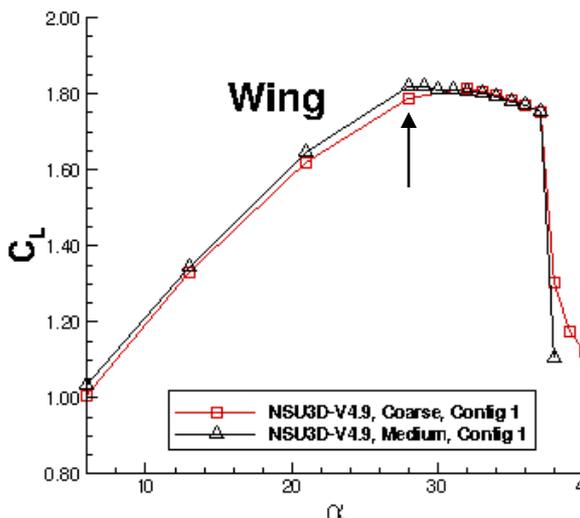
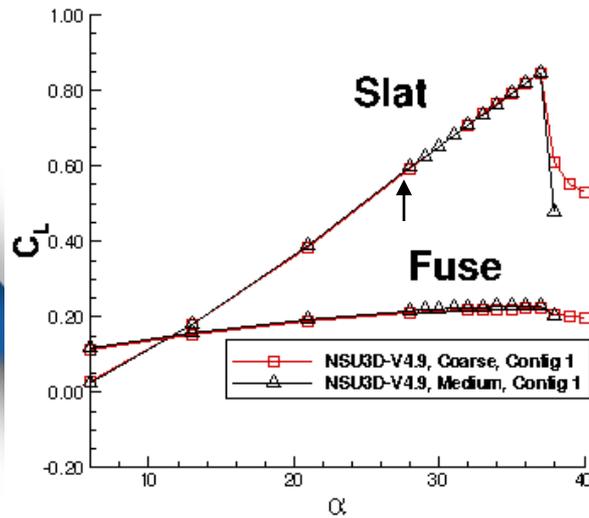
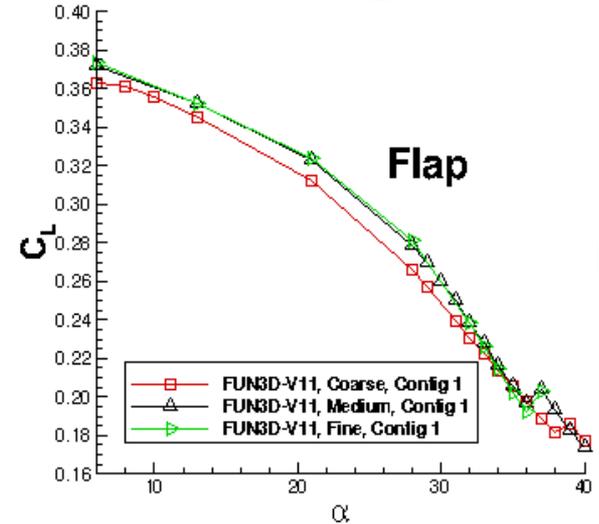
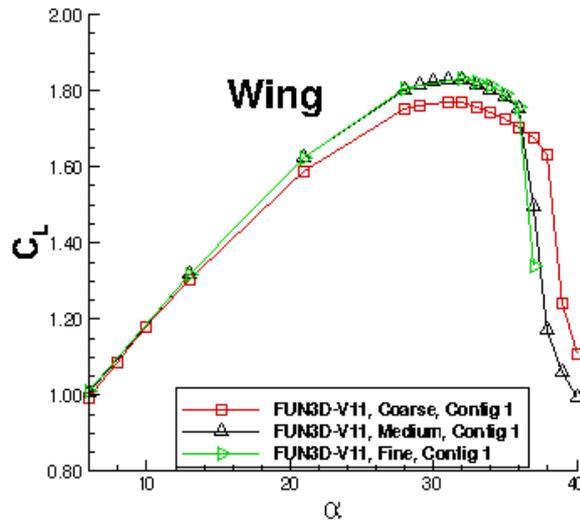
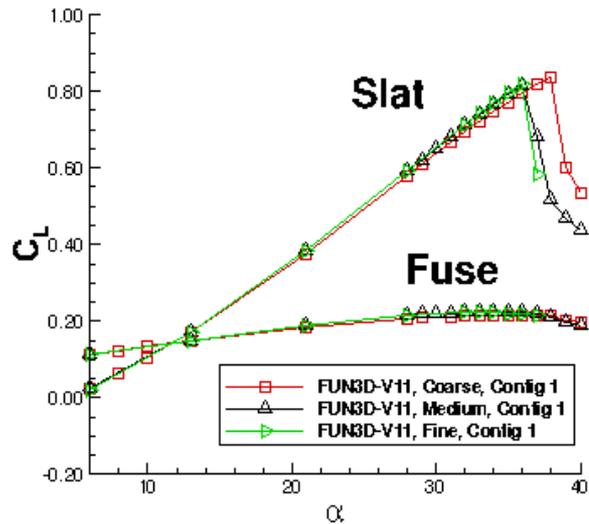
FUN3D



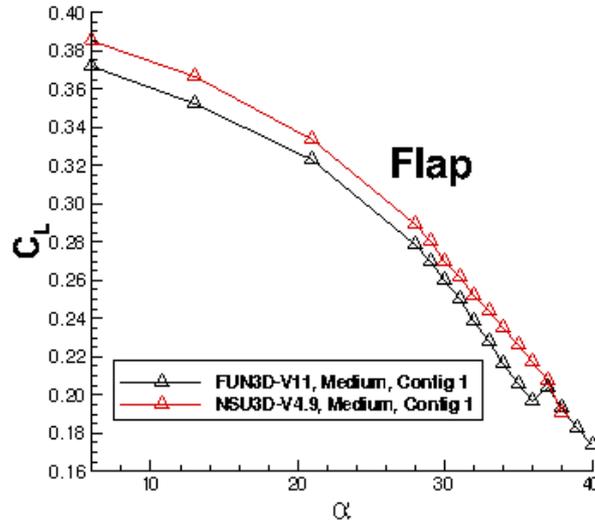
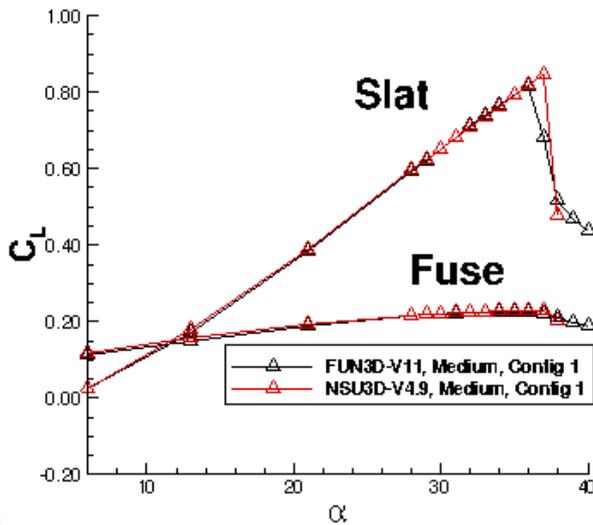
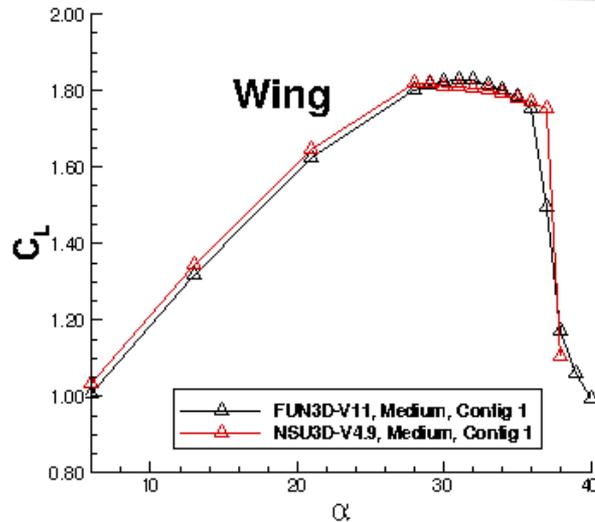
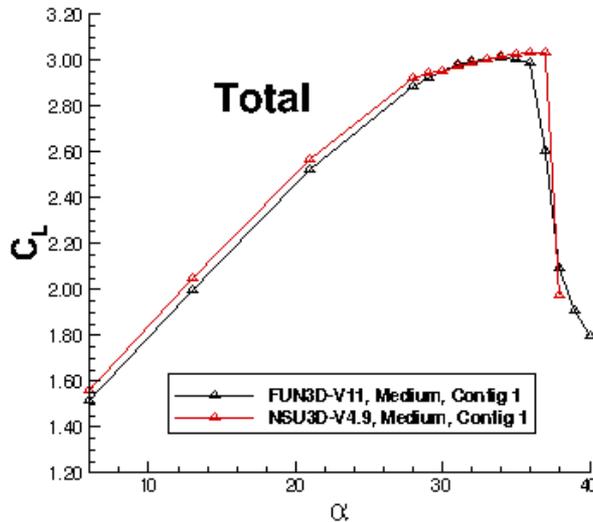
NSU3D



Case 1 – Component C_L



Case 1 – Component C_L

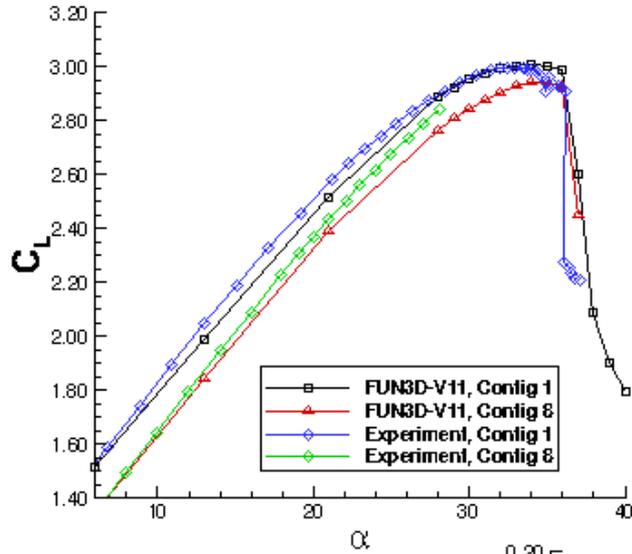


Case 2 – Flap deflection study

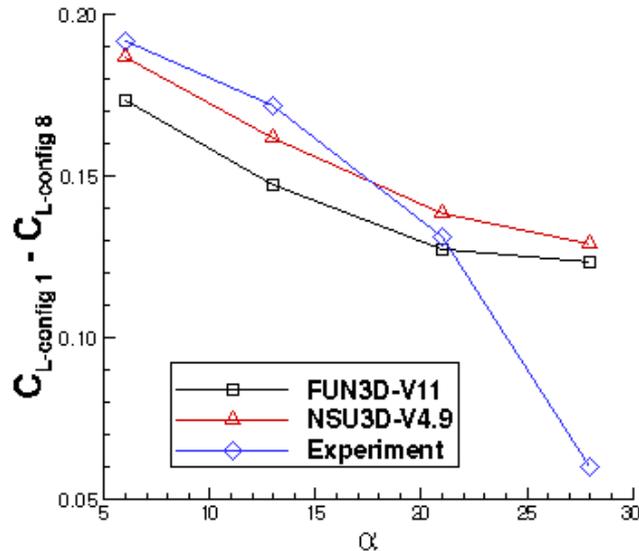
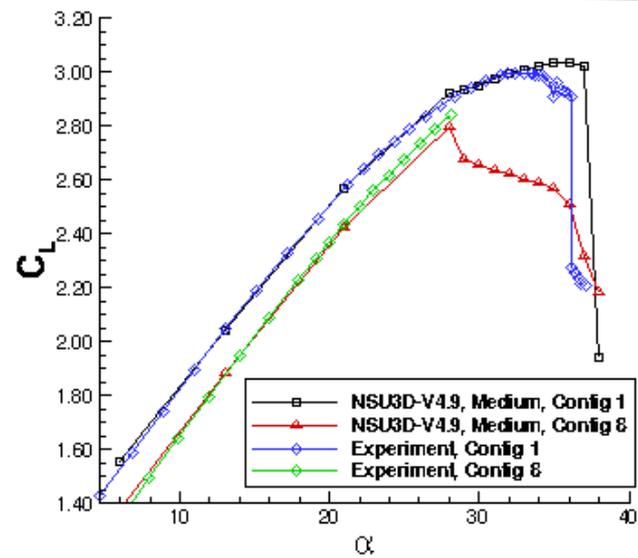
- Config 1 – Slat 30, Flap 25
- Config 8 – Slat 30, Flap 20
- Medium grids
- Conditions:
 - Mach = 0.20
 - Angle of attack = 6, 13, 21, 28, 32, 34, 37 degrees
 - Re = 4.3 M based on MAC

Case 2 – C_L

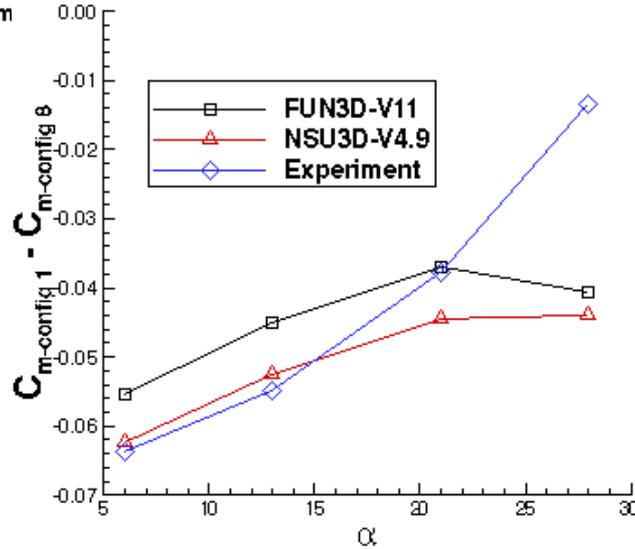
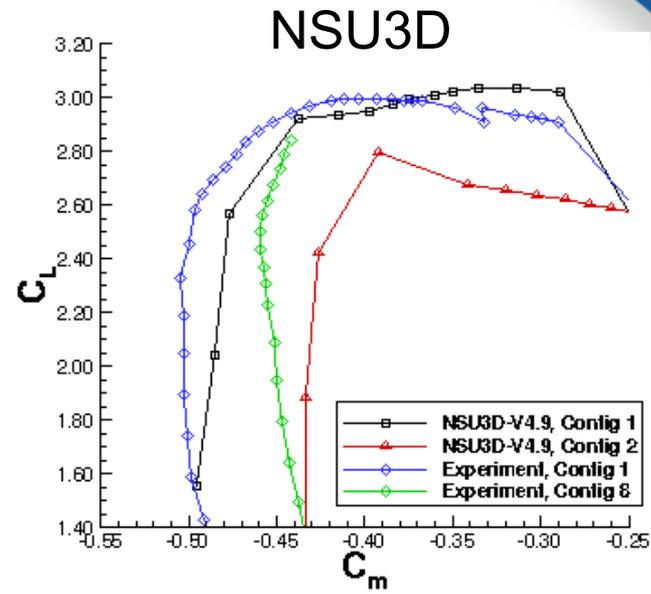
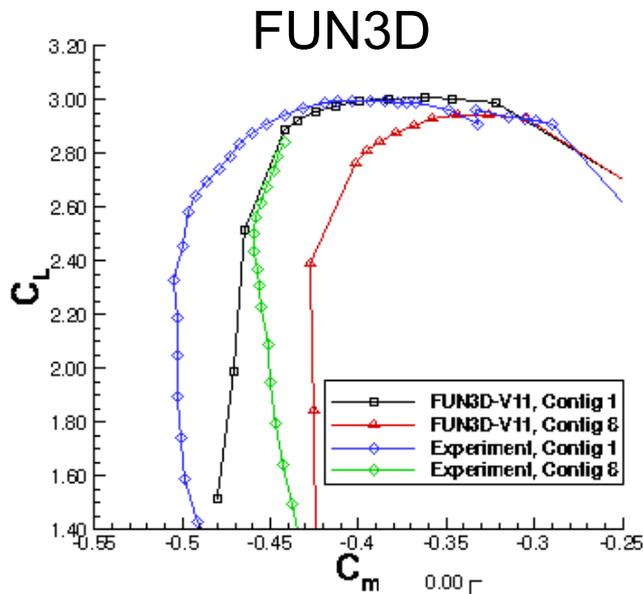
FUN3D



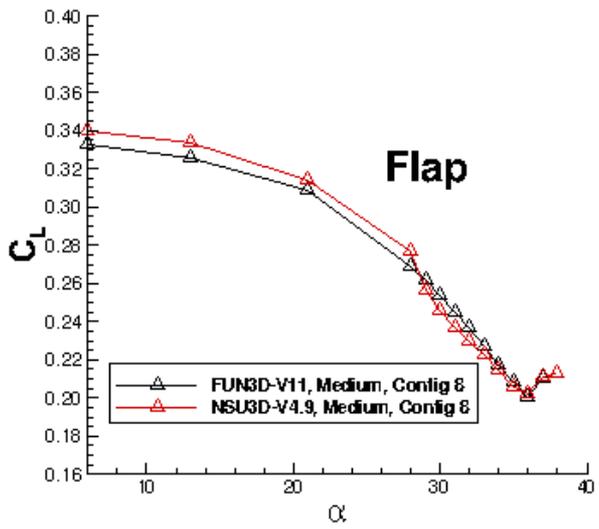
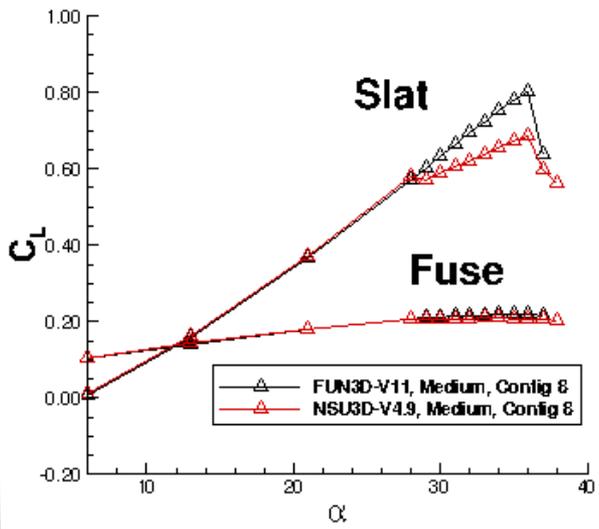
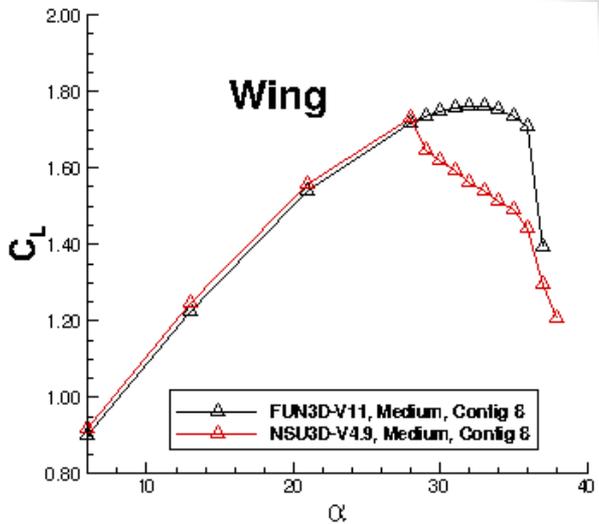
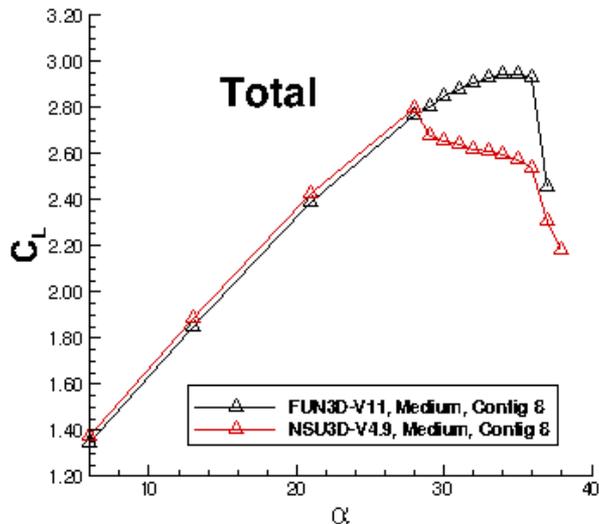
NSU3D



Case 2 – C_m



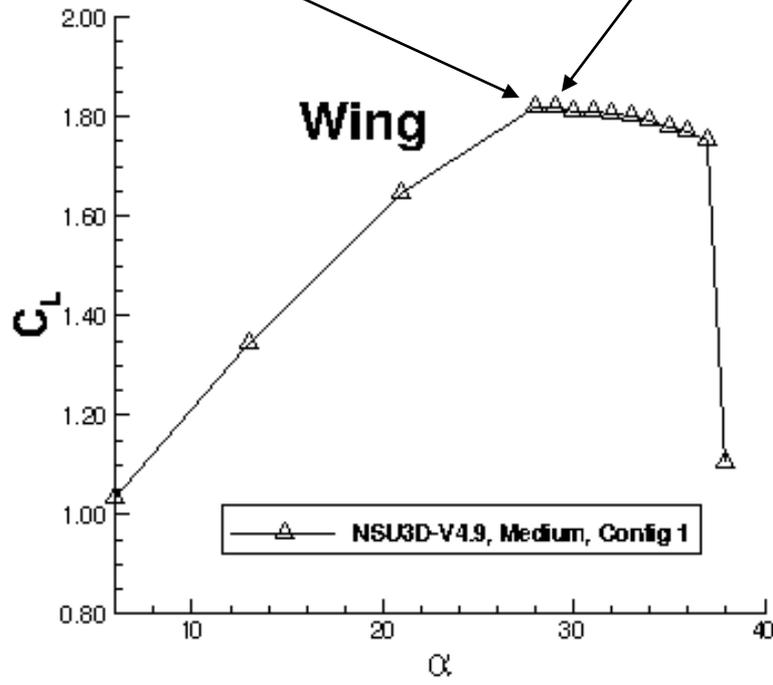
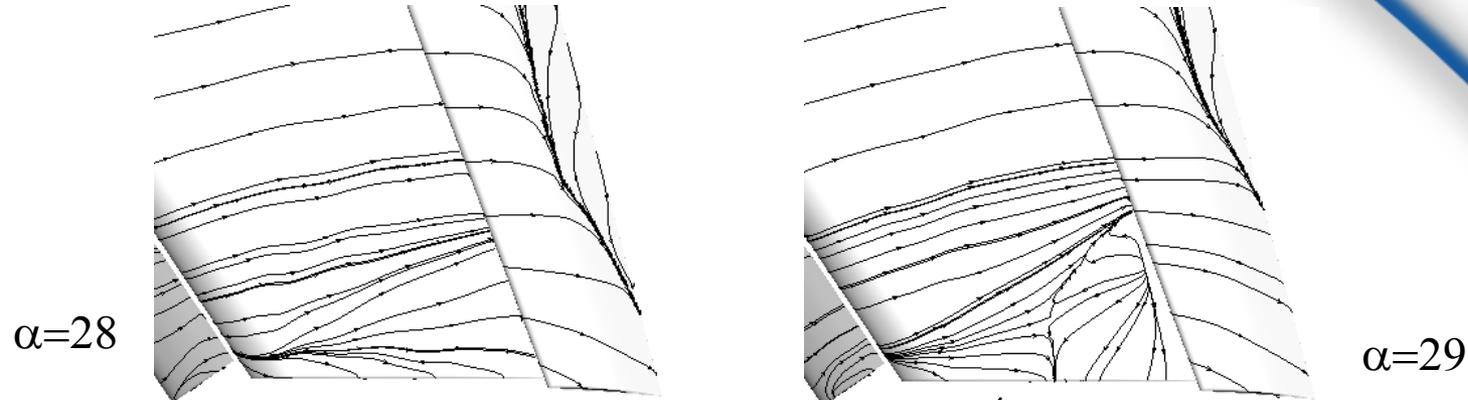
Case 2 – Component C_L , Config 8



Flow field

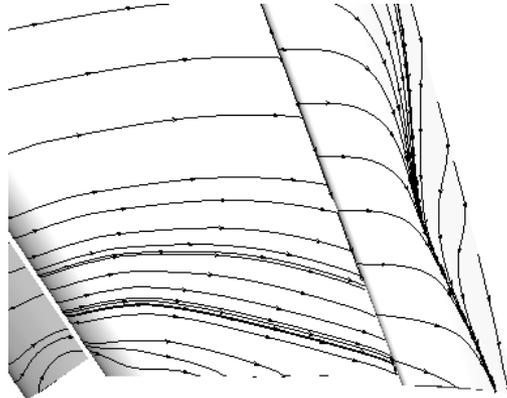
- Flow field at tip related to CL of wing
- Flow field at stall
- Flow field at side of body

Config 1 - Wingtip, NSU3D

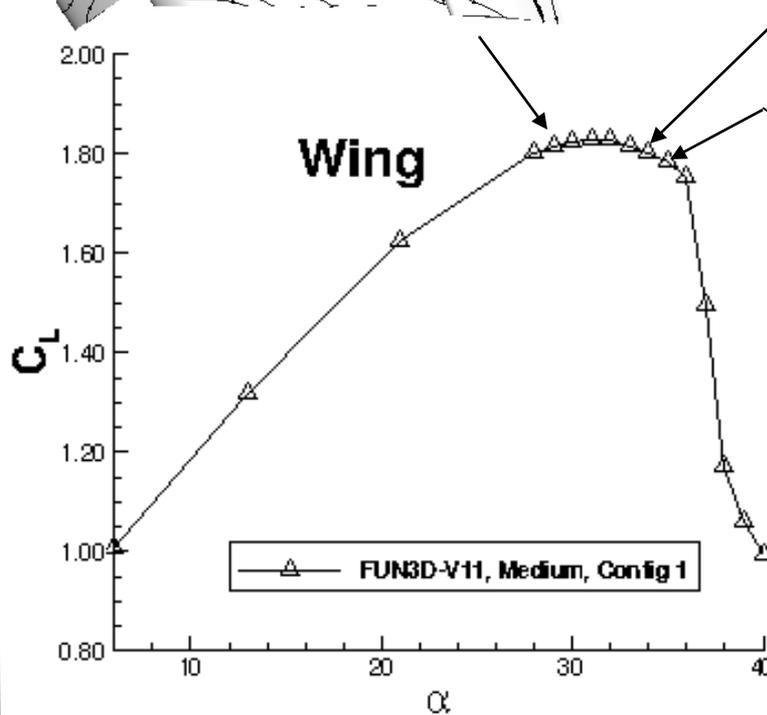
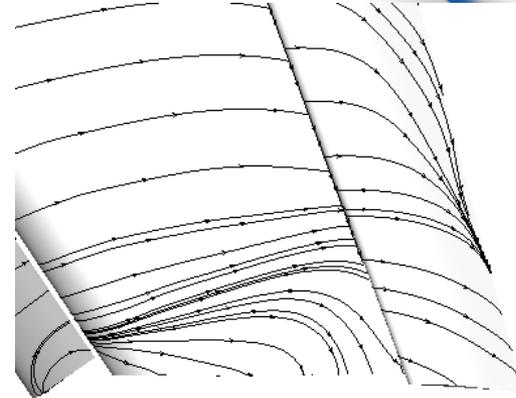


Config 1 - Wingtip, FUN3D

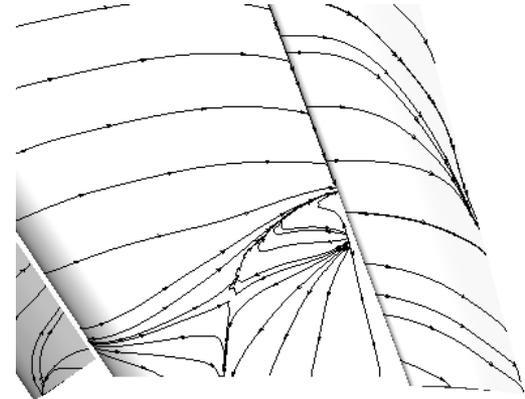
$\alpha=29$



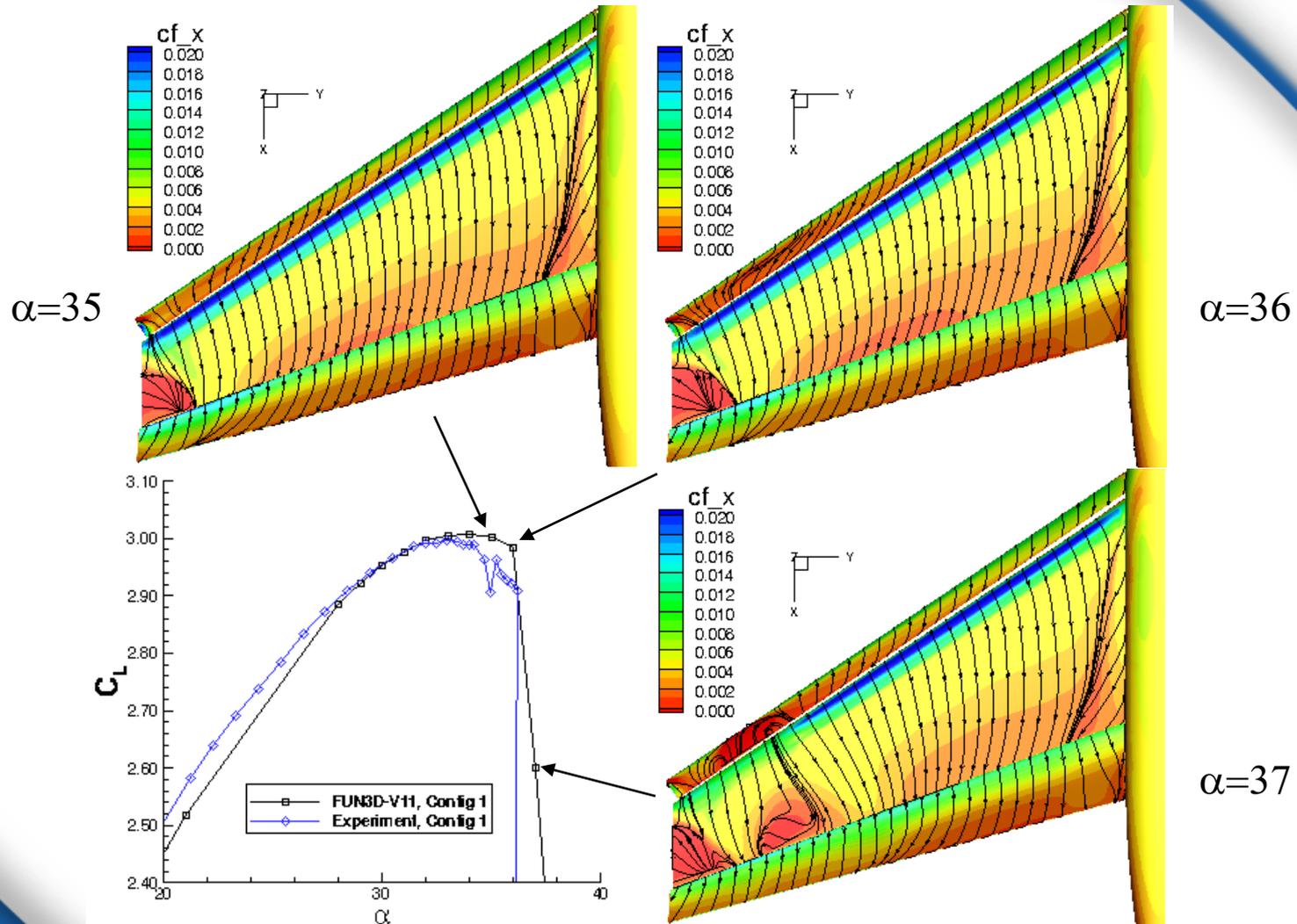
$\alpha=34$



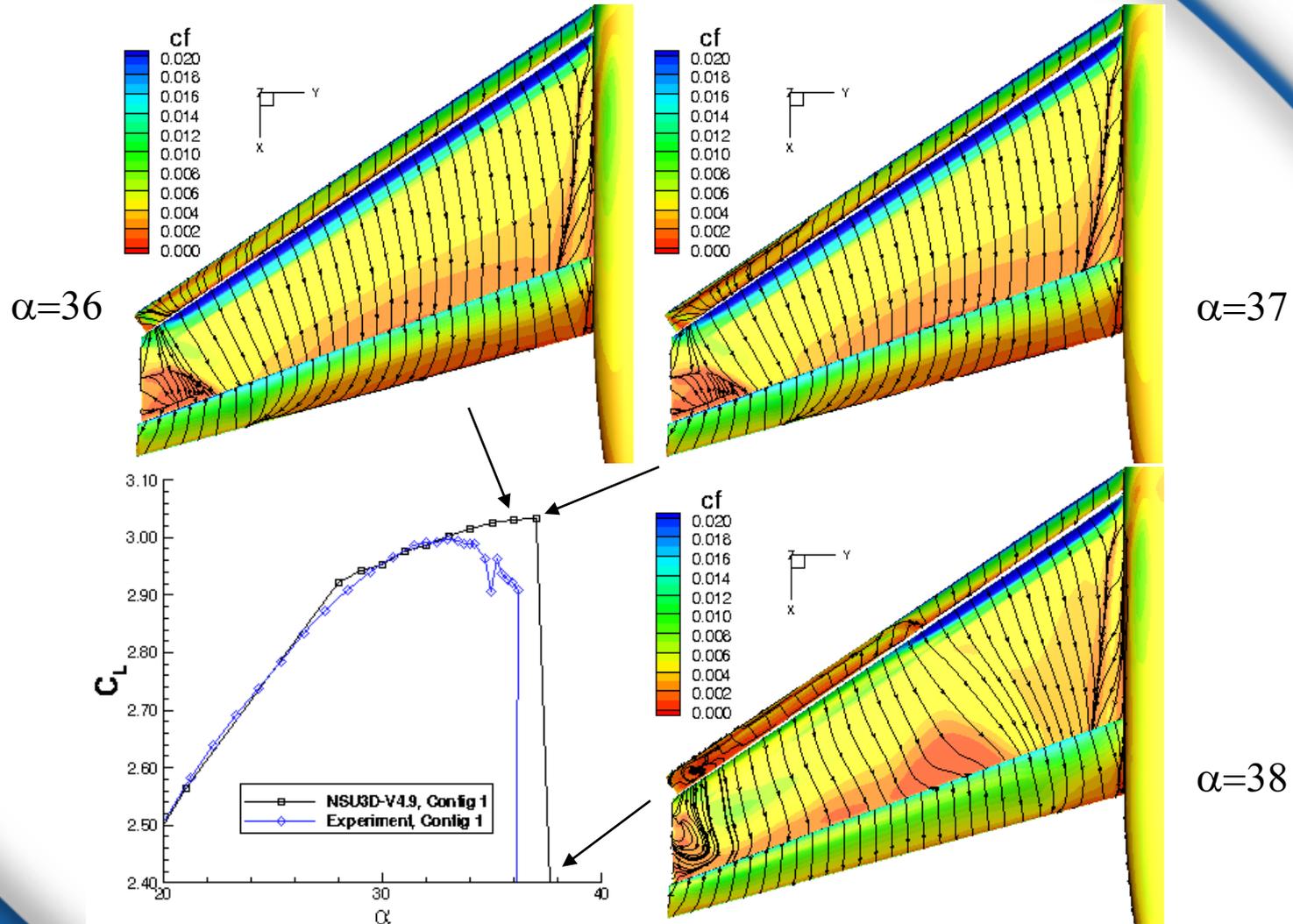
$\alpha=35$



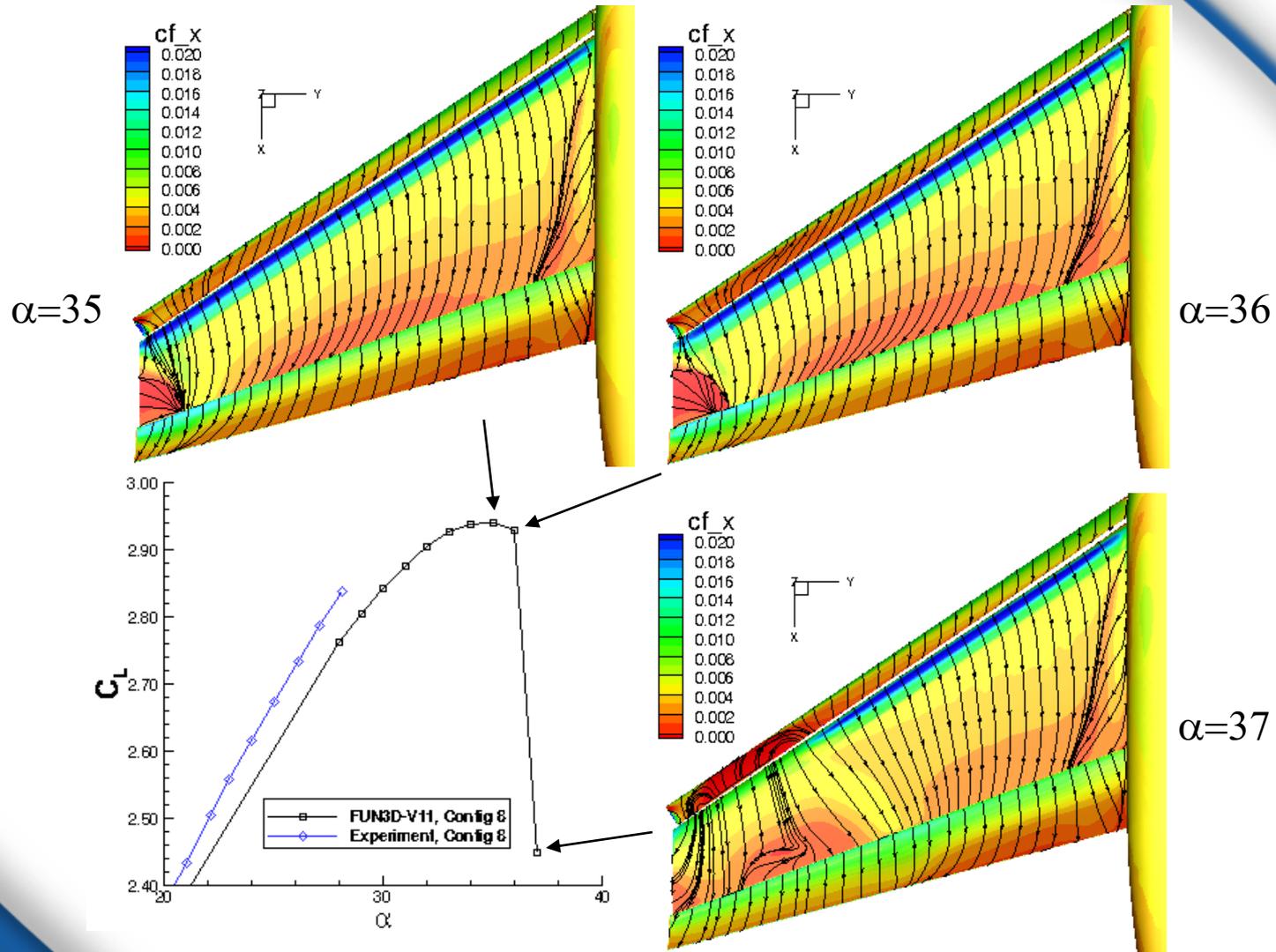
Config 1 – Stall, FUN3D, Medium



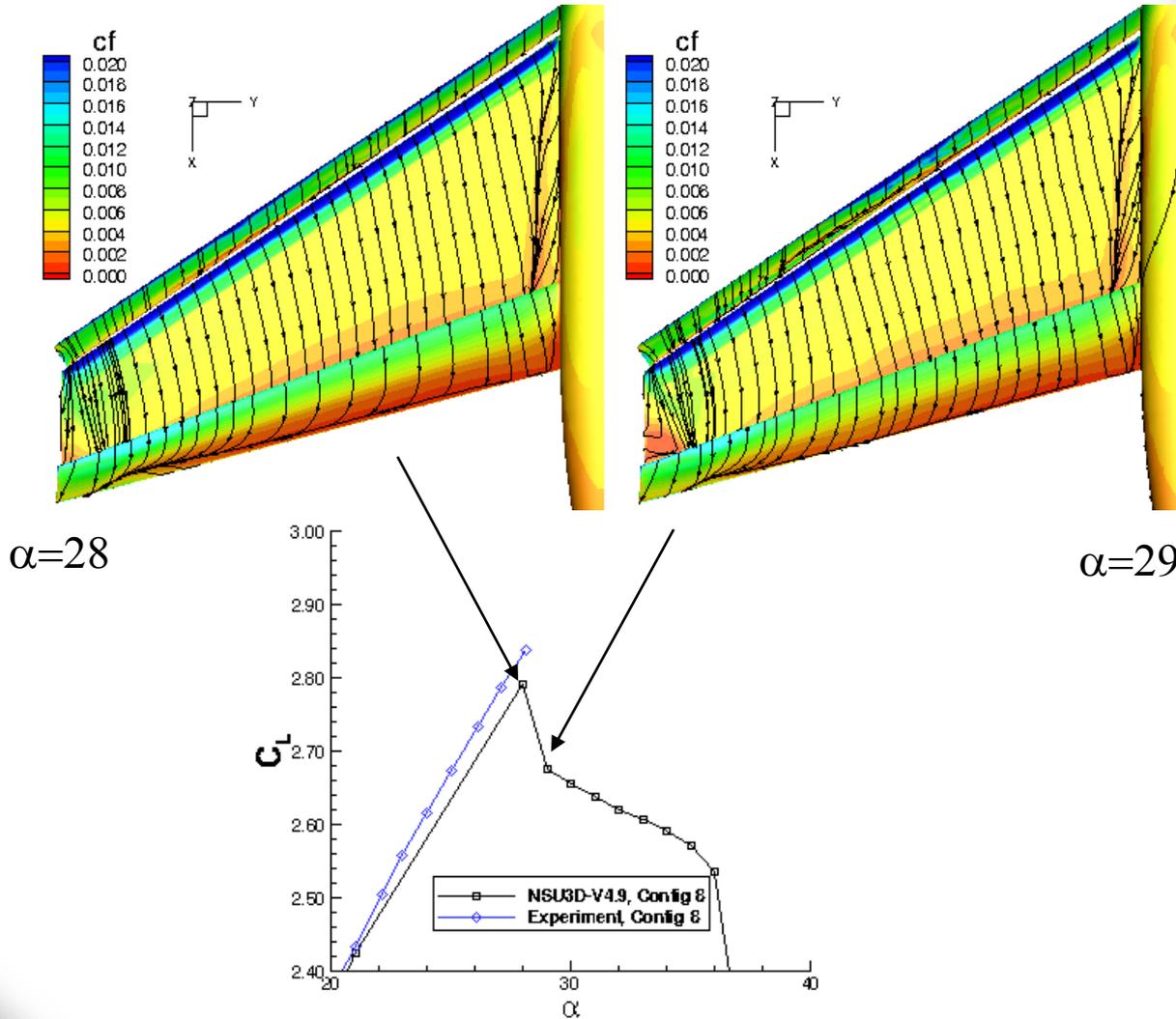
Config 1 – Stall, NSU3D, Medium



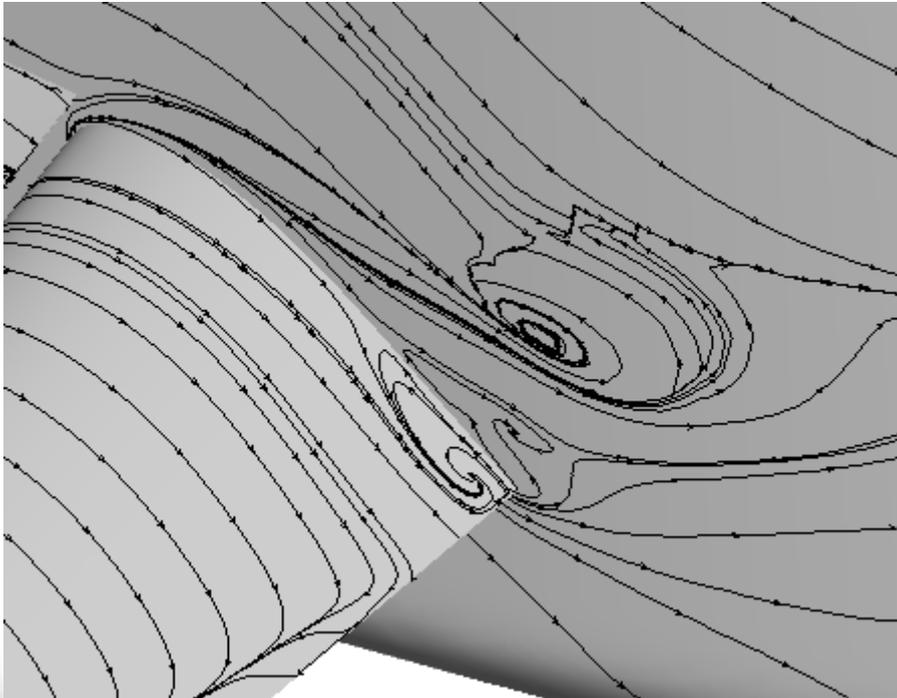
Config 8 – Stall, FUN3D, Medium



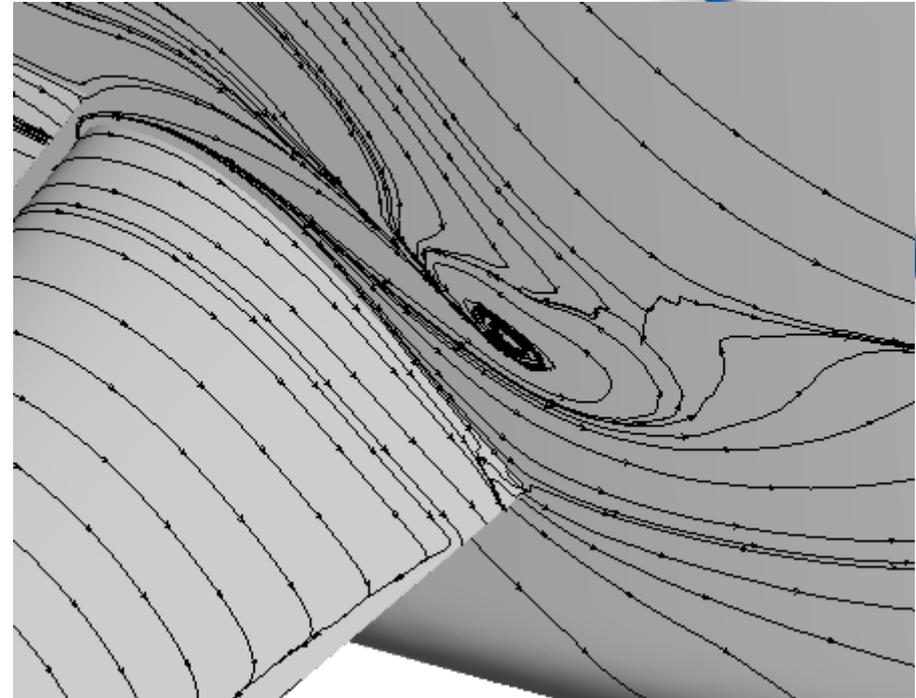
Config 8 – Stall, NSU3D, Medium



Config 1 – Side of body, $\alpha=13$



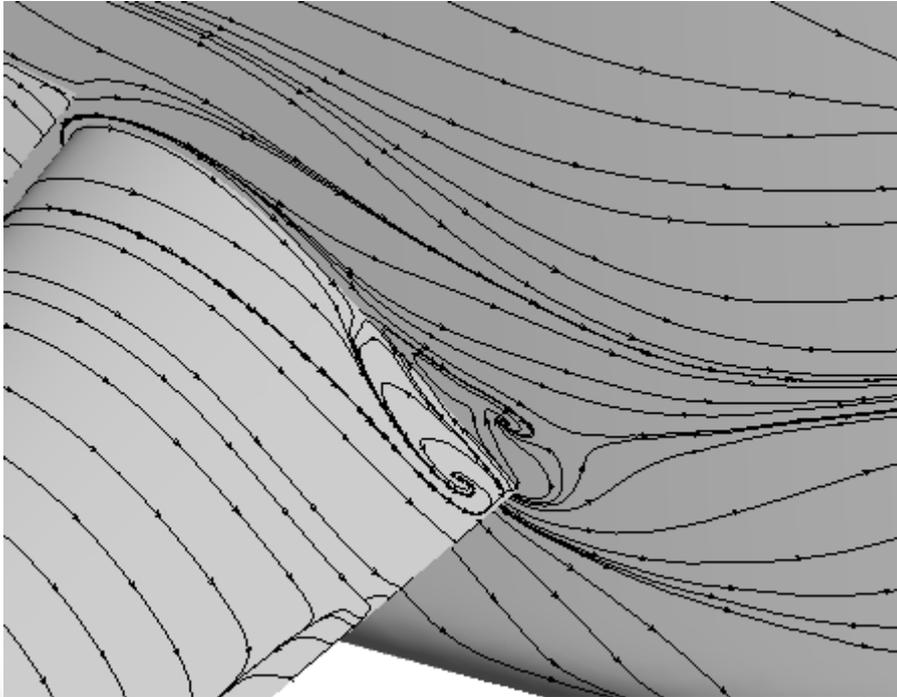
FUN3D



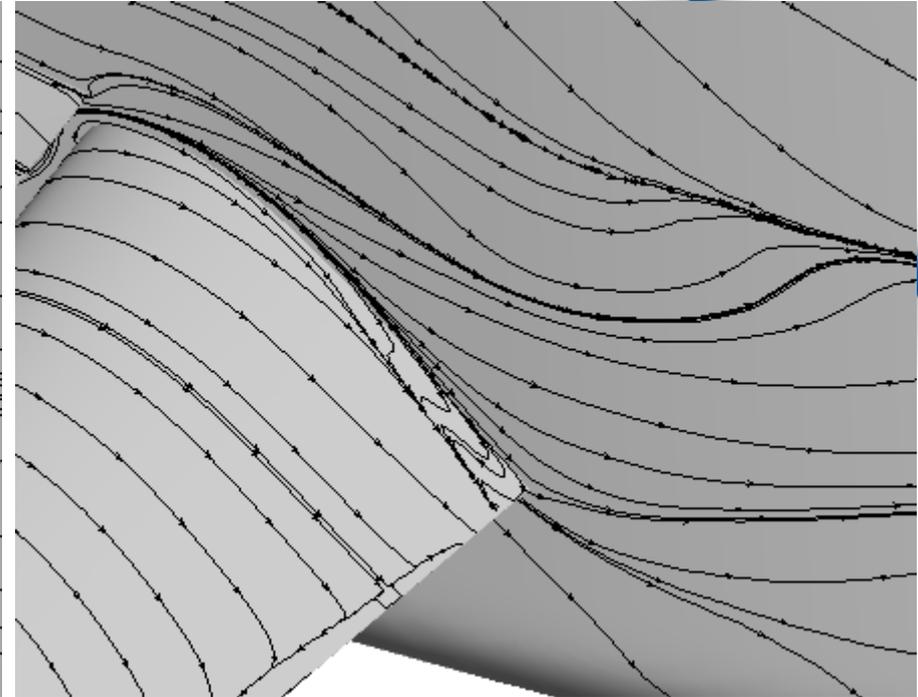
NSU3D

Medium grid

Config 1 – Side of body, $\alpha=28$



FUN3D



NSU3D

Medium grid

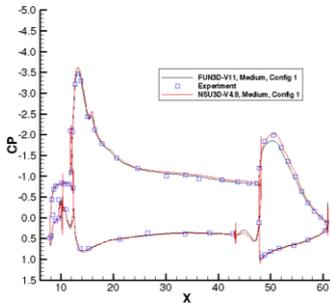
Conclusions

- Better grid convergence at lower α 's
- Higher loading on wing/flap at lower α 's with NSU3D
- Different characteristics near C_{Lmax} between codes
- NSU3D better predicts flap effects at low α 's
- NSU3D has trouble at high α 's for Config 8
 - likely multigrid issues?
- Both codes show stall initiates with slat
- Differences in side of body prediction between codes
- Many opportunities for further study

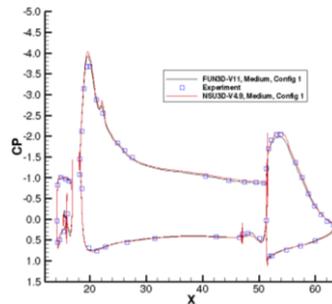
- Backup slides

Medium Grid Cps, 13 deg

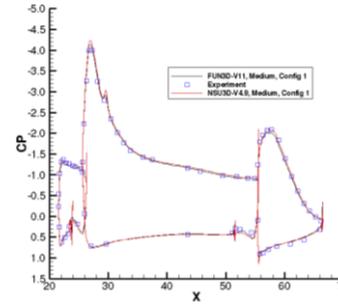
A13, w17



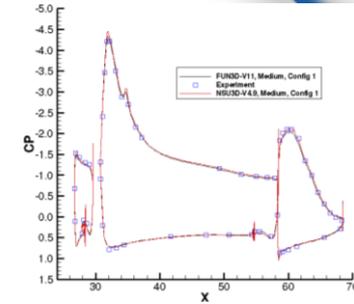
A13, w28



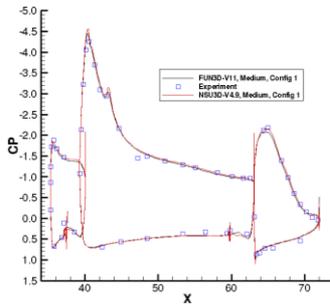
A13, w41



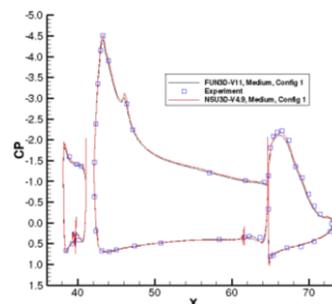
A13, w50



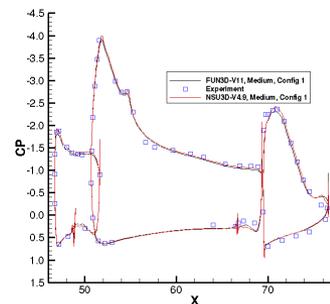
A13, w65



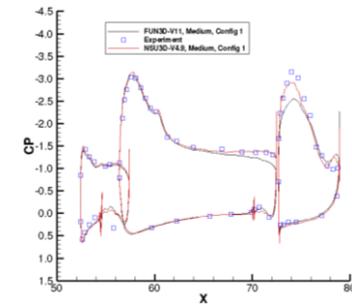
A13, w70



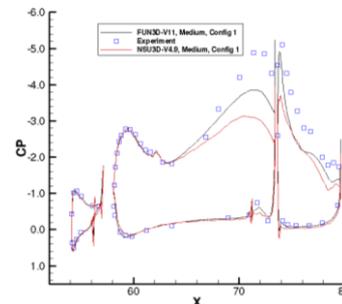
A13, w85



A13, w95

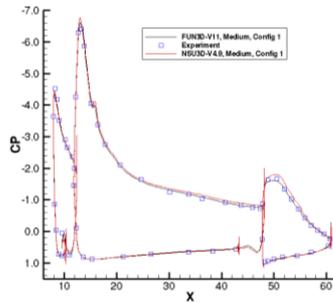


A13, w98

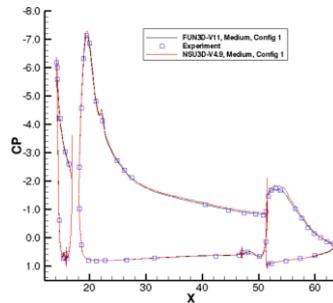


Medium Grid Cps, 28 deg.

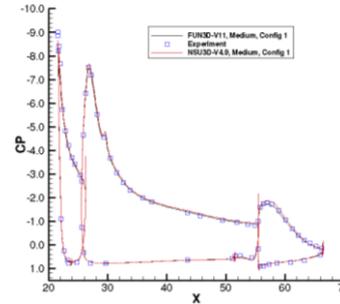
A28, w17



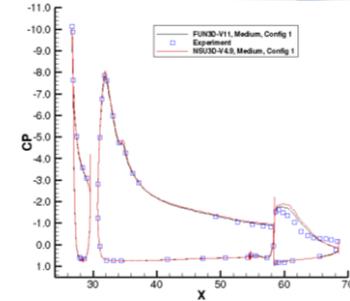
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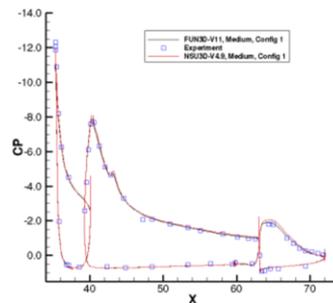
A28, w41



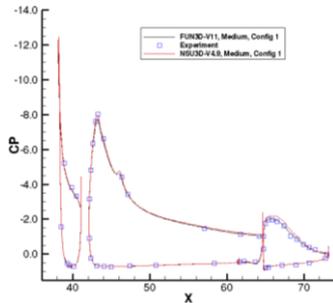
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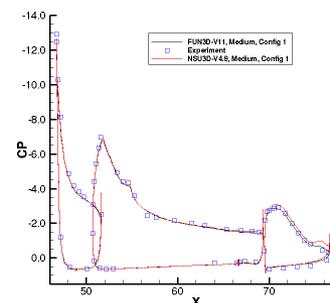
A28, w65



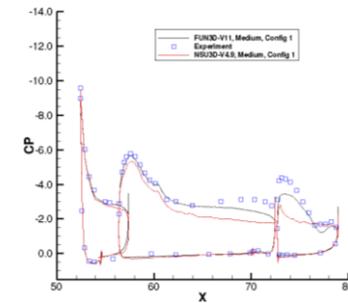
A28, w70



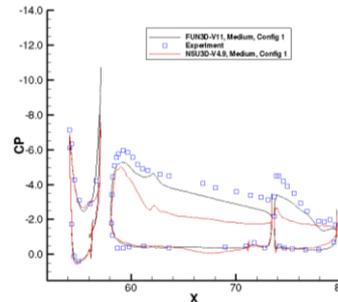
A28, w85



A28, w95

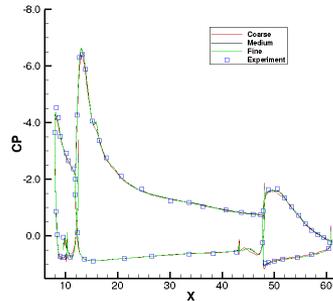


A28, w98

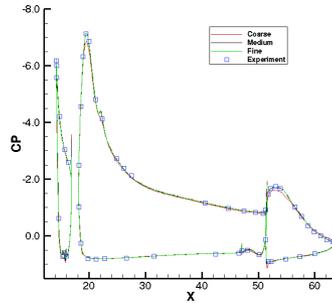


Grid convergence, FUN3D

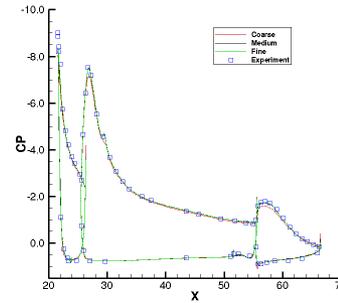
A28, w17



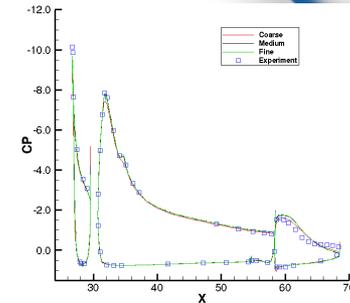
A28, w28



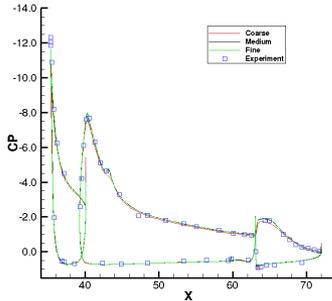
A28, w41



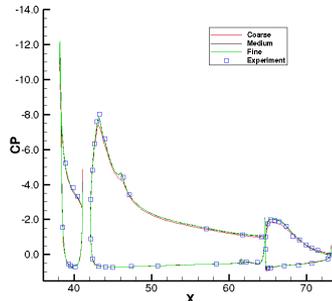
A28, w50



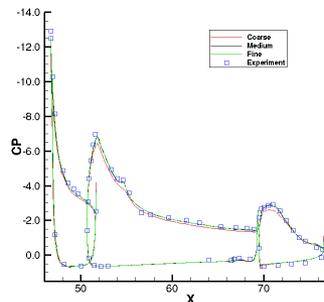
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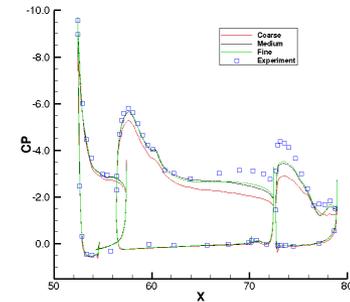
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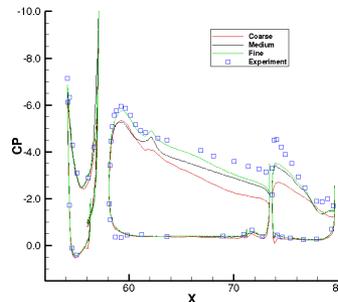
A28, w85



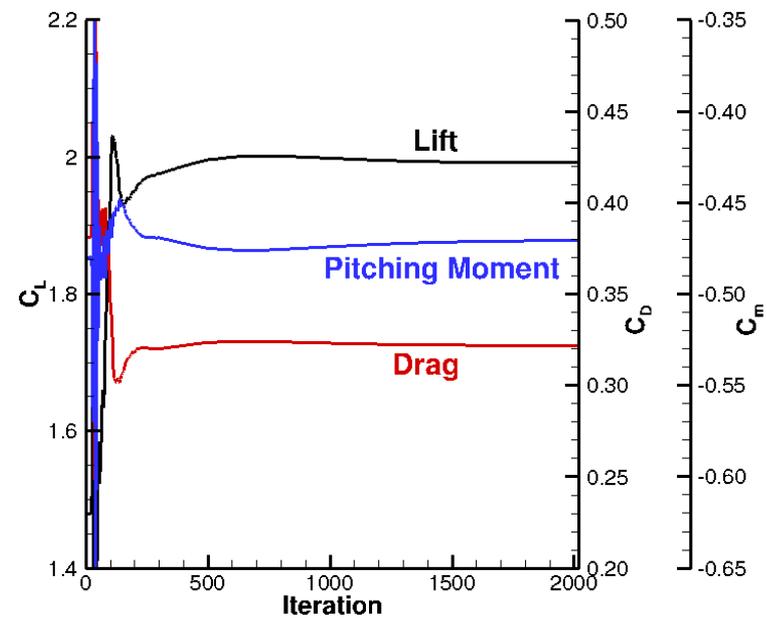
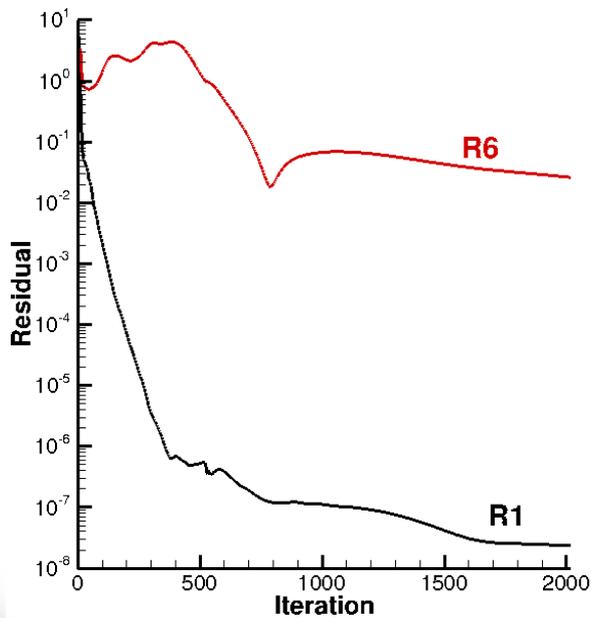
A28, w95



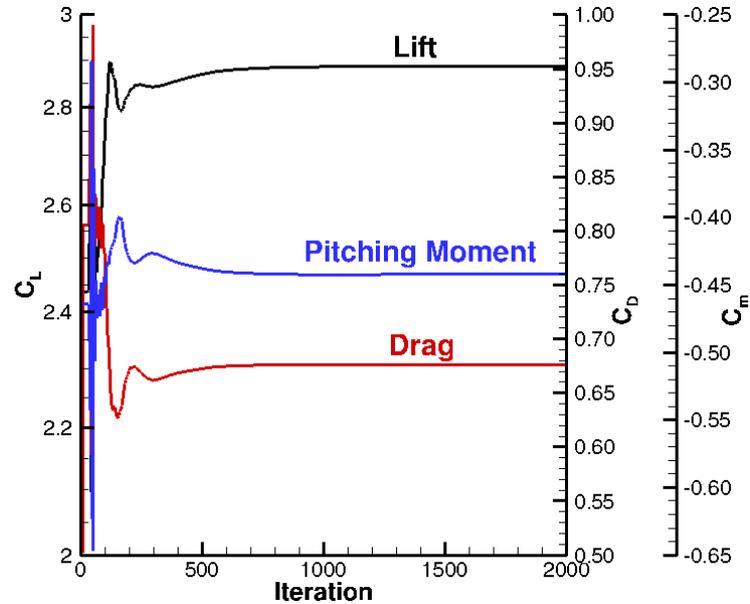
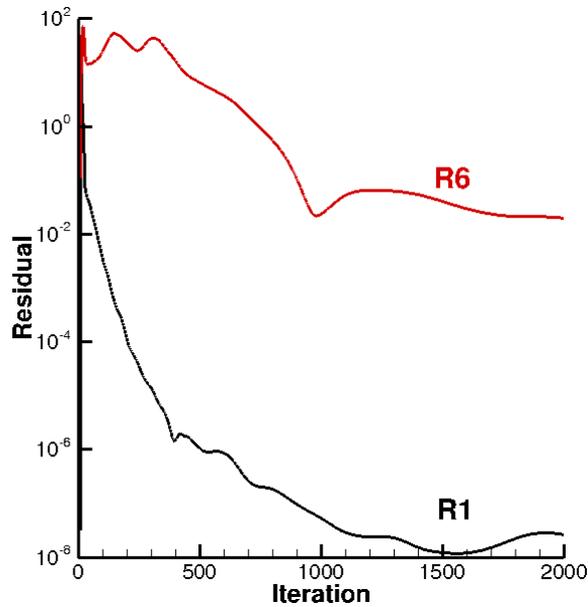
A28, w98



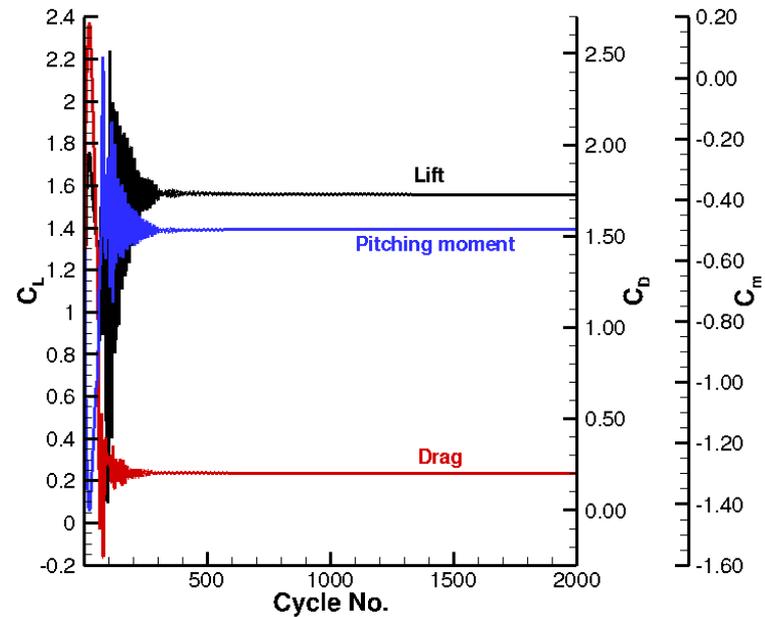
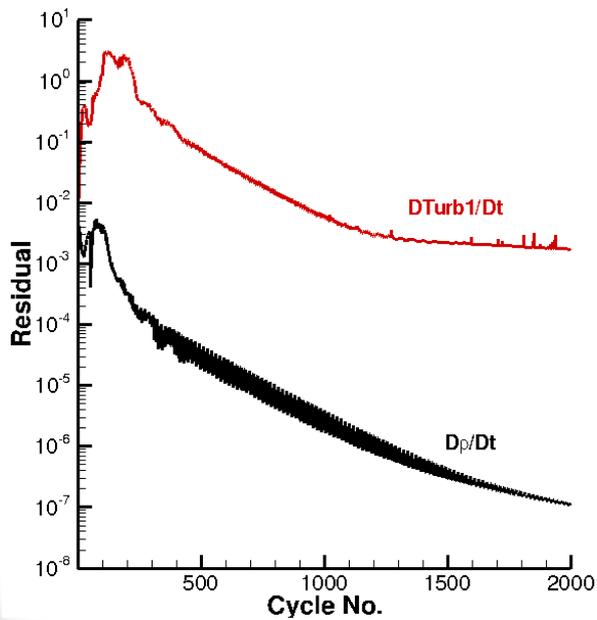
FUN3D convergence, 13 deg.



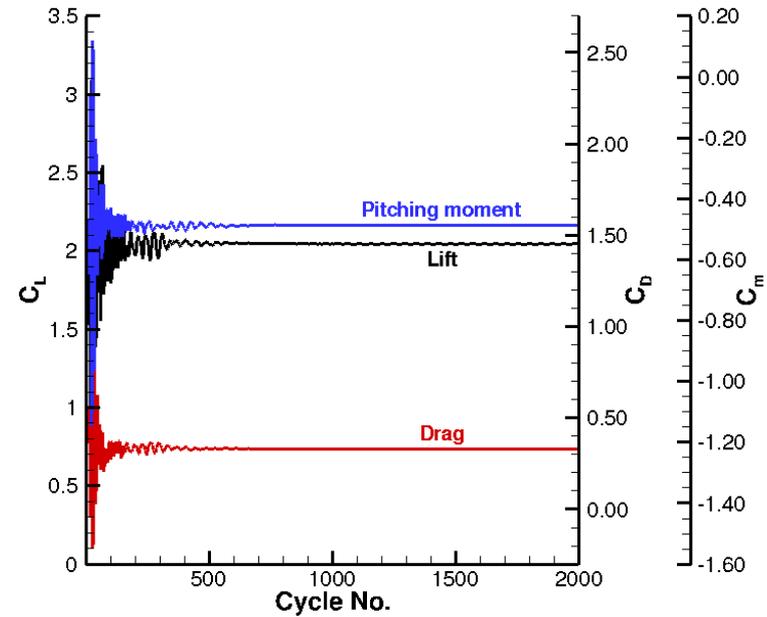
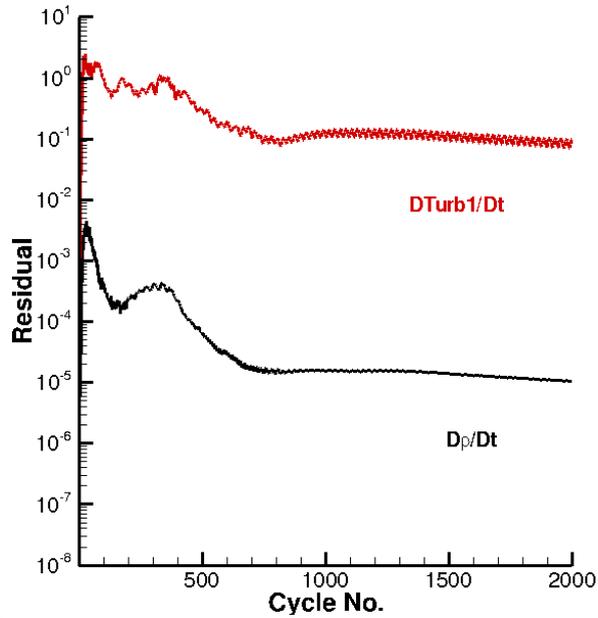
FUN3D convergence, 28 deg.



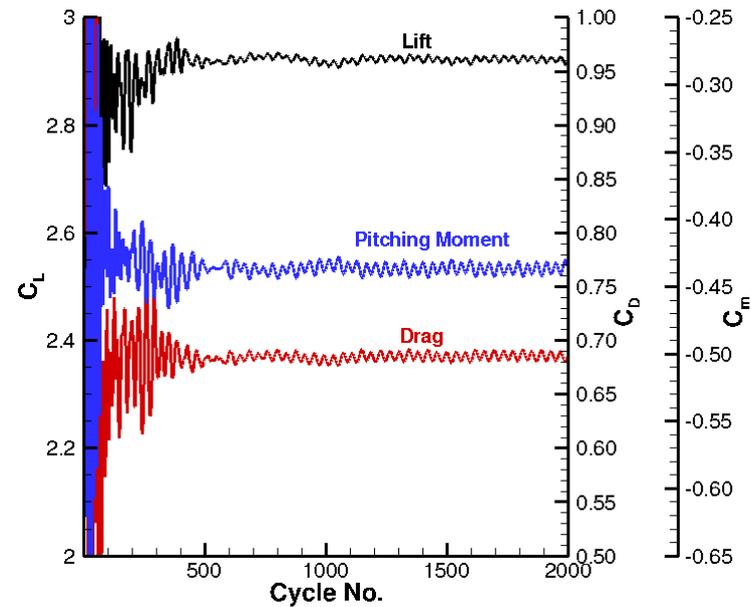
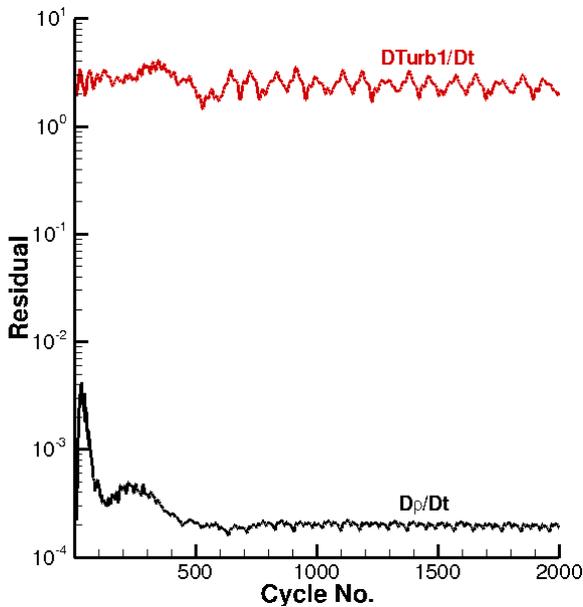
NSU3D convergence, 6 deg.



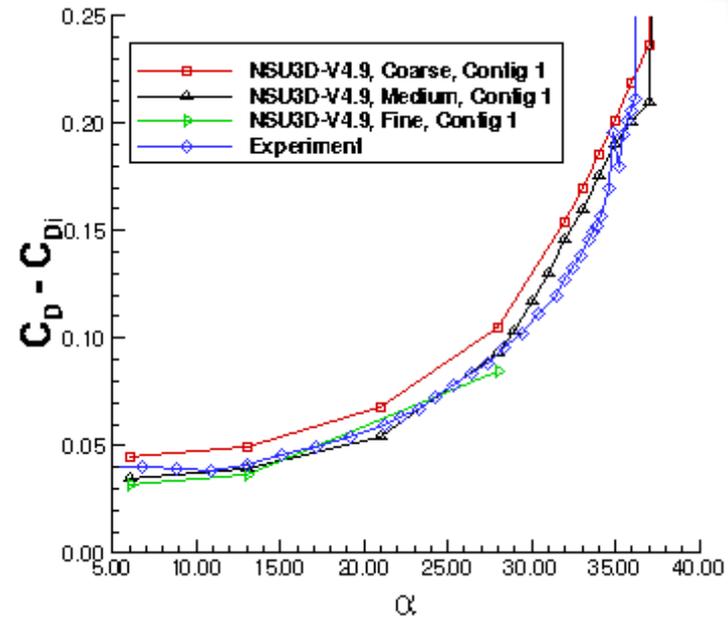
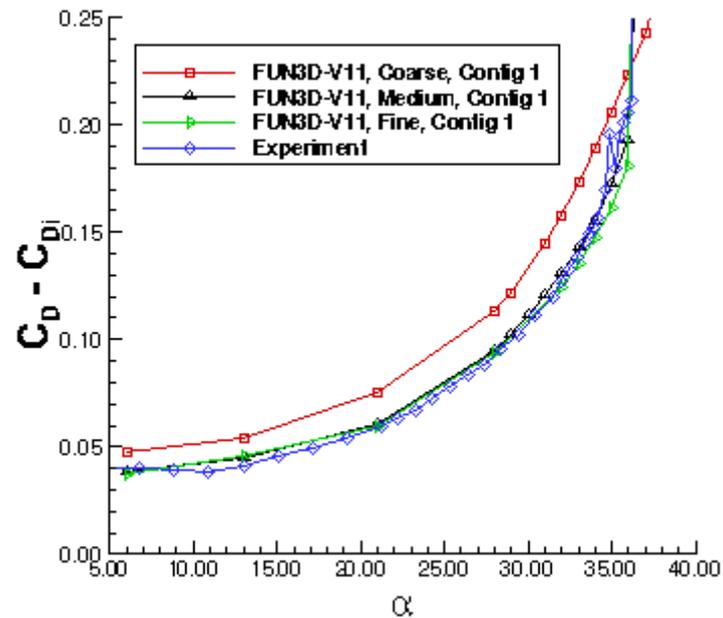
NSU3D convergence, 13 deg.



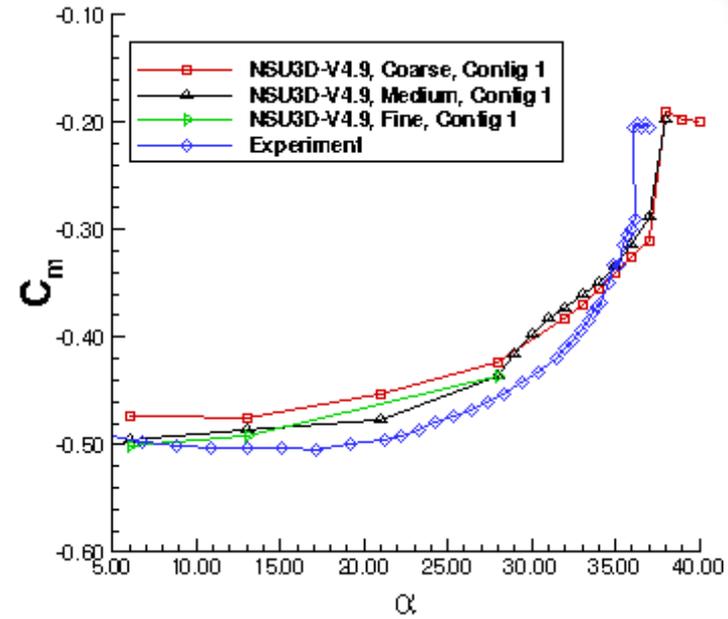
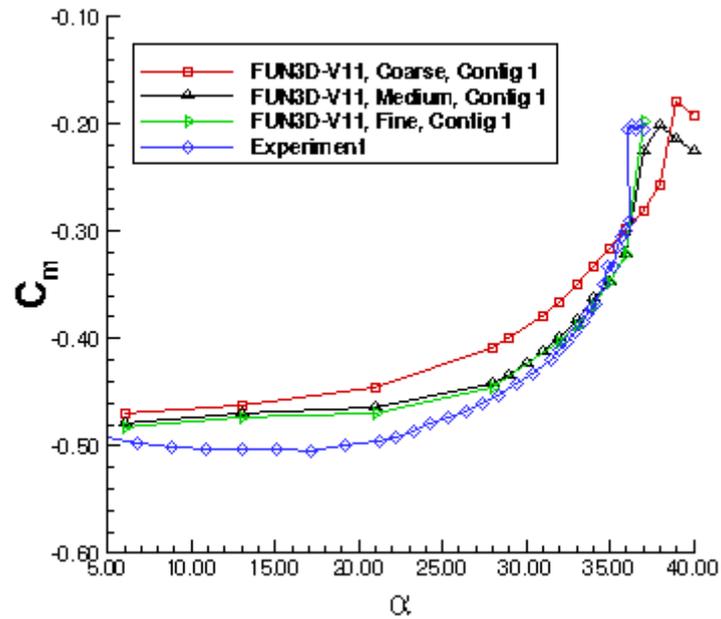
NSU3D convergence, 28 deg.



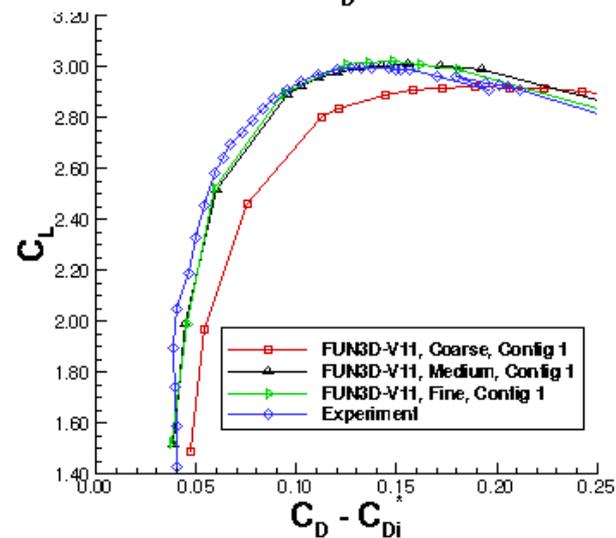
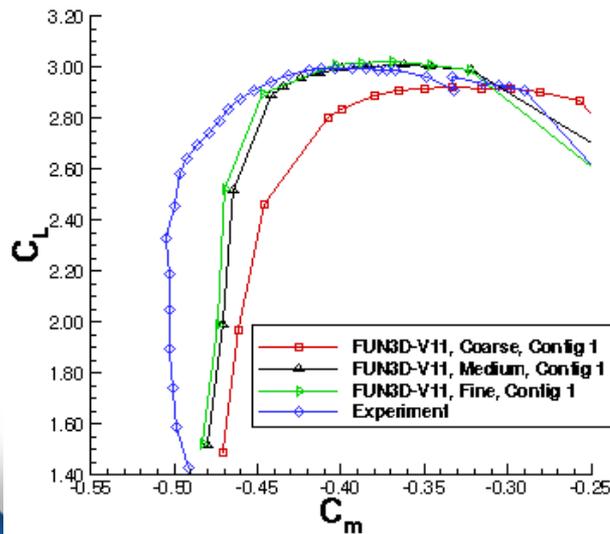
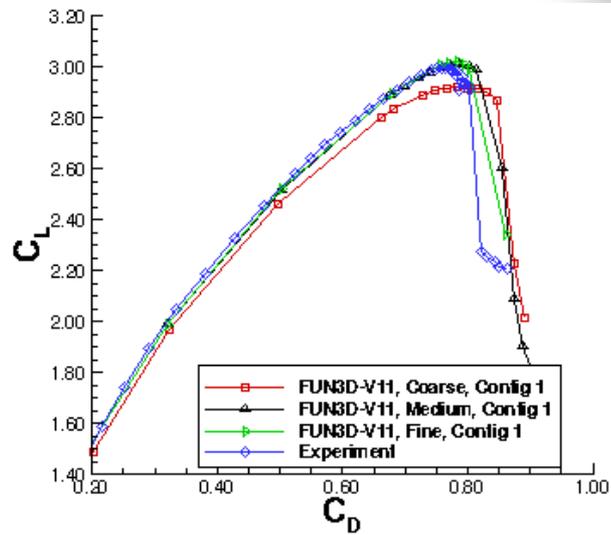
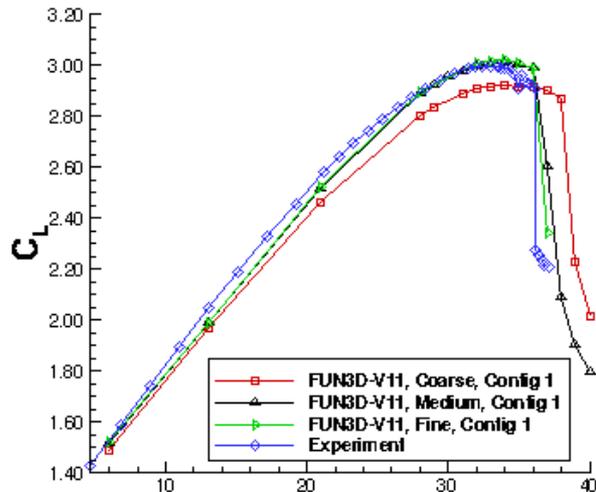
Config 1 – Grid comparison



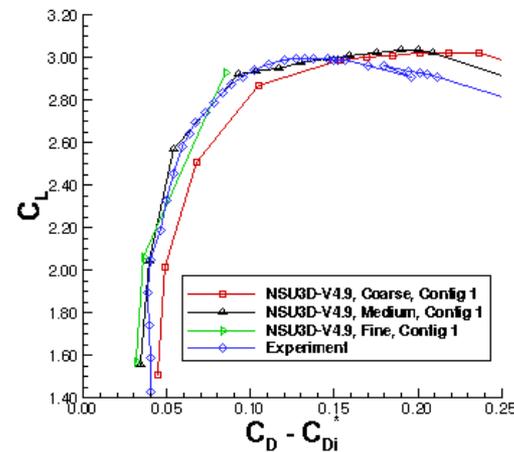
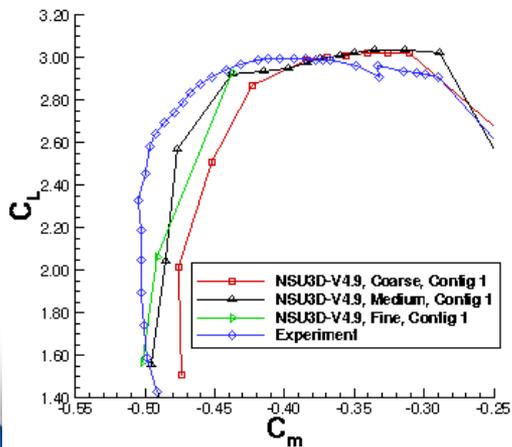
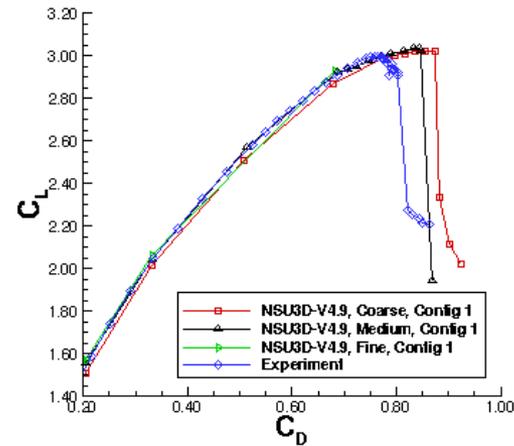
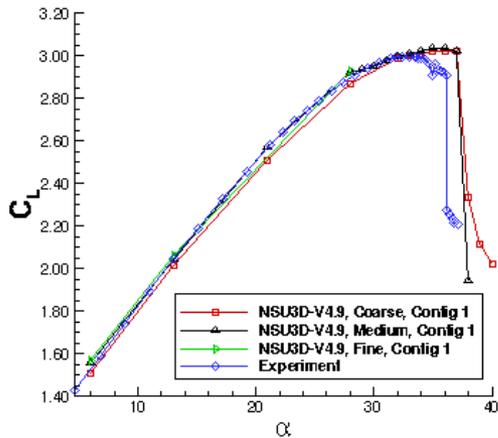
Config 1 – Grid comparison



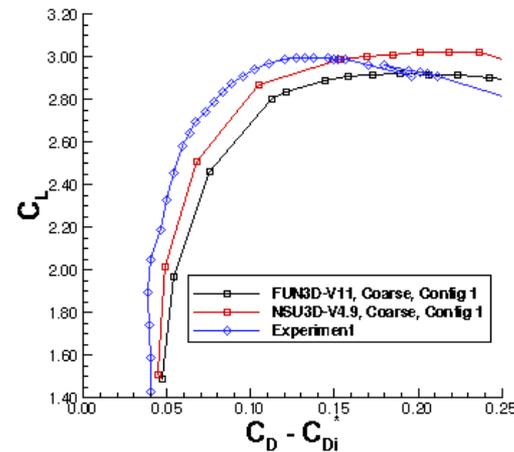
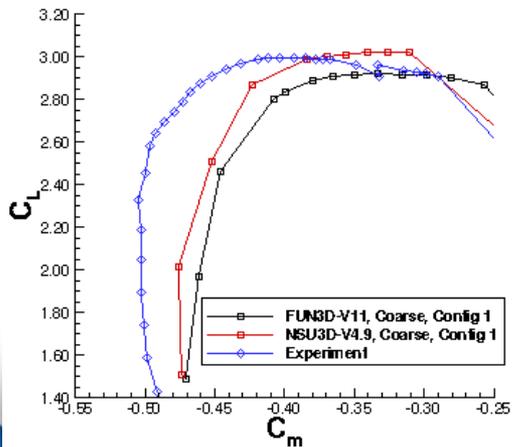
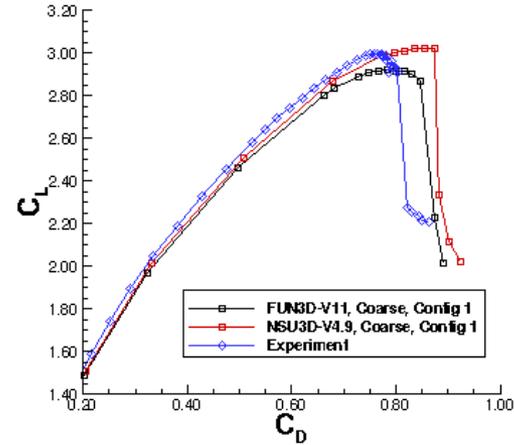
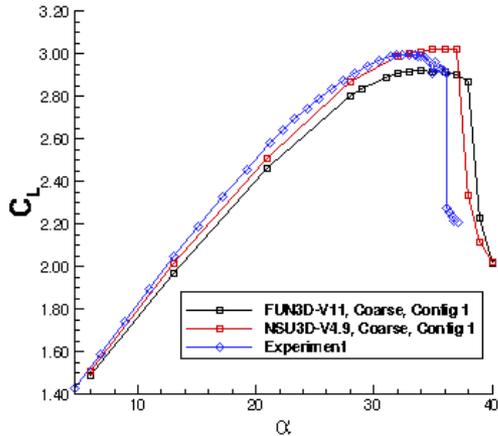
FUN3D – Grid comparison



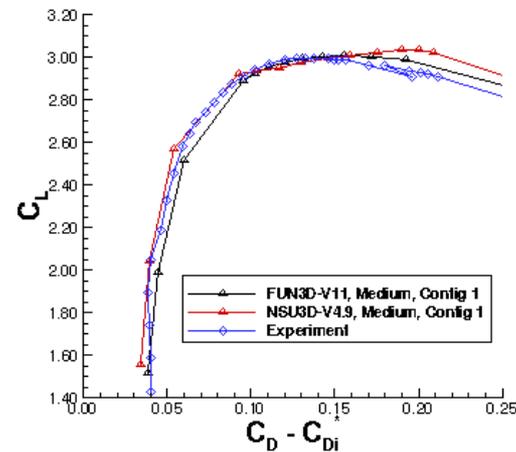
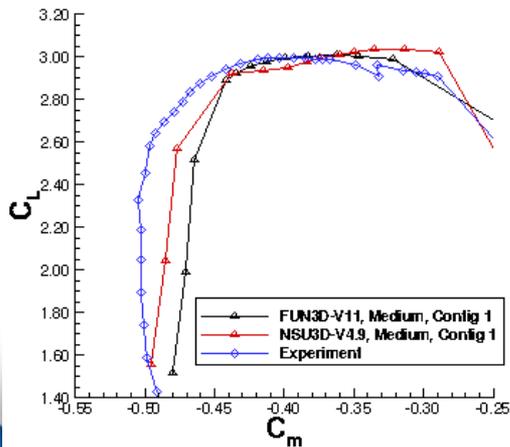
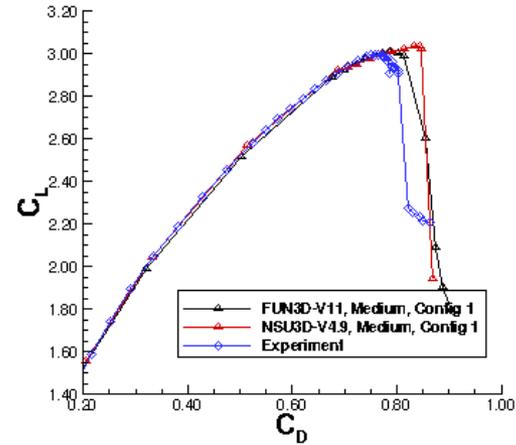
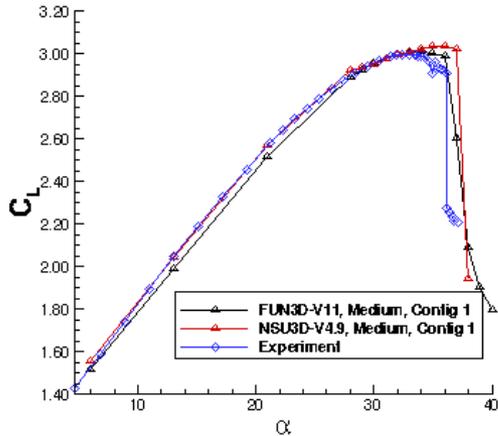
NSU3D – Grid comparison



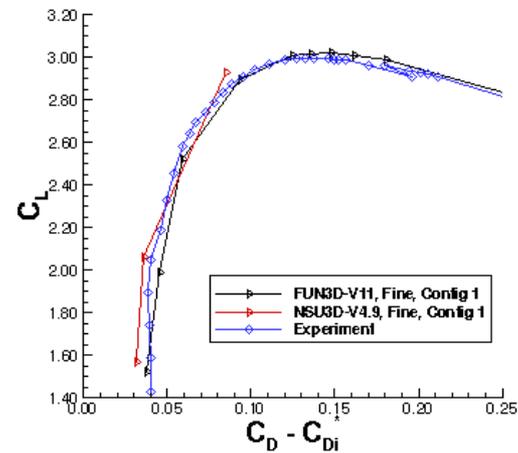
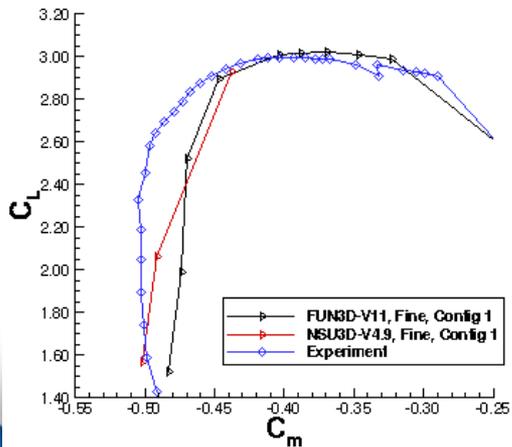
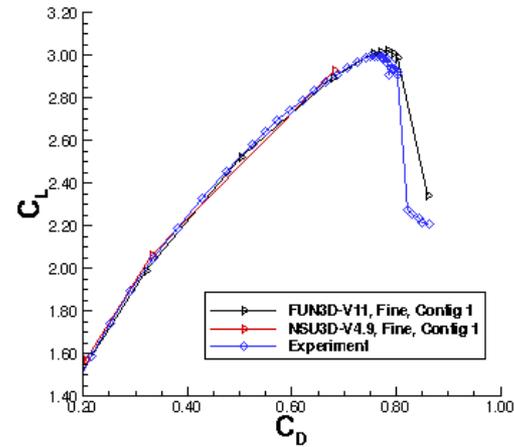
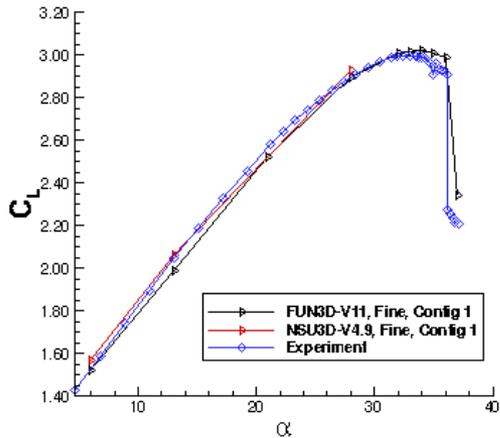
Coarse – Code comparison



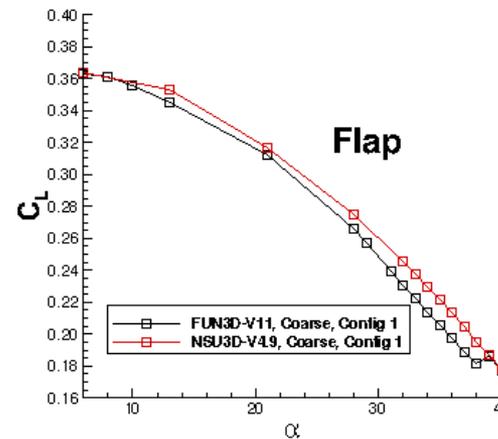
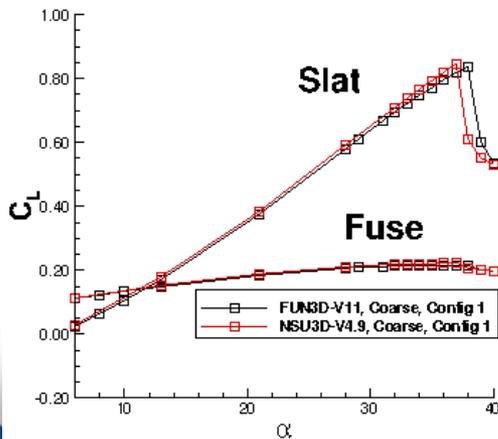
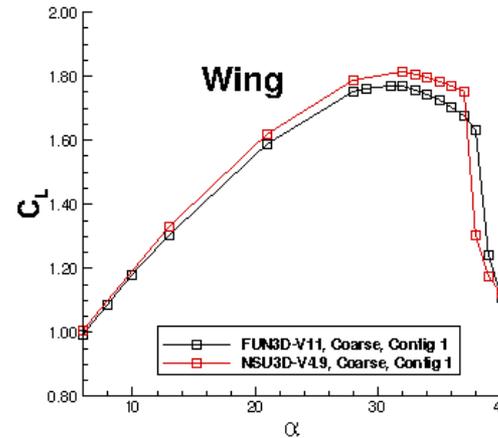
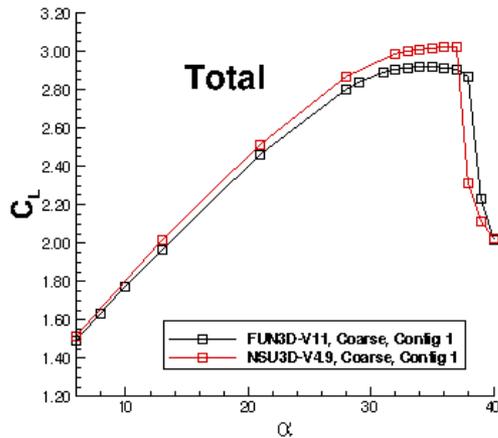
Medium – Code comparison



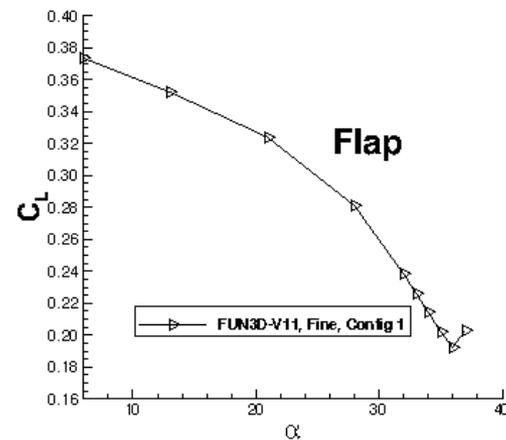
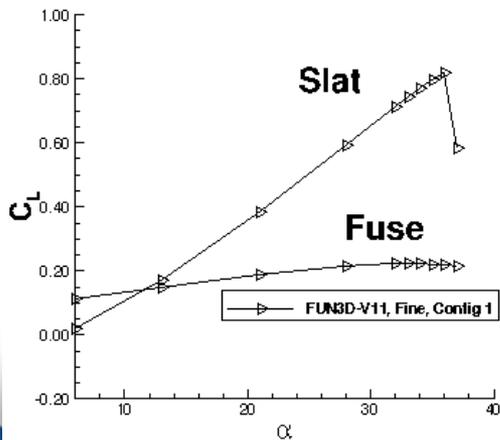
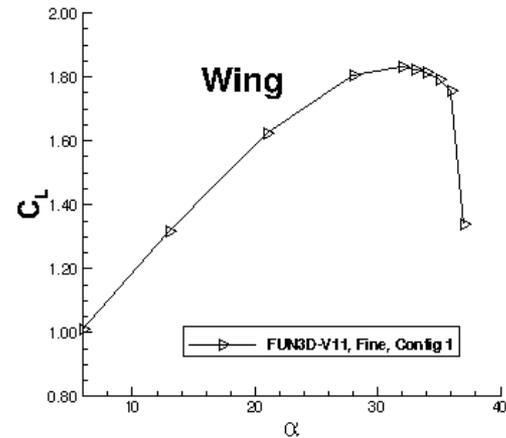
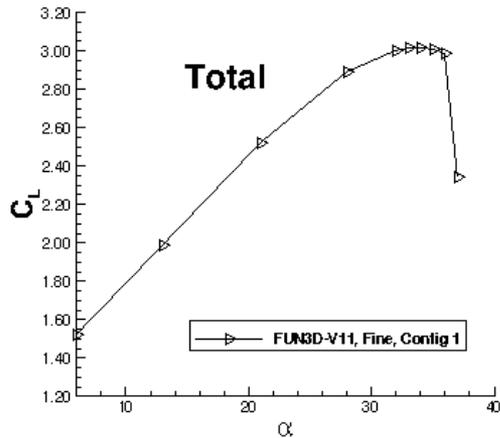
Fine – Code comparison



Breakdown, coarse

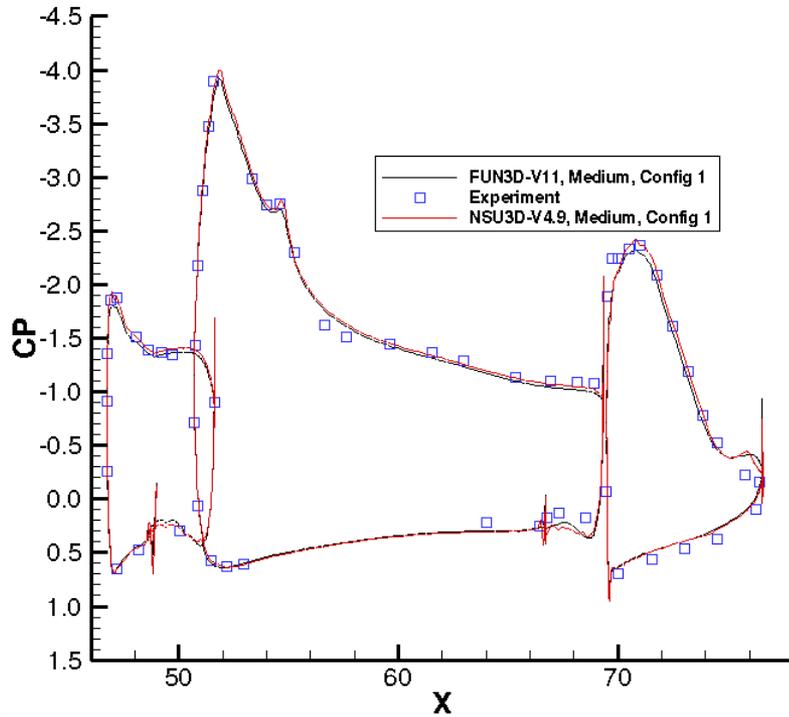


Breakdown, fine

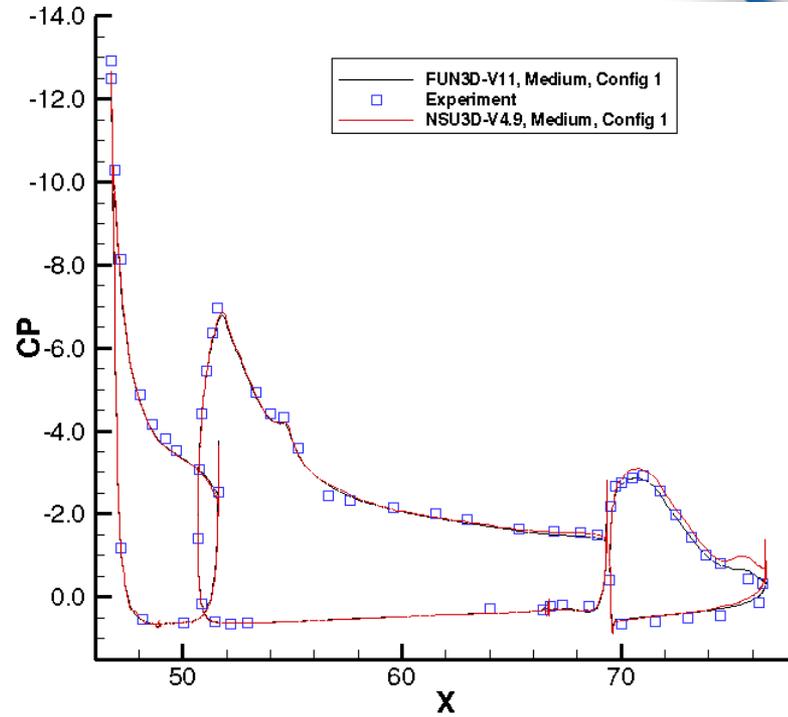


Case 1 – Cp, y=85

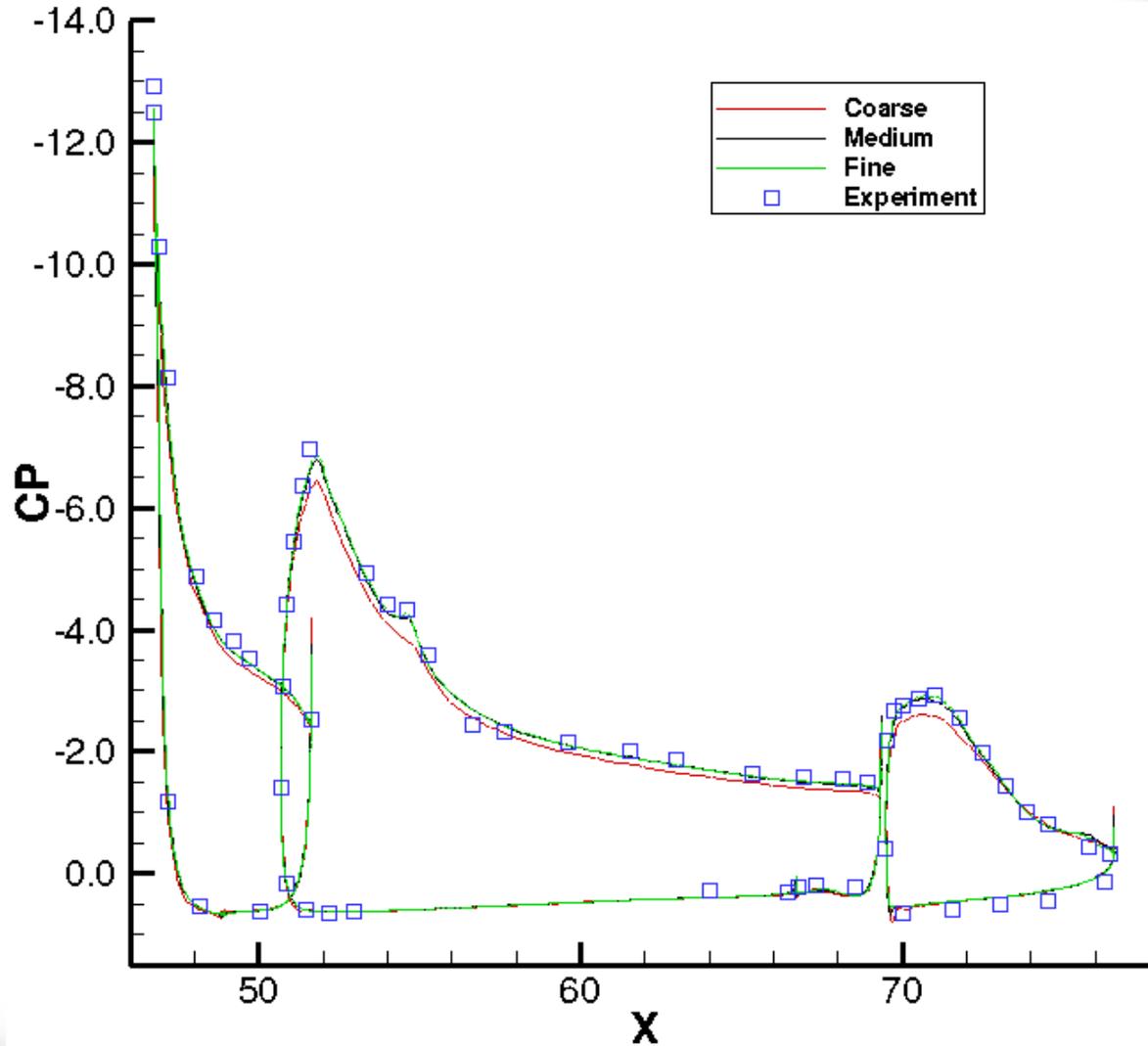
$\alpha=13$



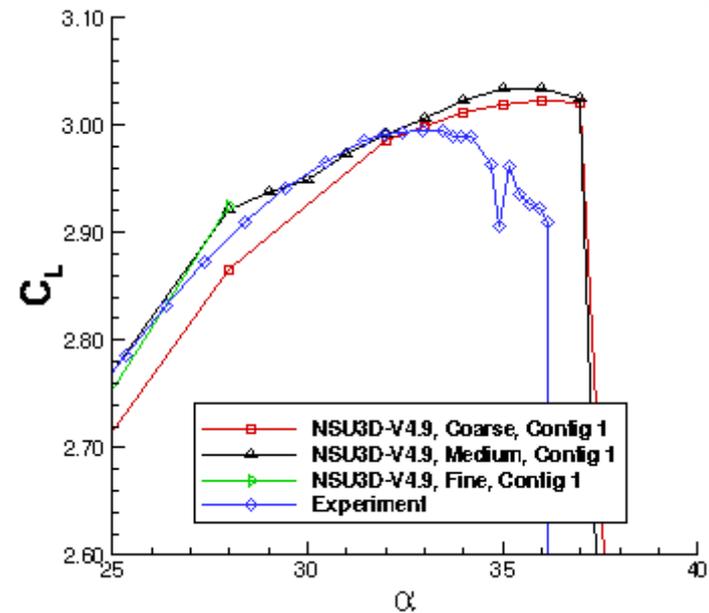
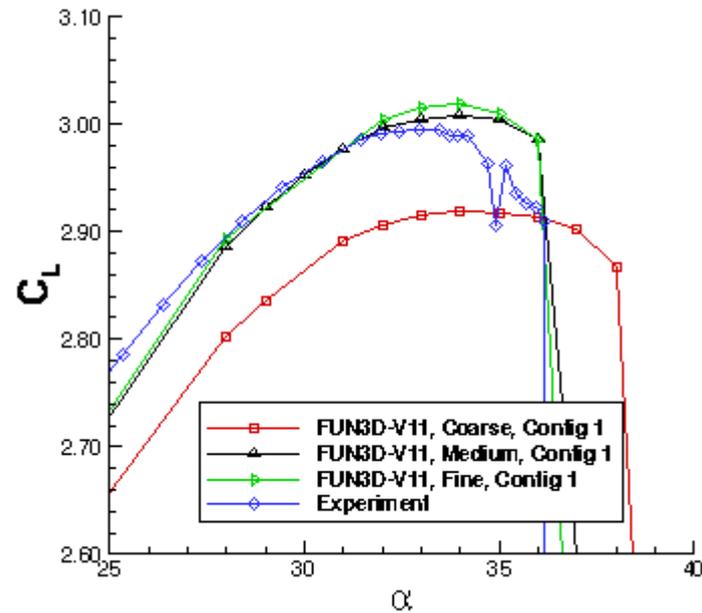
$\alpha=28$



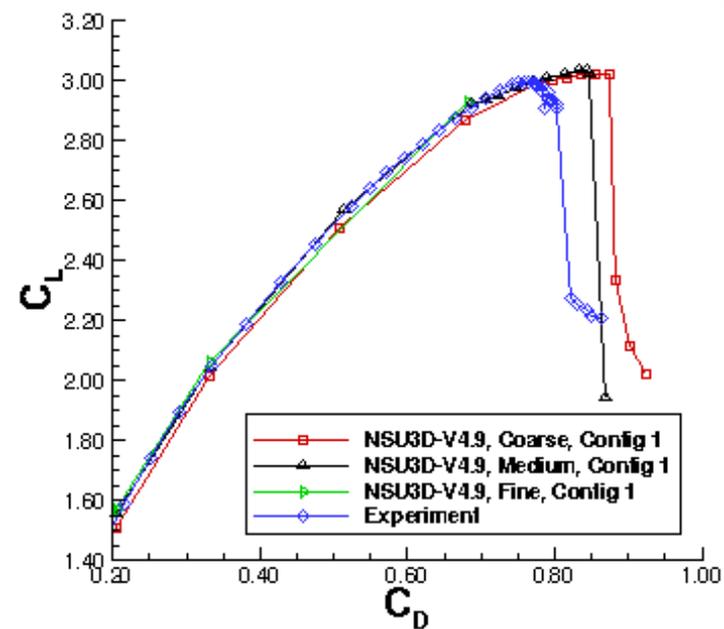
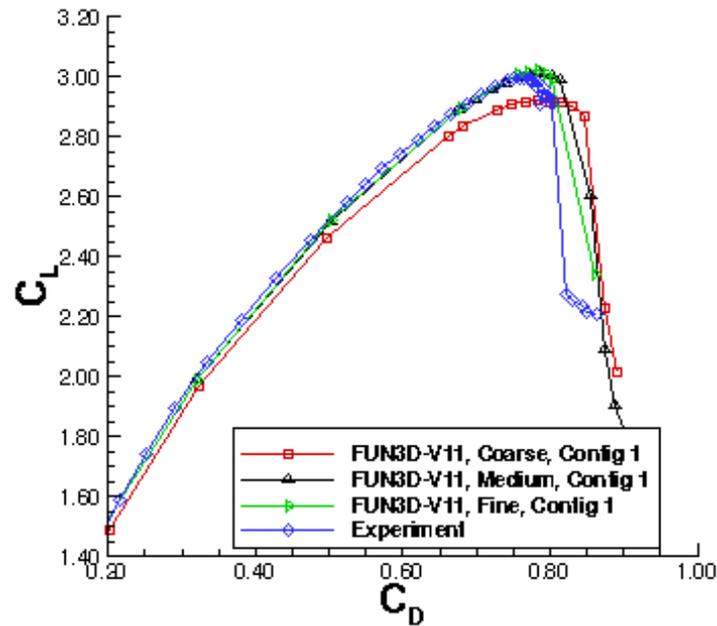
Case 1 – Cp, y=85, FUN3D



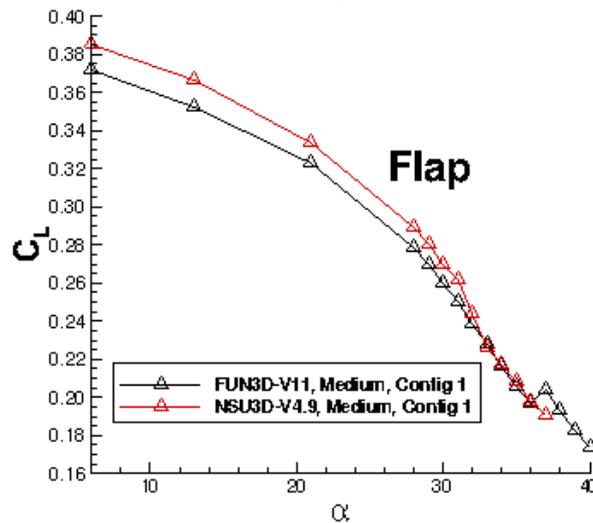
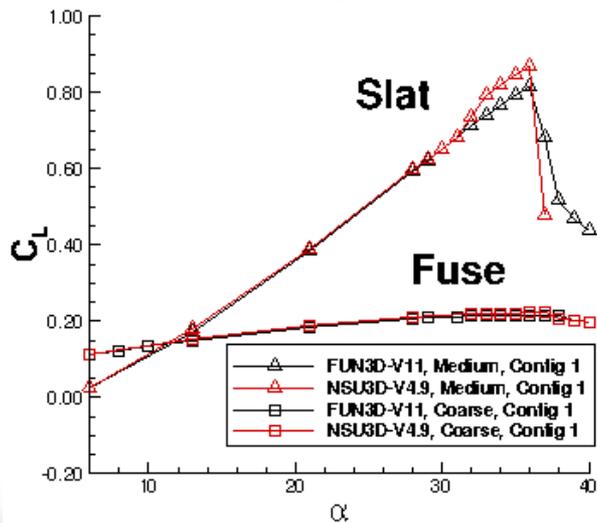
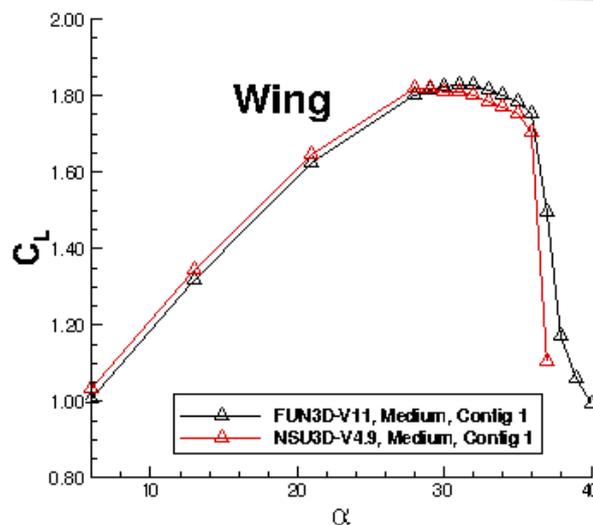
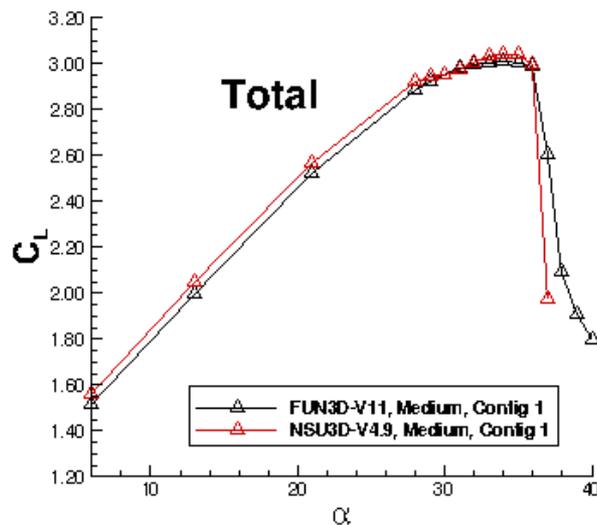
Case 1 – Grid comparison, C_L



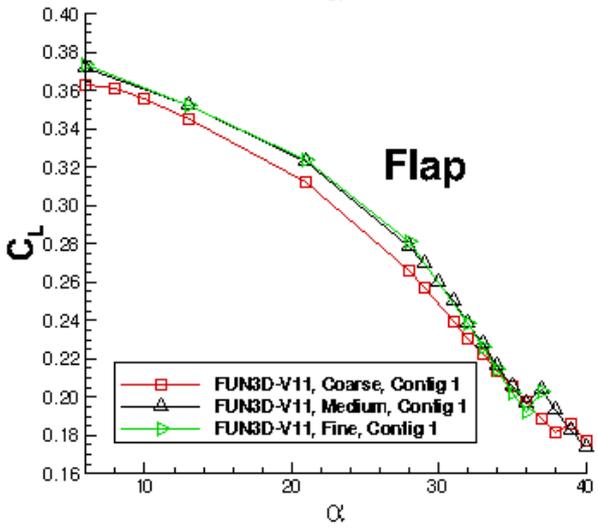
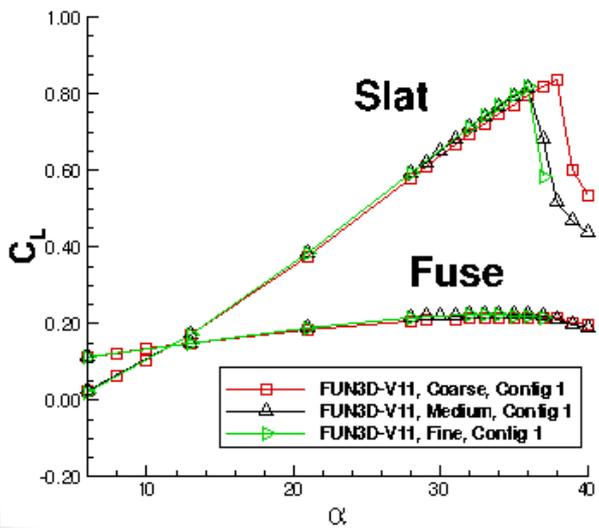
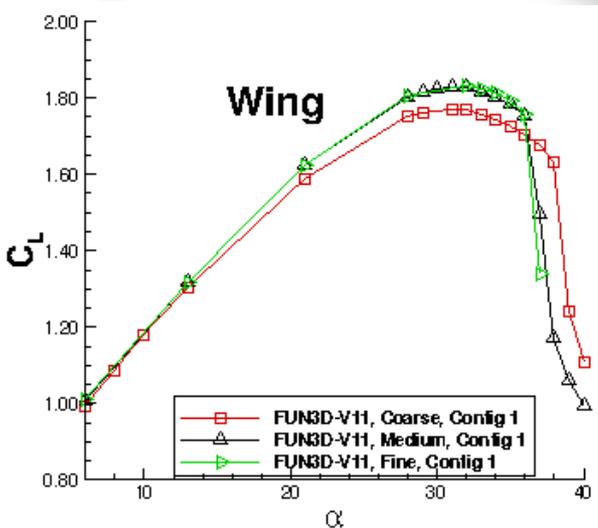
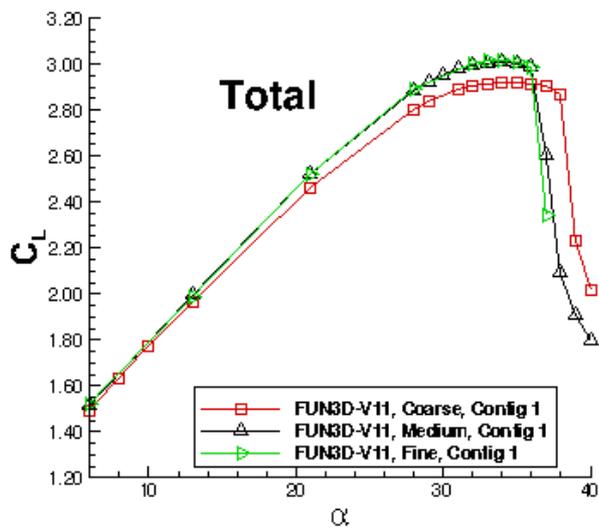
Case 1 – Grid convergence , C_D



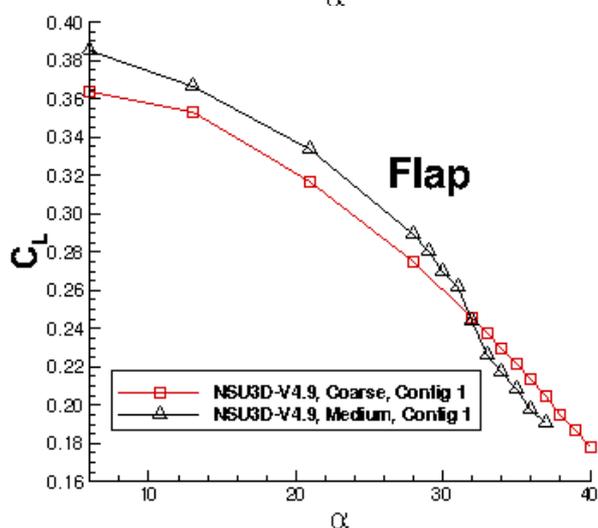
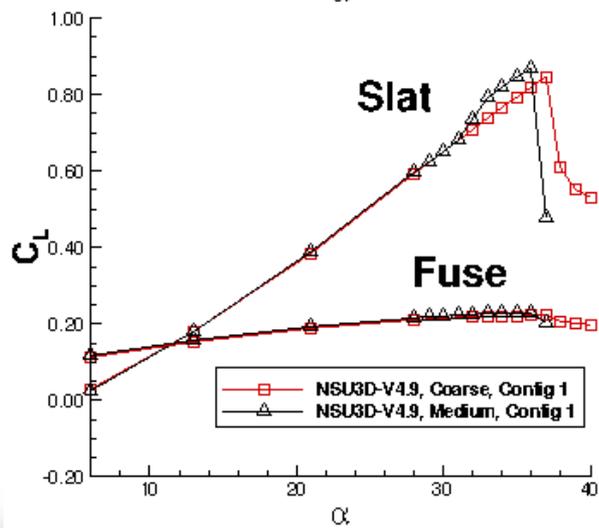
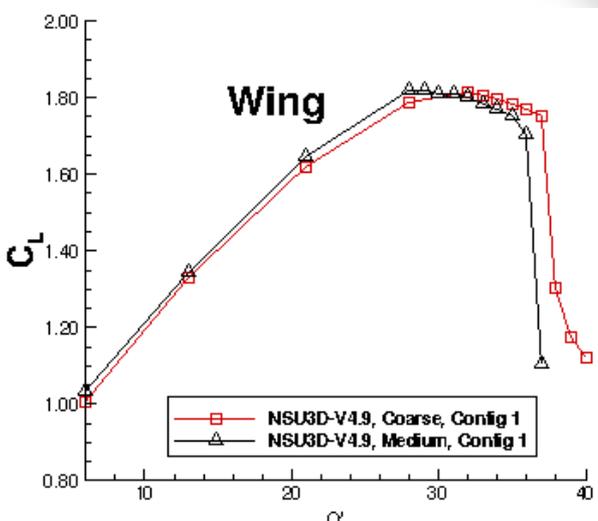
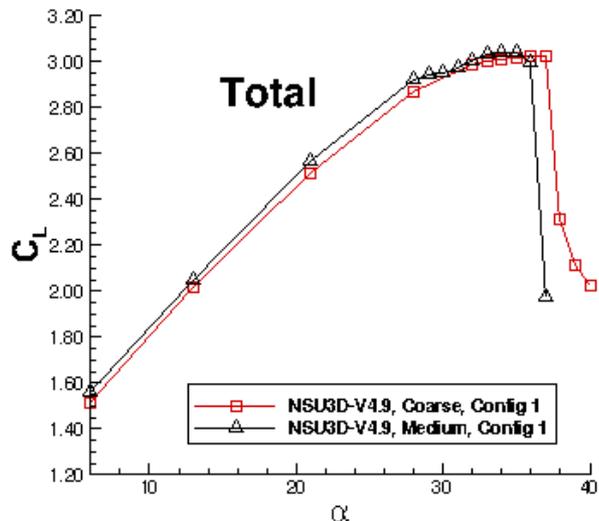
Breakdown, medium

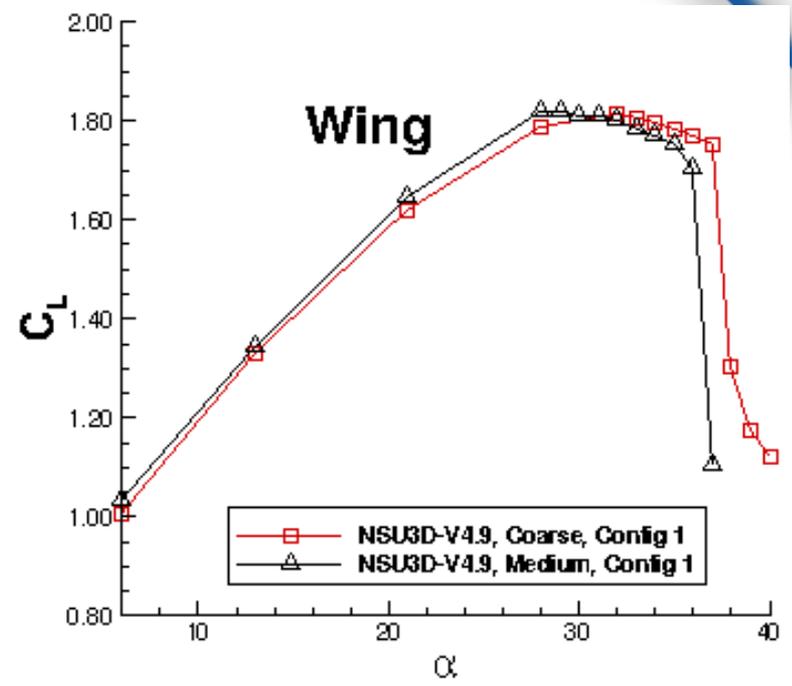
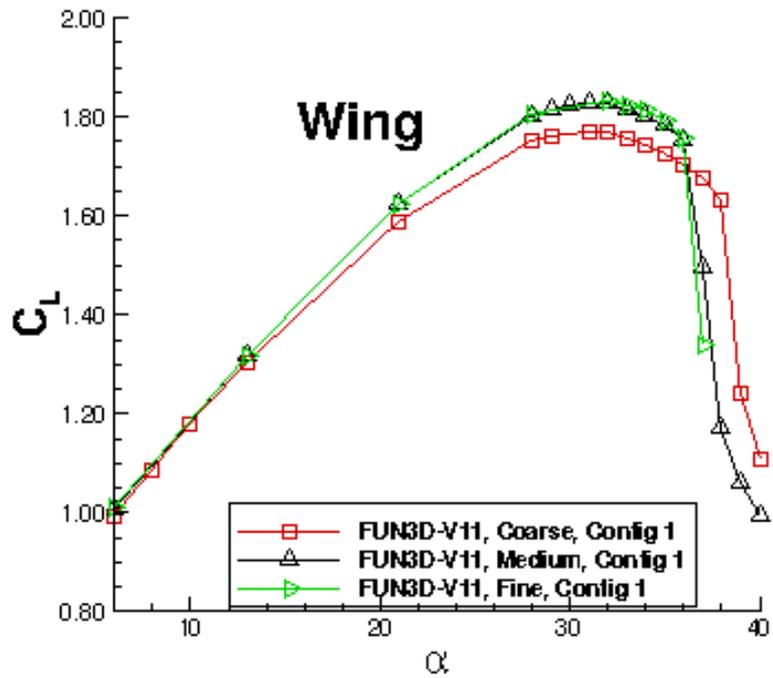


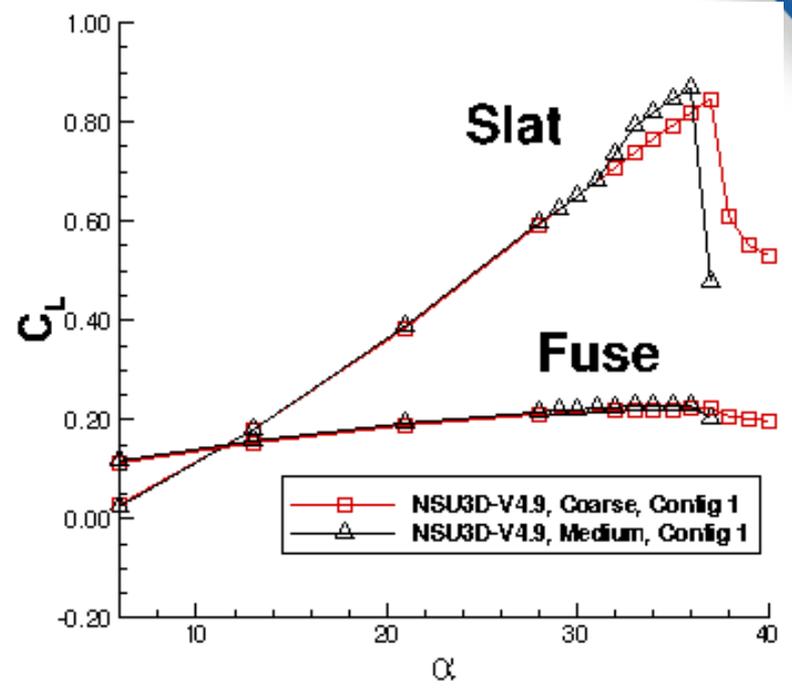
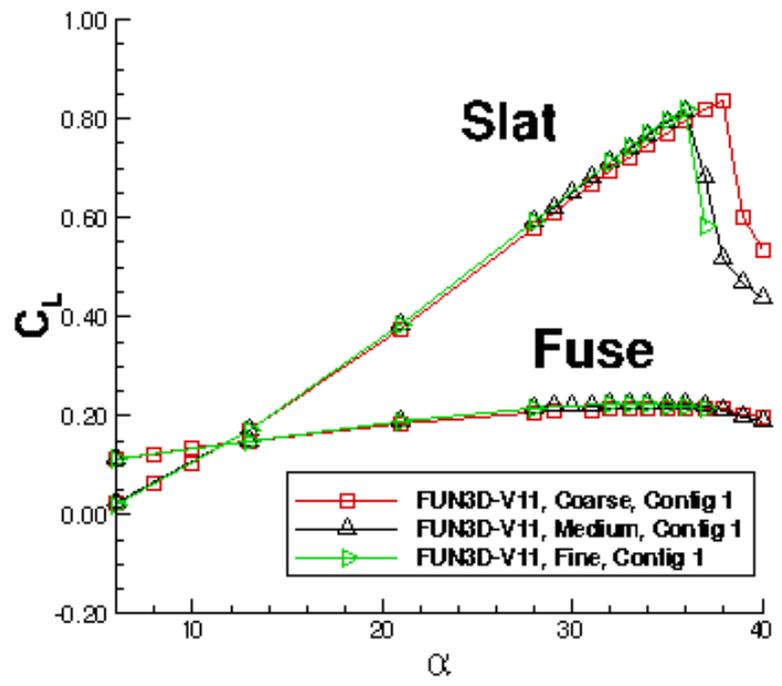
Case 1 – Component C_L , FUN3D

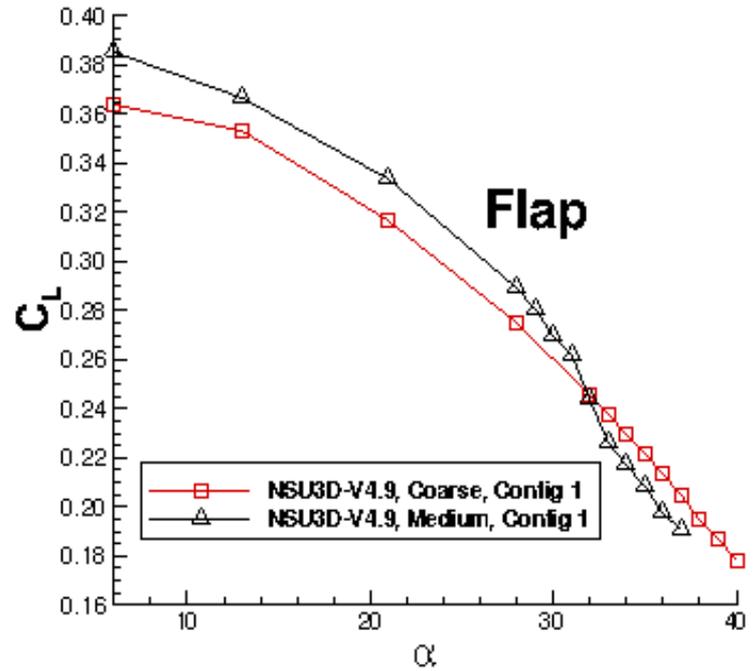
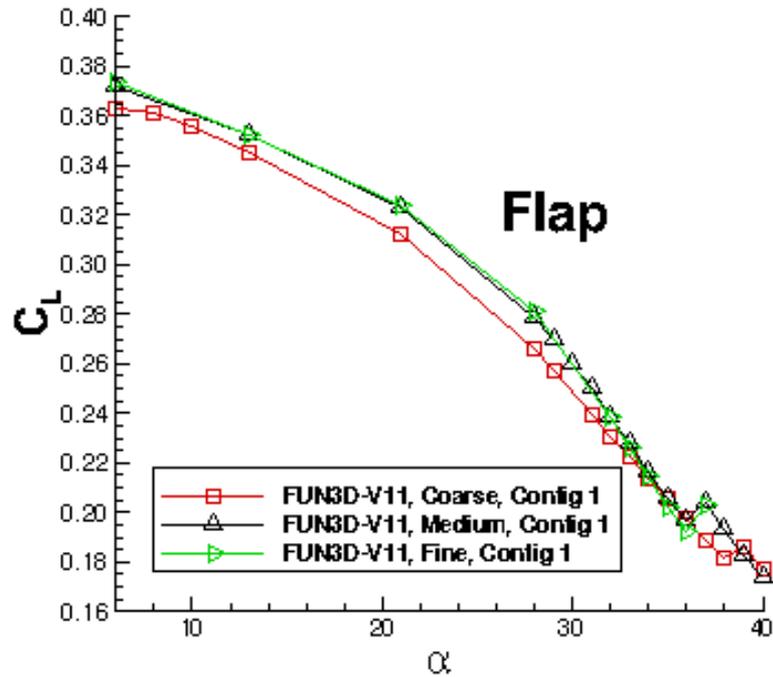


Case 1 – Component C_L , NSU3D

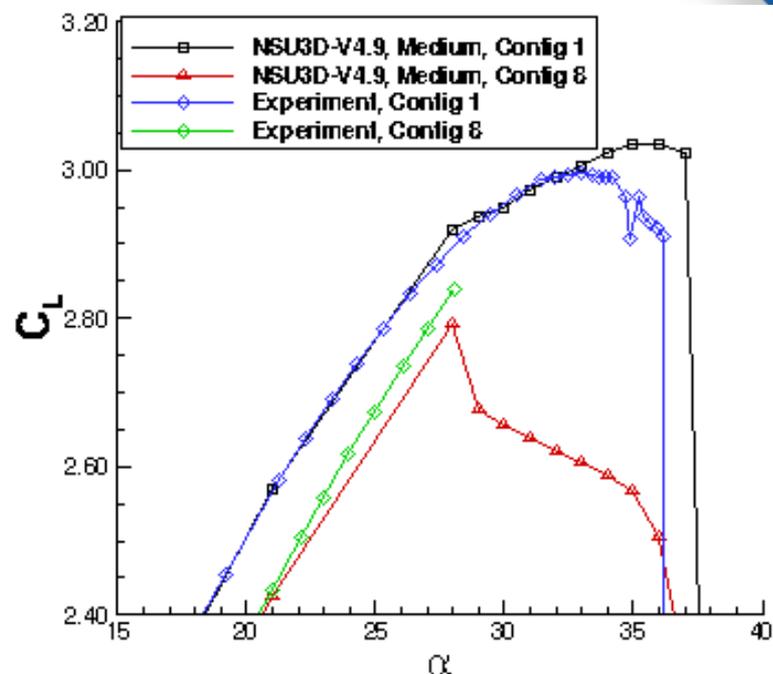
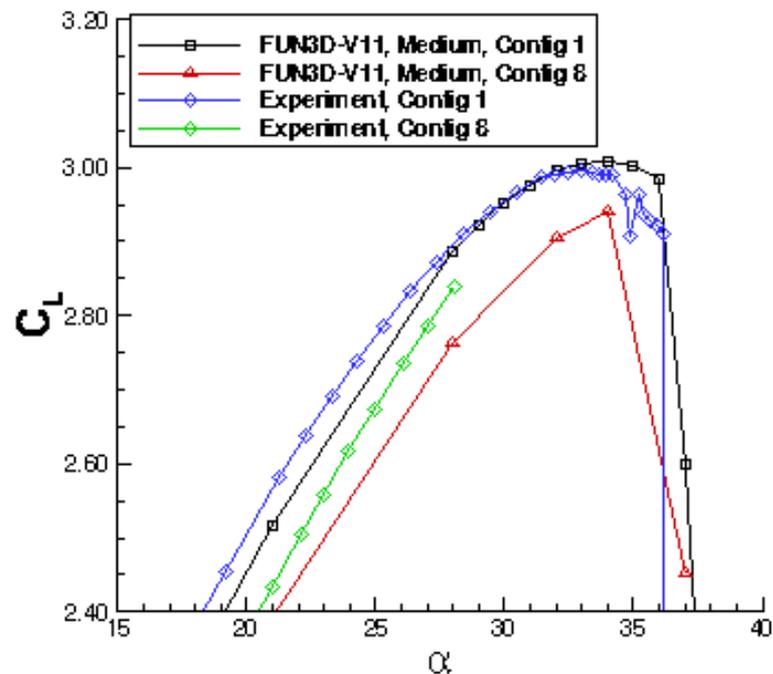








Case 2 – C_L , NSU3D



Case 2 – C_m

