Universidad de los Andes

Universidad de San Buenaventura Sede Bogotá

Contribution to the 3rd AIAA CFD High Lift Prediction Workshop (HiLiftPW-3)

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Agenda

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Team and motivation

Universidad de los Andes	Universidad de San Buenaventura
✓ 15000+ students, 7000+ in engineering ✓ 8th best university in Latin-America according to QS Ranking 2016.	✓ 2800 students in Bogotá, 15000+ in Colombia. ✓ First Aerospace Engineering program in Colombia (celebrating 20 years).

- ✓ Test our computational capabilities with world class problems.
- ✓ Build-up experience/knowledge in applied computational aerodynamics.
- ✓ Assess open-source code's capabilities to predict aerodynamic forces/moments with complex geometries.
- ✓ Continue our participation in HLPW.

Summary of cases :

Case	Alpha=8, Fully turb, grid study	Alpha=16, Fully turb, grid study
1a (full gap)	✓ Medium and coarse grids	✓ Medium and coarse grids
2a	No, will be done in the future	No, will be done in the future

Case	2D Verification study	Other
3	Yes, five unstructured grids	
Other		

Code and numerics

- CFD Solver and Discretization: SU2
  - Open source Code developed at Stanford University (Aerospace Design Lab).
  - Coupled solver for the compressible NS equations.
  - Finite volume discretization – Vertex based scheme.
  - Parallel implementation with MPI
- Turbulence Model:
  - RANS Spalart-Allmaras (SA-noft2).
  - One equation model for the modified eddy viscosity.
  - Specially designed for aerospace applications (external flow).

SU2
The Open-Source CFD Code

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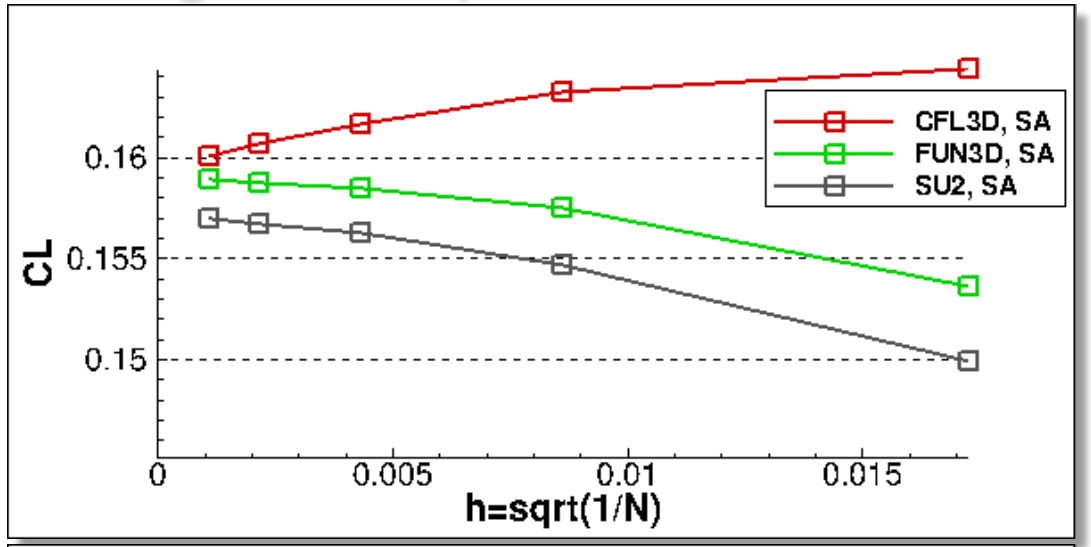
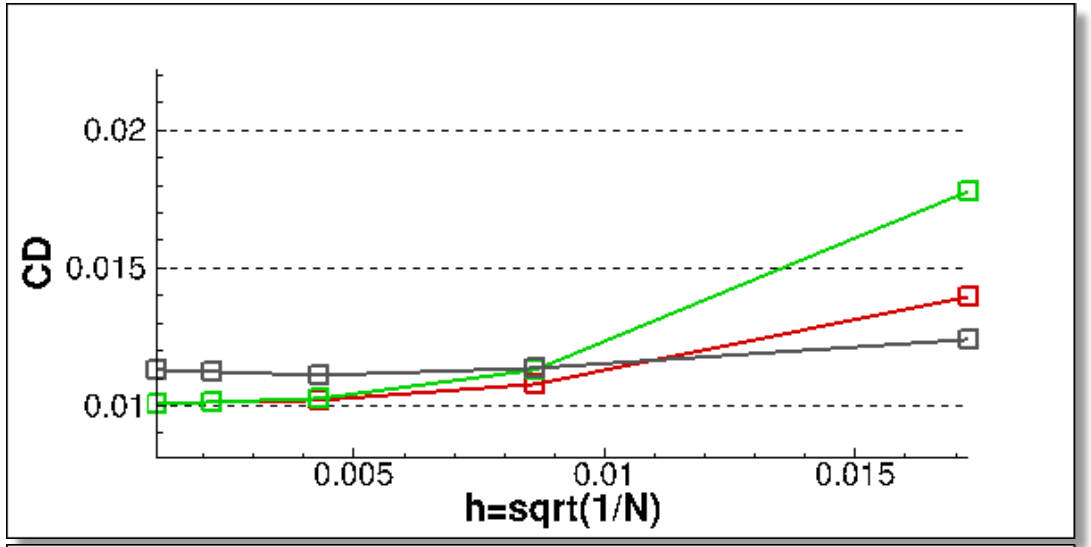
Paper AIAA 2013-0287

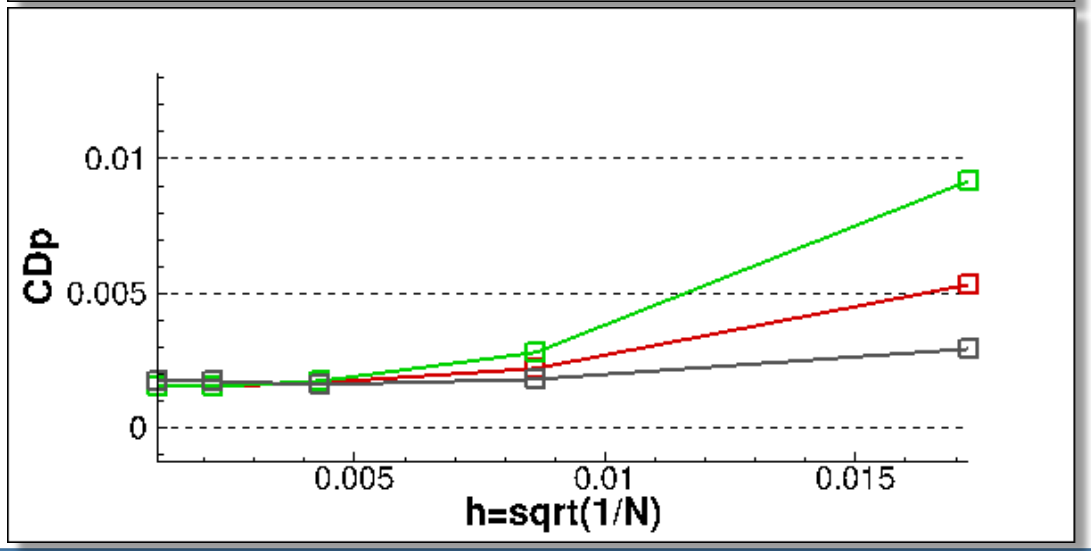
Solution strategy:

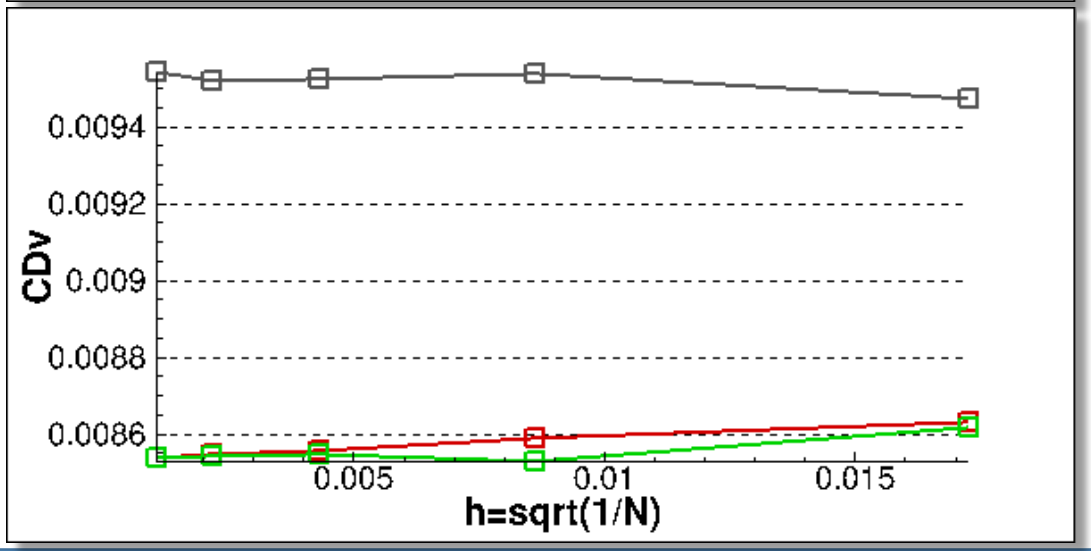
- ✓ Gradients: Green-Gauss method.
- ✓ Convective numerical method: ROE
- ✓ Convective fluxes discretization: Second order accurate in space with gradient limitation (MUSCL).
- ✓ Viscous fluxes discretization: second order
- ✓ Time discretization: implicit Euler Scheme.
- ✓ CFL for the local-time-stepping was set to adaptive, with a maximum value of 10.0 and a minimum value of 1.0.
- ✓ Method for the linear solver: FGMRES – Krylov subspace.
- ✓ Preconditioner: LU-SGS
- ✓ Low Mach number preconditioner: Roe-Turkel
- ✓ Convergence acceleration: 2 levels of multigrid (V-Cycle). Convergence was difficult using multigrid for the medium and fine meshes.
- ✓ BC: Wall (wing, slat, flaps and fuselage), Symmetry and Farfield.

Grid convergence study







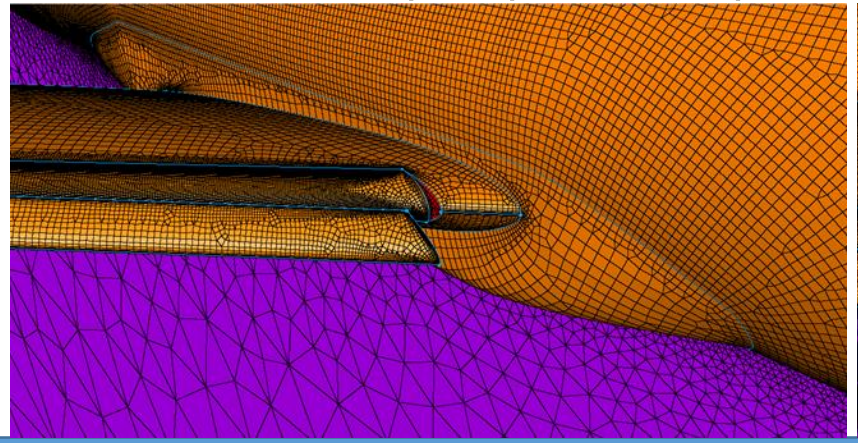
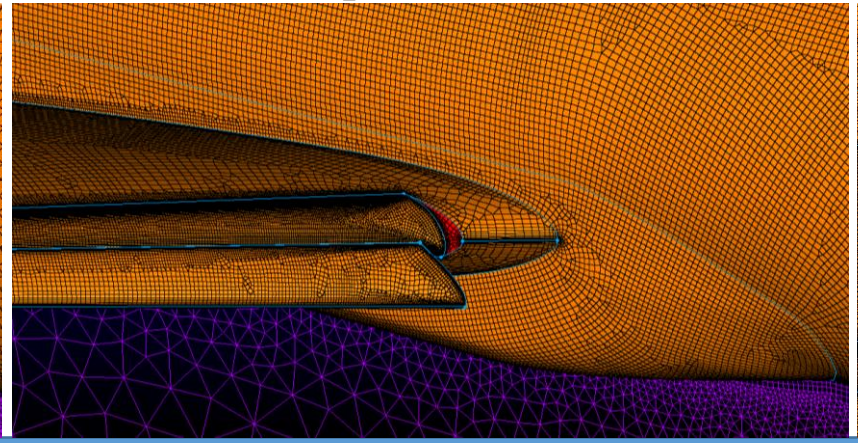
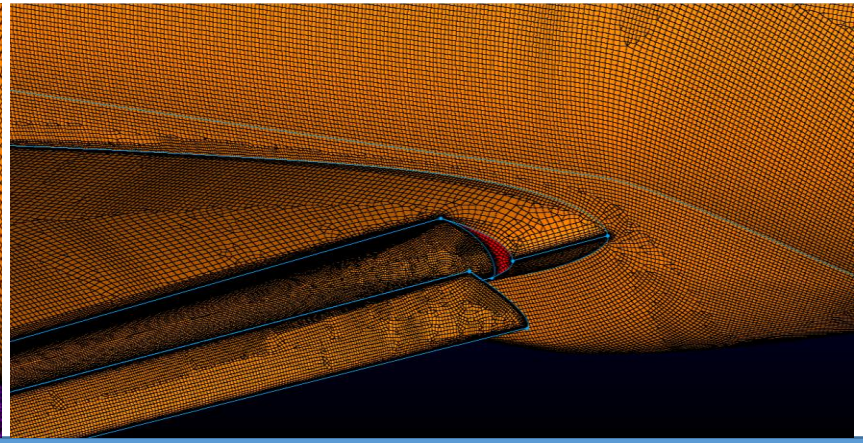


HLC – CRM Grids

- ✓ Grid reference: Committee Grid- B3-UnstrHexPrimsPyrTet_PW

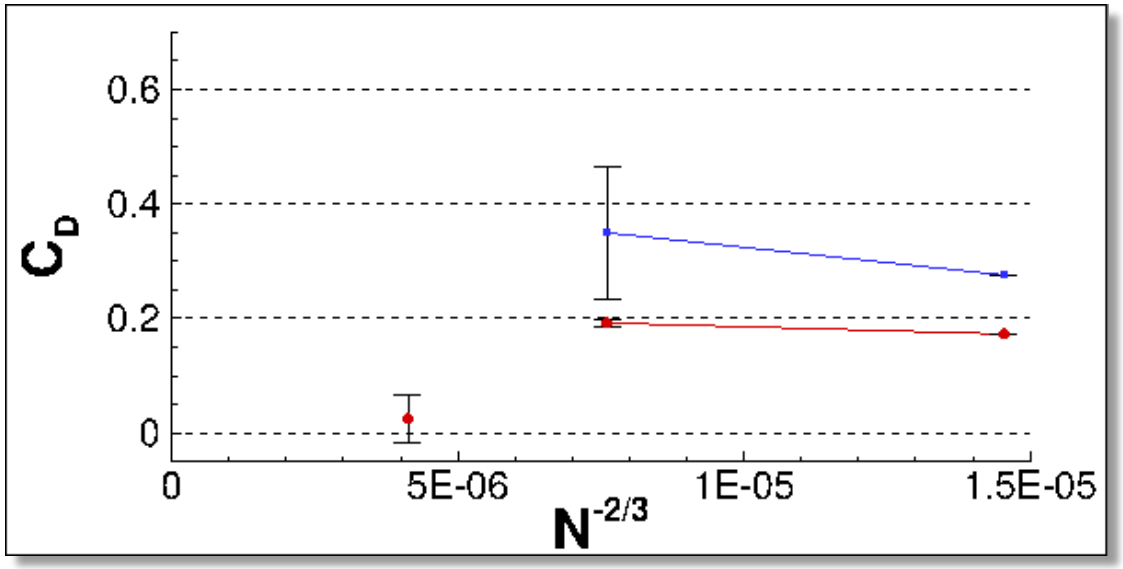
  Coarse : 18,011,980 Cells Medium: 47,557,044 Cells Fine: 118,774,267 Cells
- ✓ Pointwise to convert grids into SU2.
- ✓ Process to export
  - Scale to meters, Committee grids were submitted in inches.
  - Scale using as point of reference [0 0 0].
  - Group surfaces into the corresponding boundary conditions.

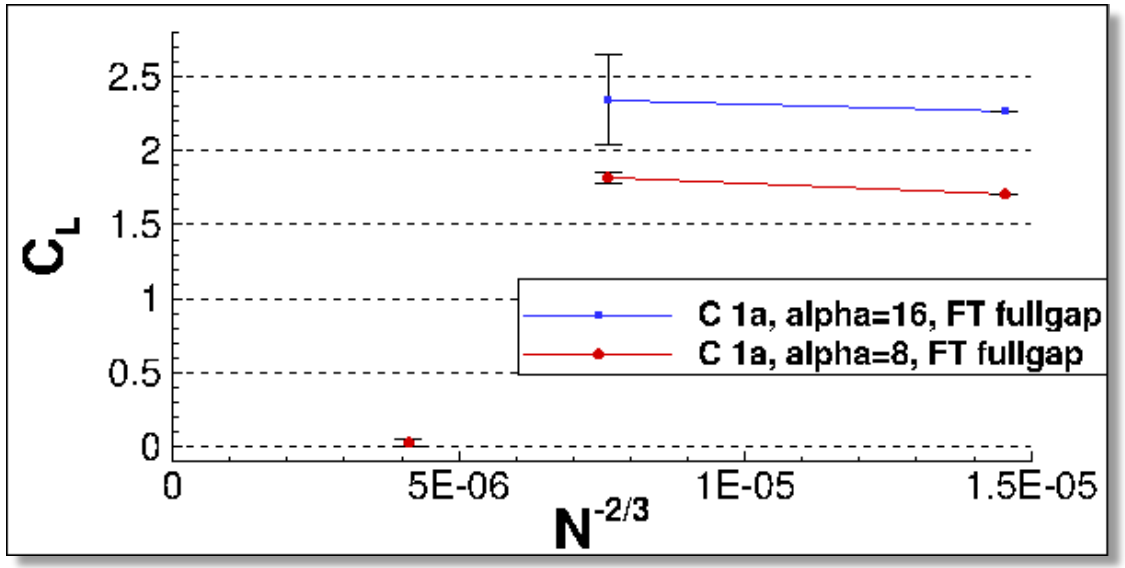
    Fuselage, Wing, Slat, Inboard Flap, Outboard Flap, Symmetry, Inflow, Outflow, Farfield
  - Basic quality check (aspect ratio and max. angle)

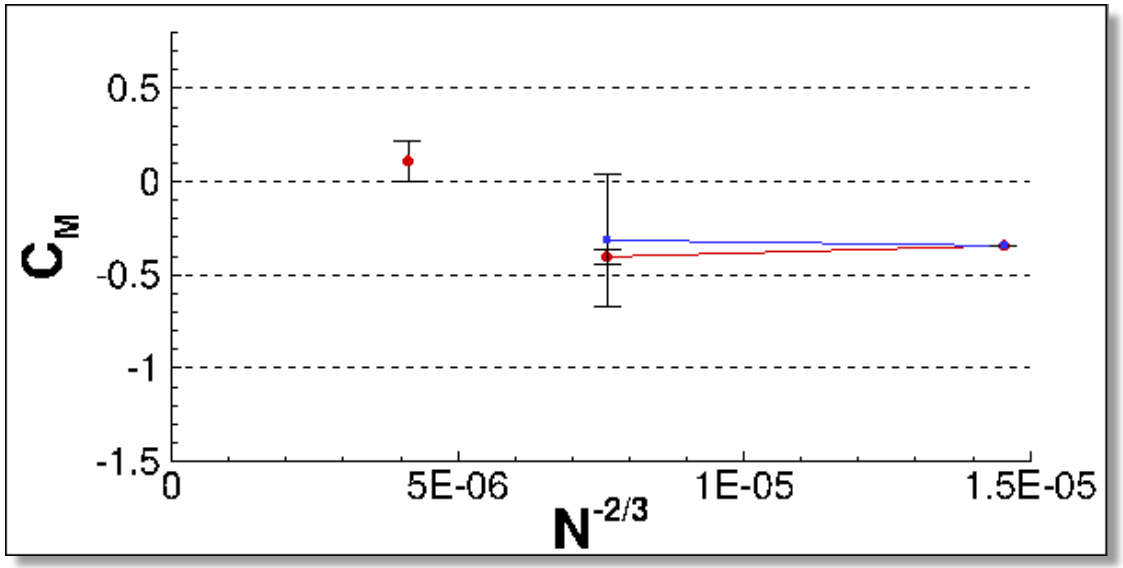




Grid convergence study

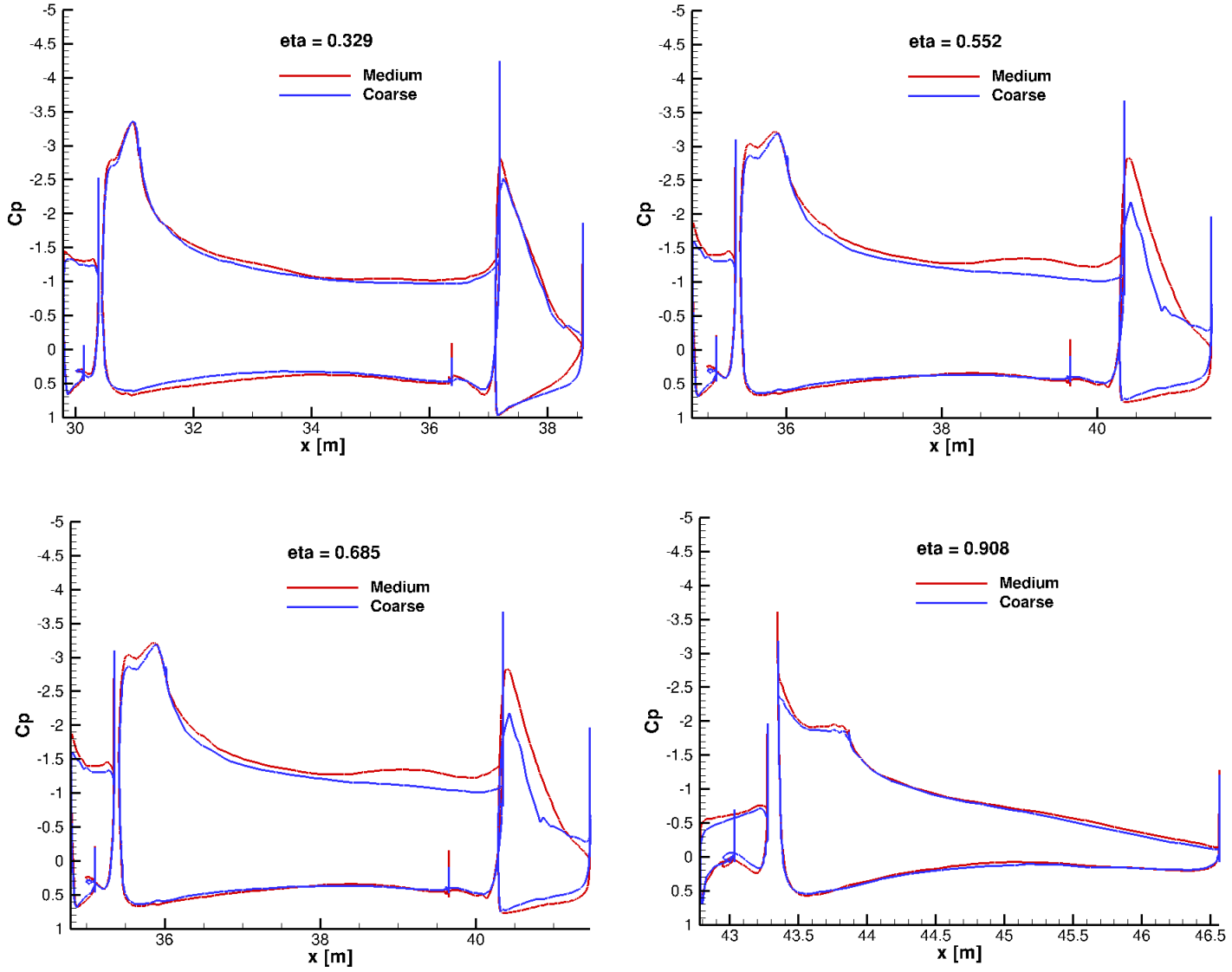
Mach :	0.2
Re_c (c=7.00532m) :	3,260,000
T_{ref} :	288.15 K
Viscosity :	Sutherland
Turbulence model.:	Spalart-Allmaras
Turbulent inflow BC:	$\hat{\nu}_{farfield} = 3\nu_\infty$
Prandtl number :	0.72



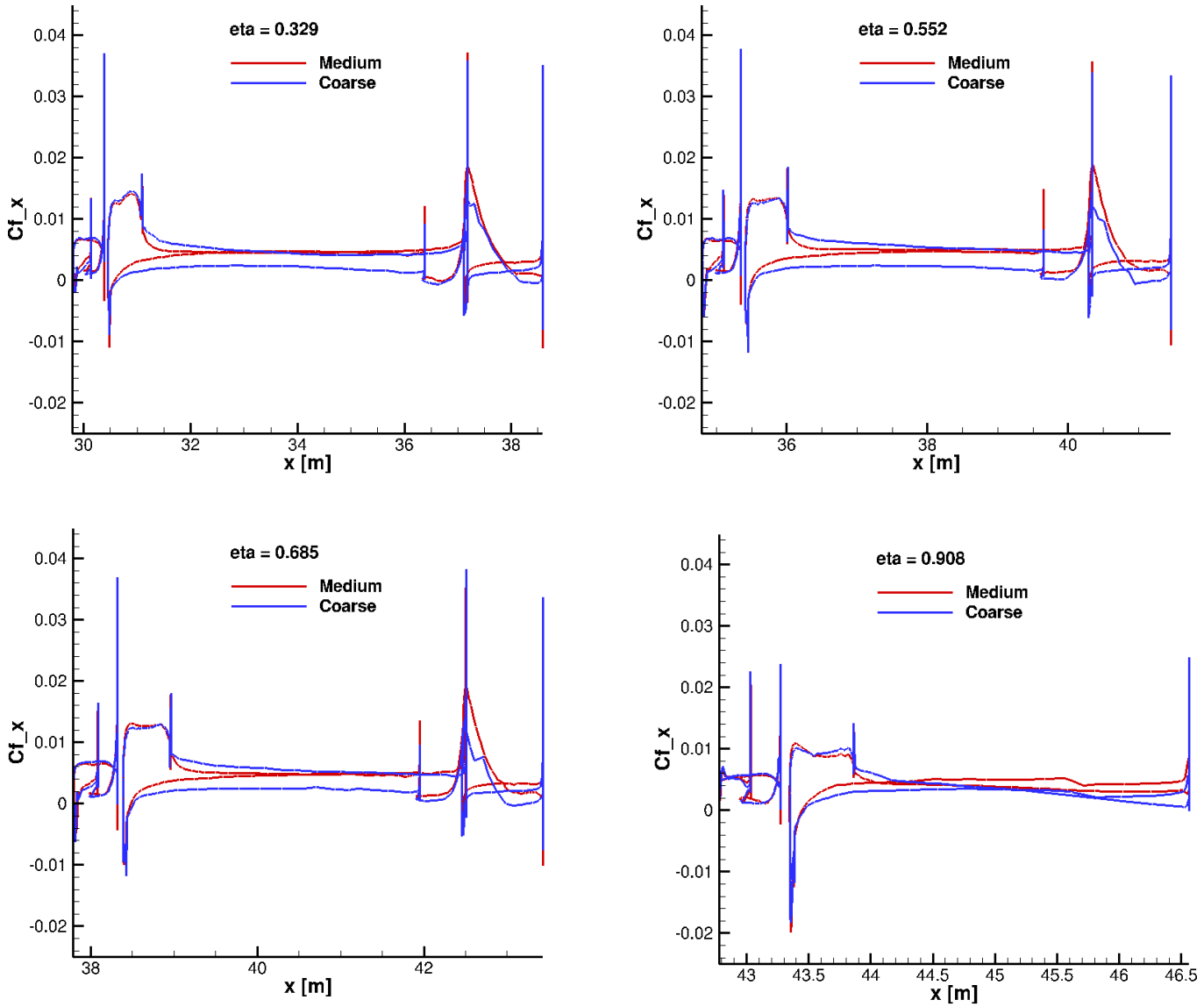




Cp distribution
α=8º



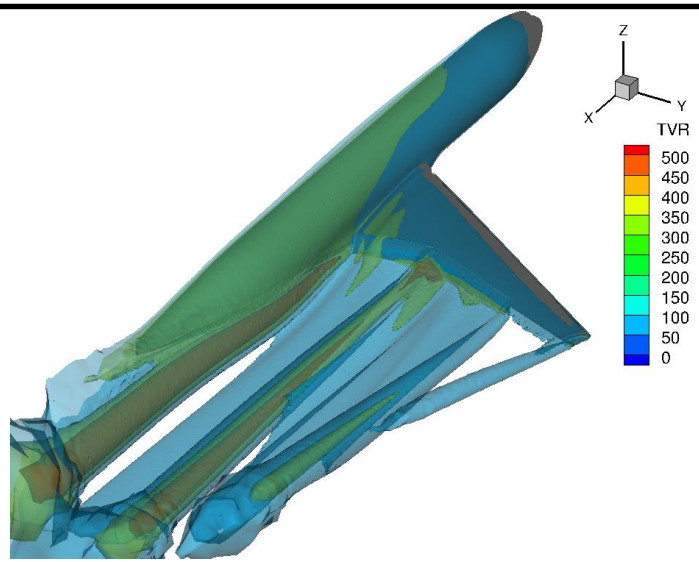
Cfx distribution
α=8º

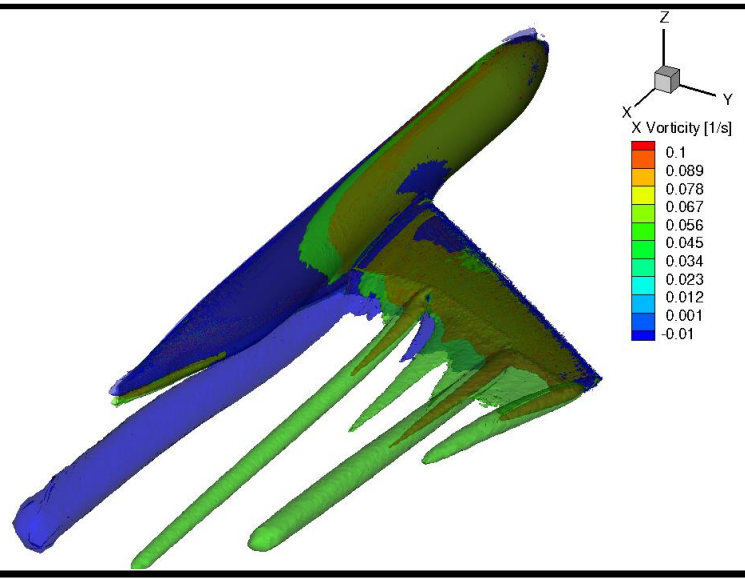


HLC- CRM Results

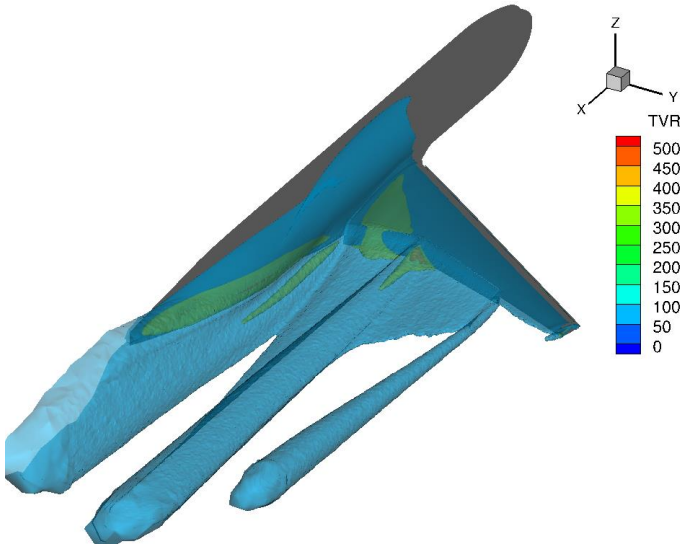
Surfaces of constant TVR

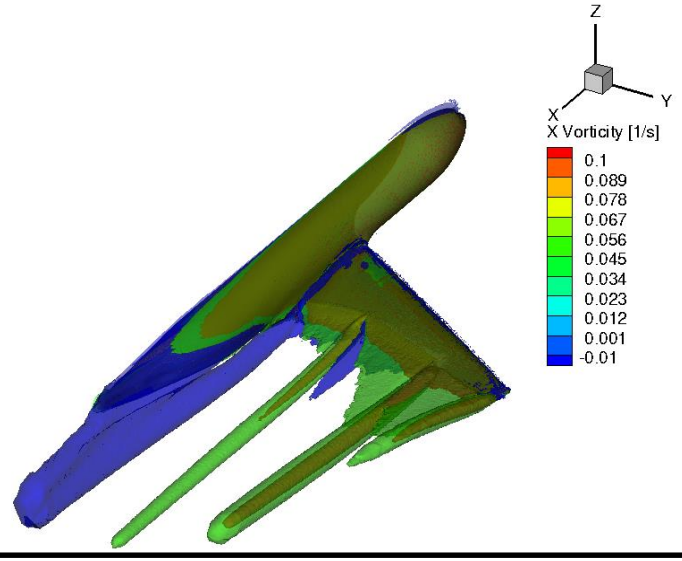
Grid: Coarse
Alpha: 8º





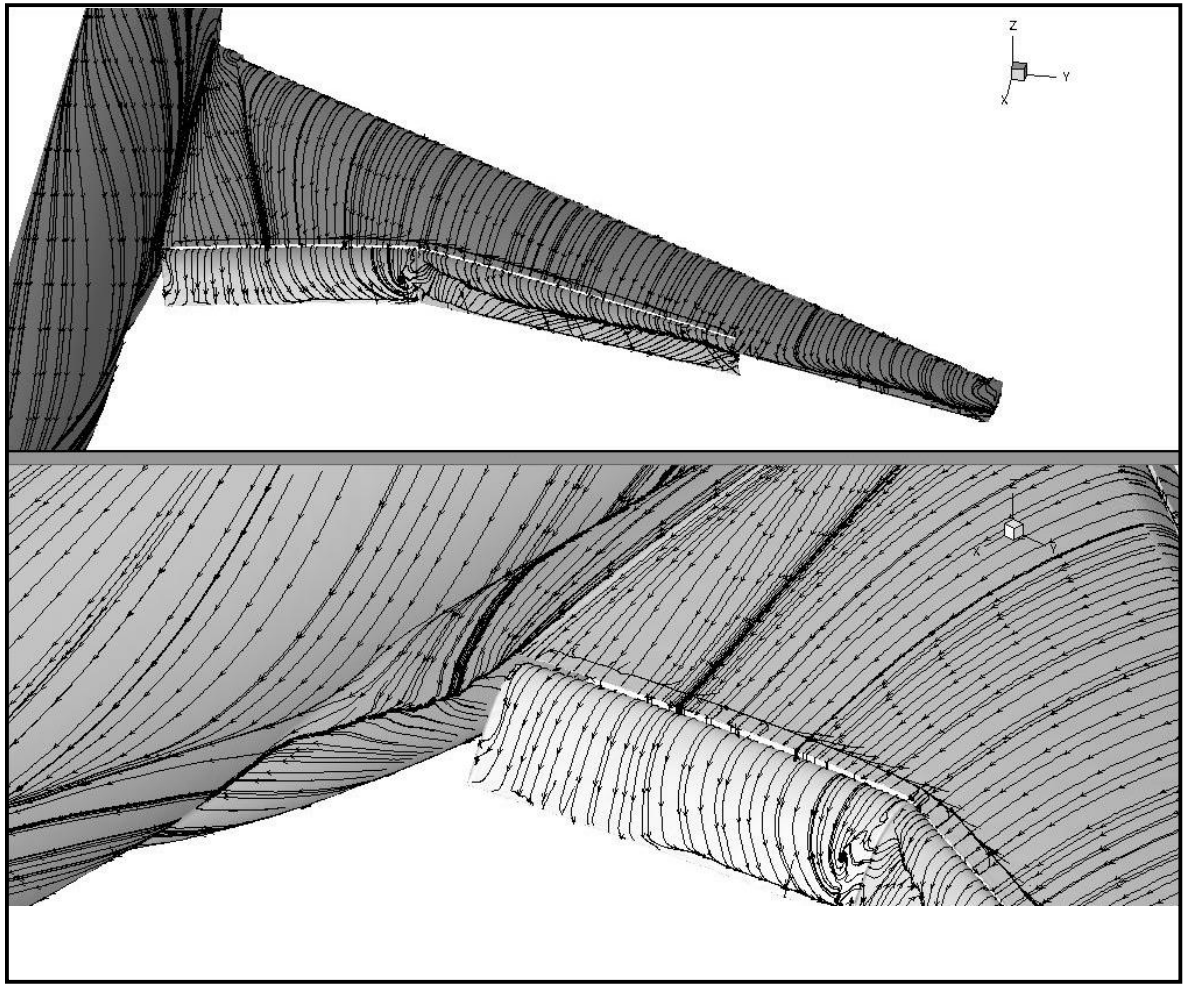
Grid: Medium
Alpha: 8º



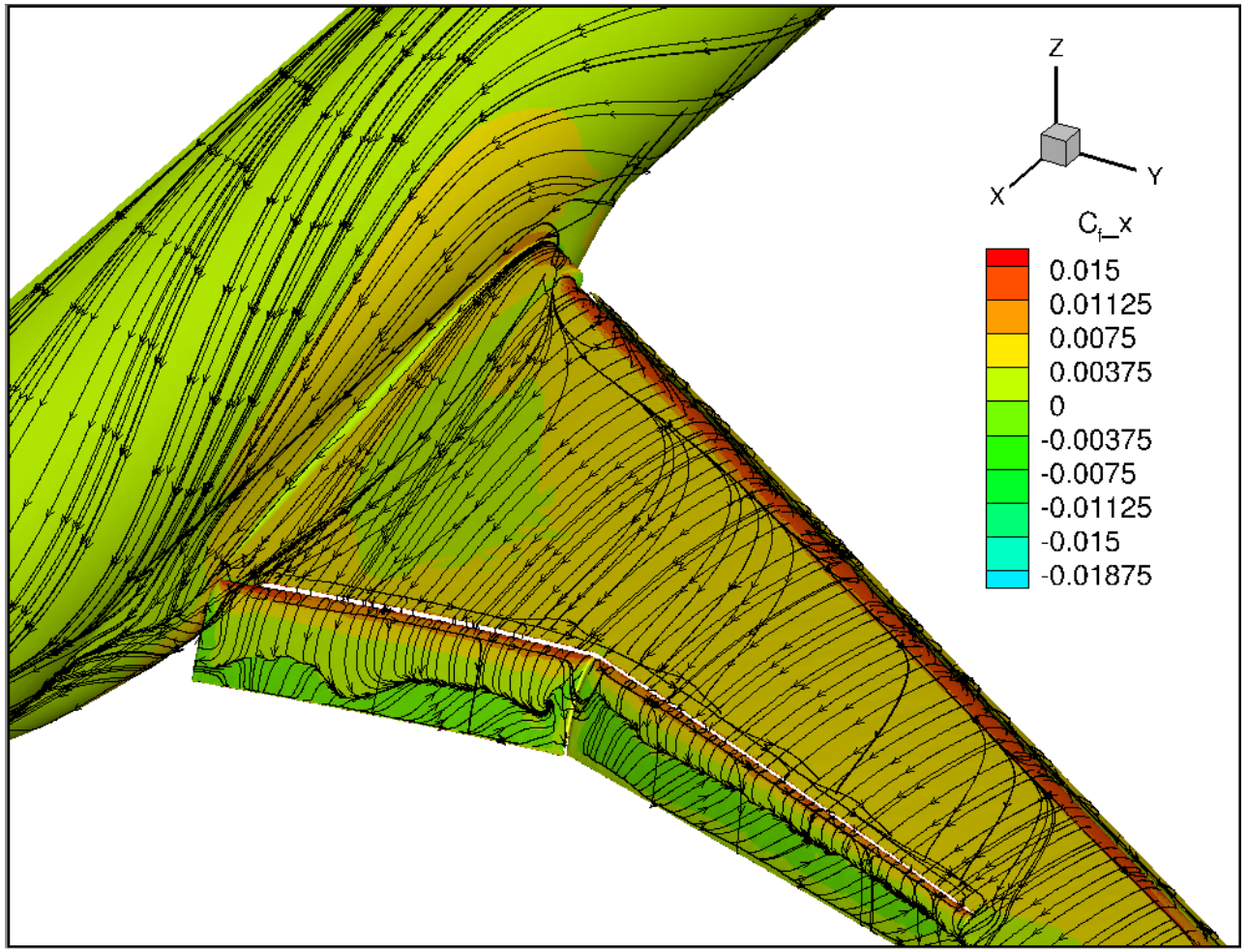


HLC– CRM Results

Streamlines – Coarse grid, alpha = 16º



alpha = 8º



5 Summary

- ✓Cases 1A and 3 were partially and fully run with SU2. Case 1A is not completely converged and still running simulations.
- ✓The conversion of meshes from PW to SU2 native format was a very easy process and alleviate the problem and time associate with mesh conversion.
- ✓Convergence acceleration was not successful is SU2 for Case 1A. This implies a very slow rate of convergence and "high" computational cost.
- ✓Some features of the flow were observed despite of the lack of convergence.
- ✓Work is currently on progress. Tuning of SU2 in our available computational resources.

6 Acknowledgments

- ✓HPC center at Universidad de los Andes.
- ✓Lab Unit at USB.
- ✓Sabalcore.

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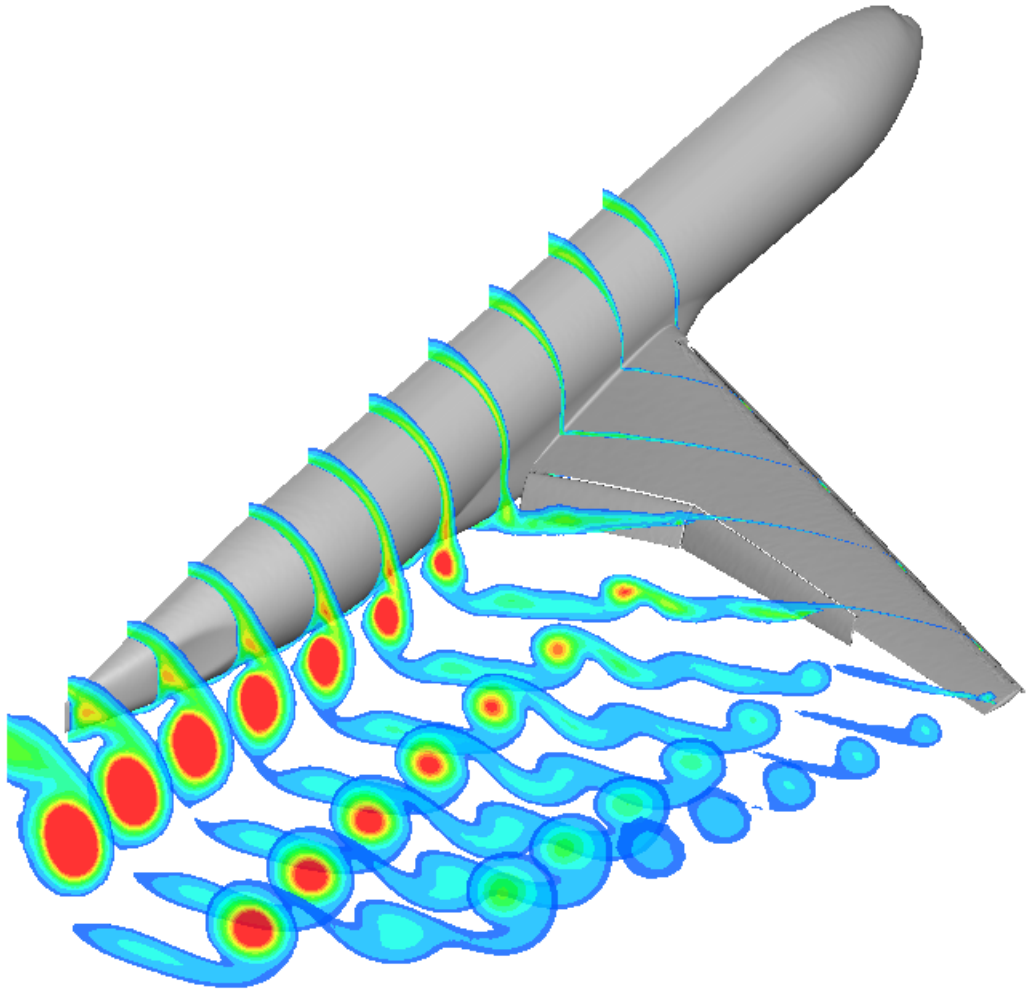
Thank you



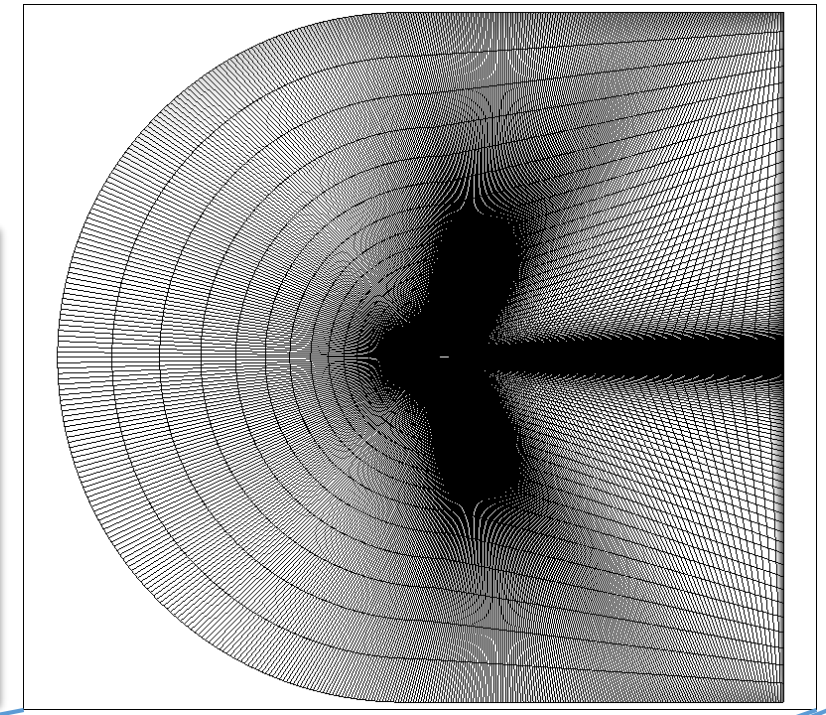
Back up slides

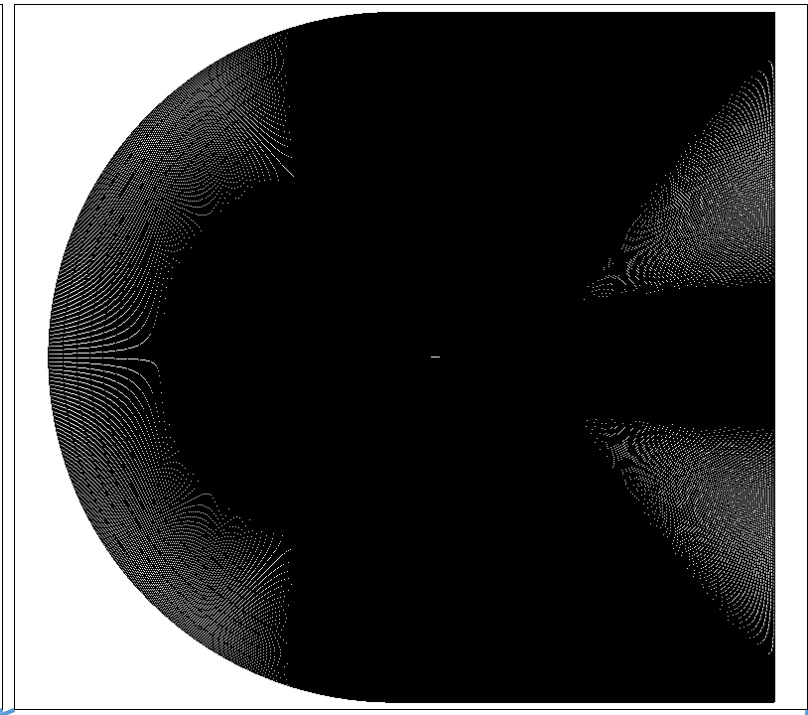
Verification Study Results

Grid convergence study

Nakayama Model-A airfoil

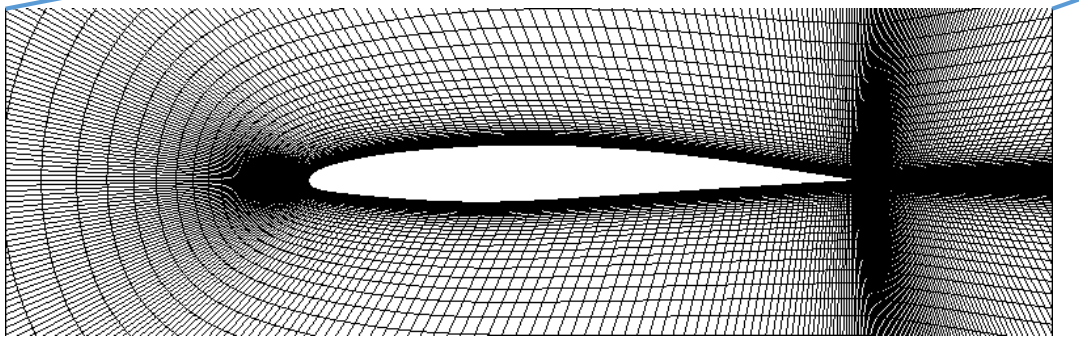
Malla	Nodos	Elementos
1	2 x 2,241 x 385	860,160
2	2 x 1121 x 193	215,040
3	2 x 561 x 97	53,760
4	2 x 281 x 49	13,440
5	2 x 141 x 25	3,360

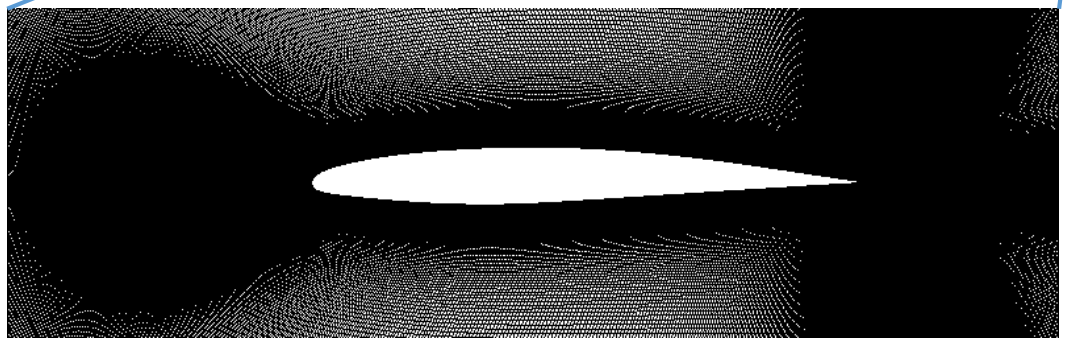




2 x 561 x 193

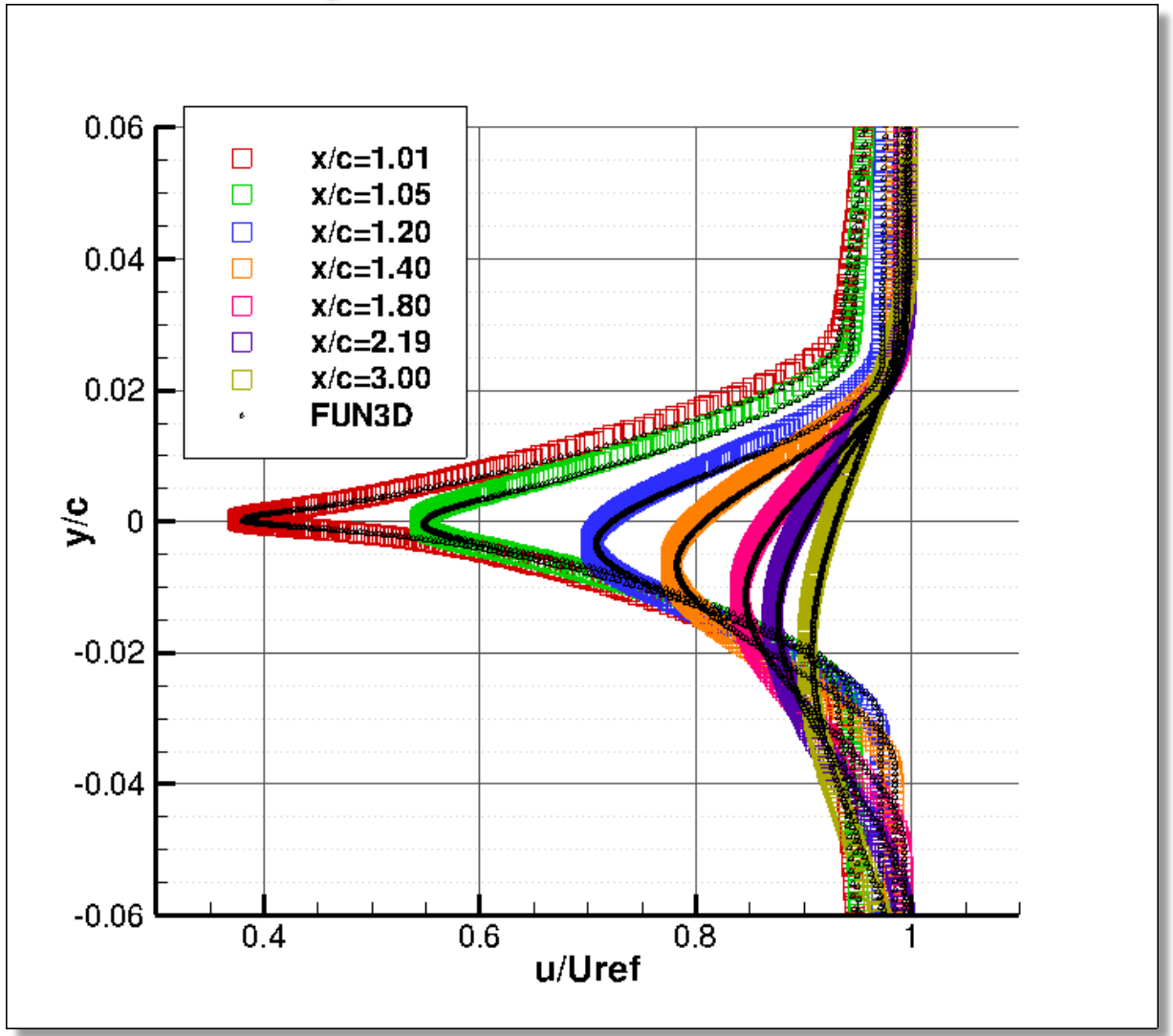
2 x 2,241 x 385

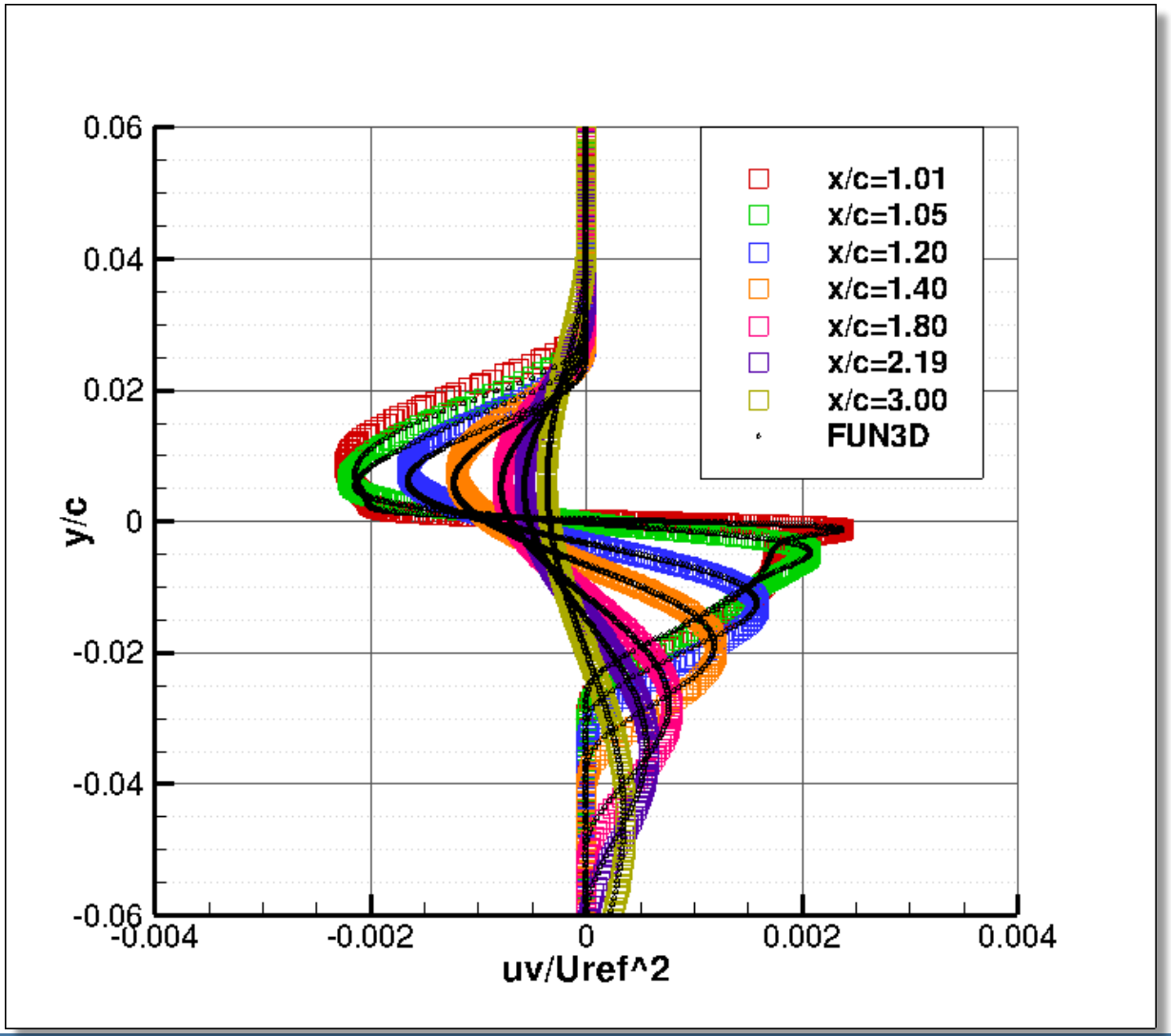




Verification Study Results (Cont'd)

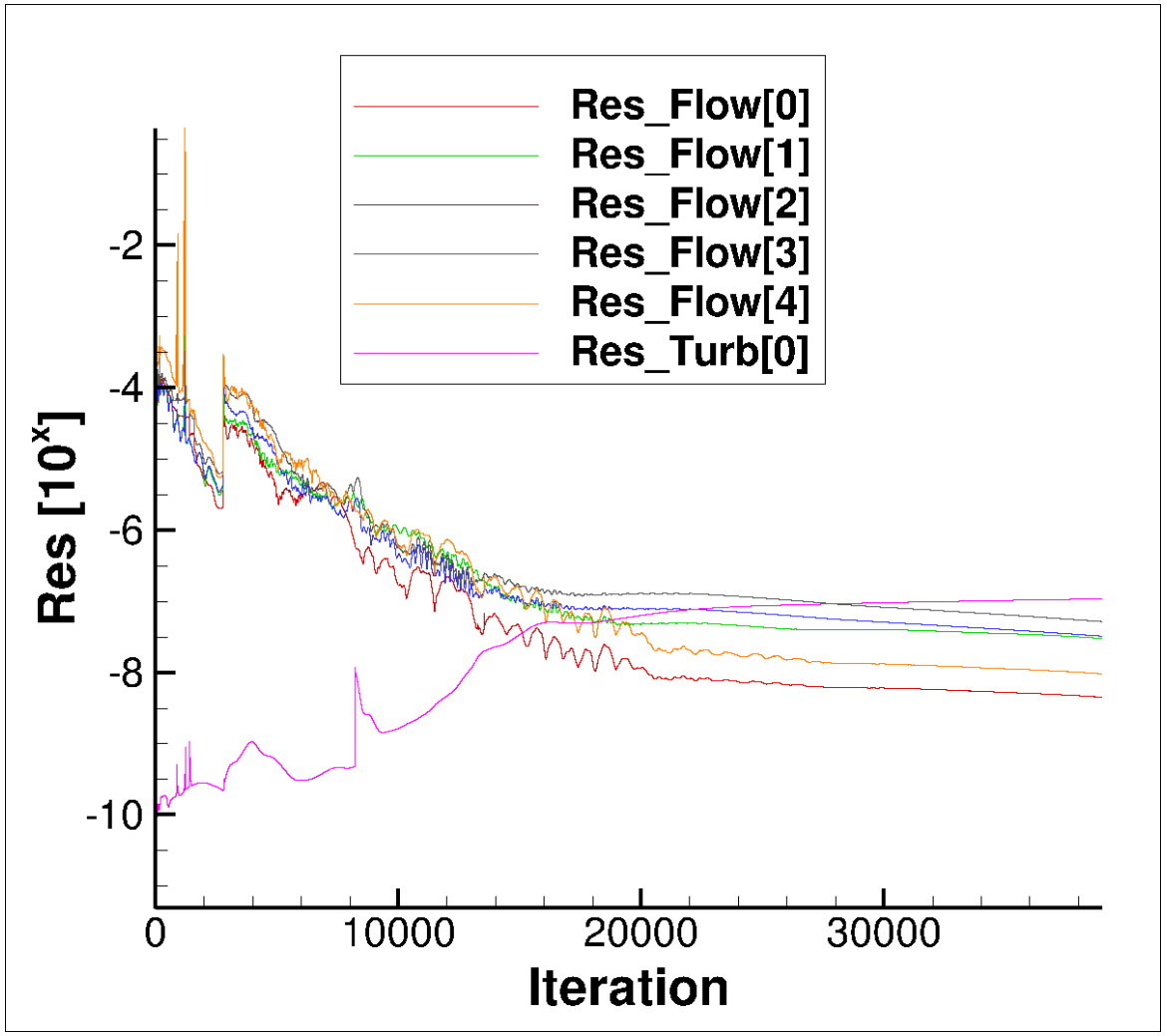
Wake survey

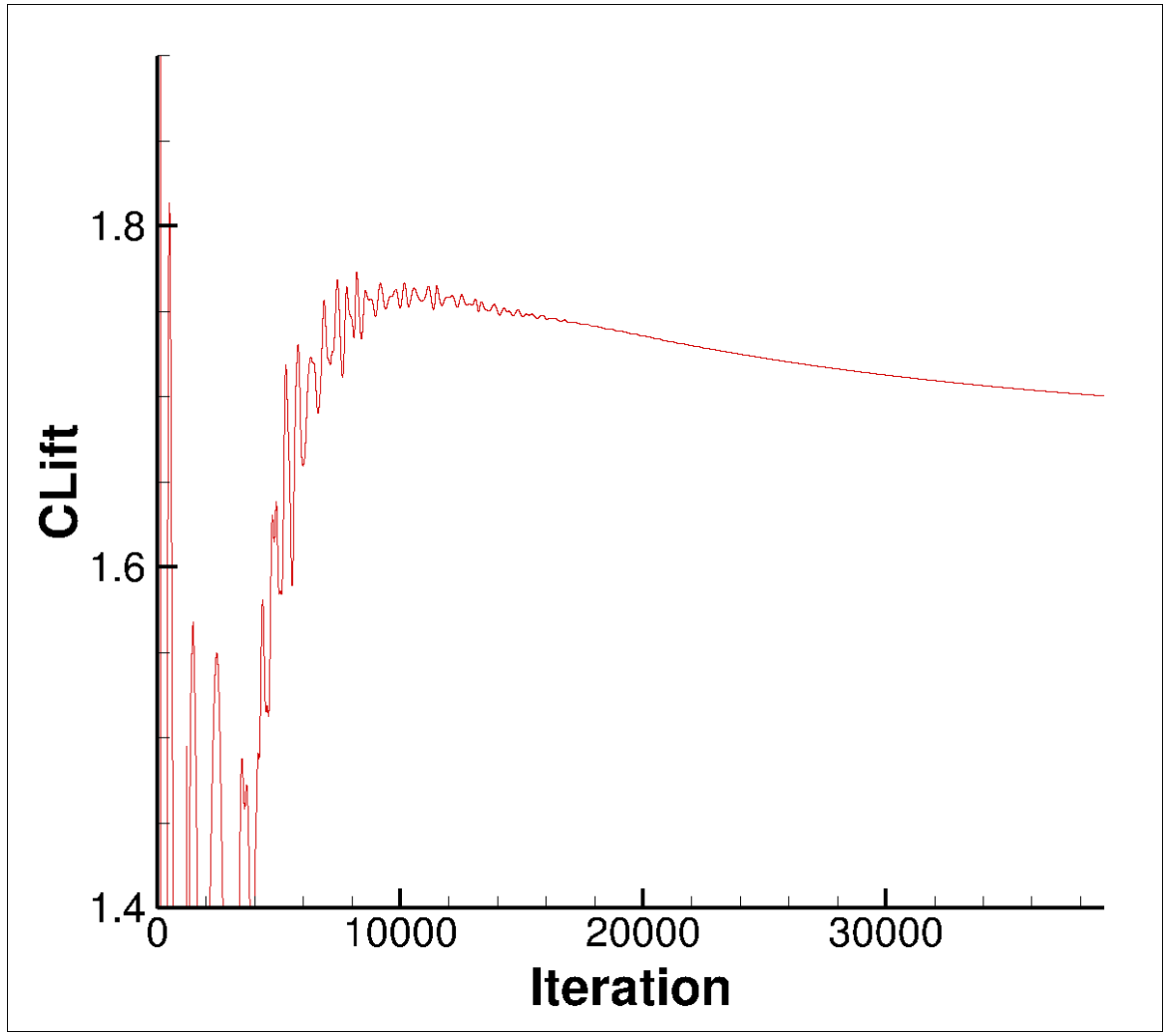




Convergence

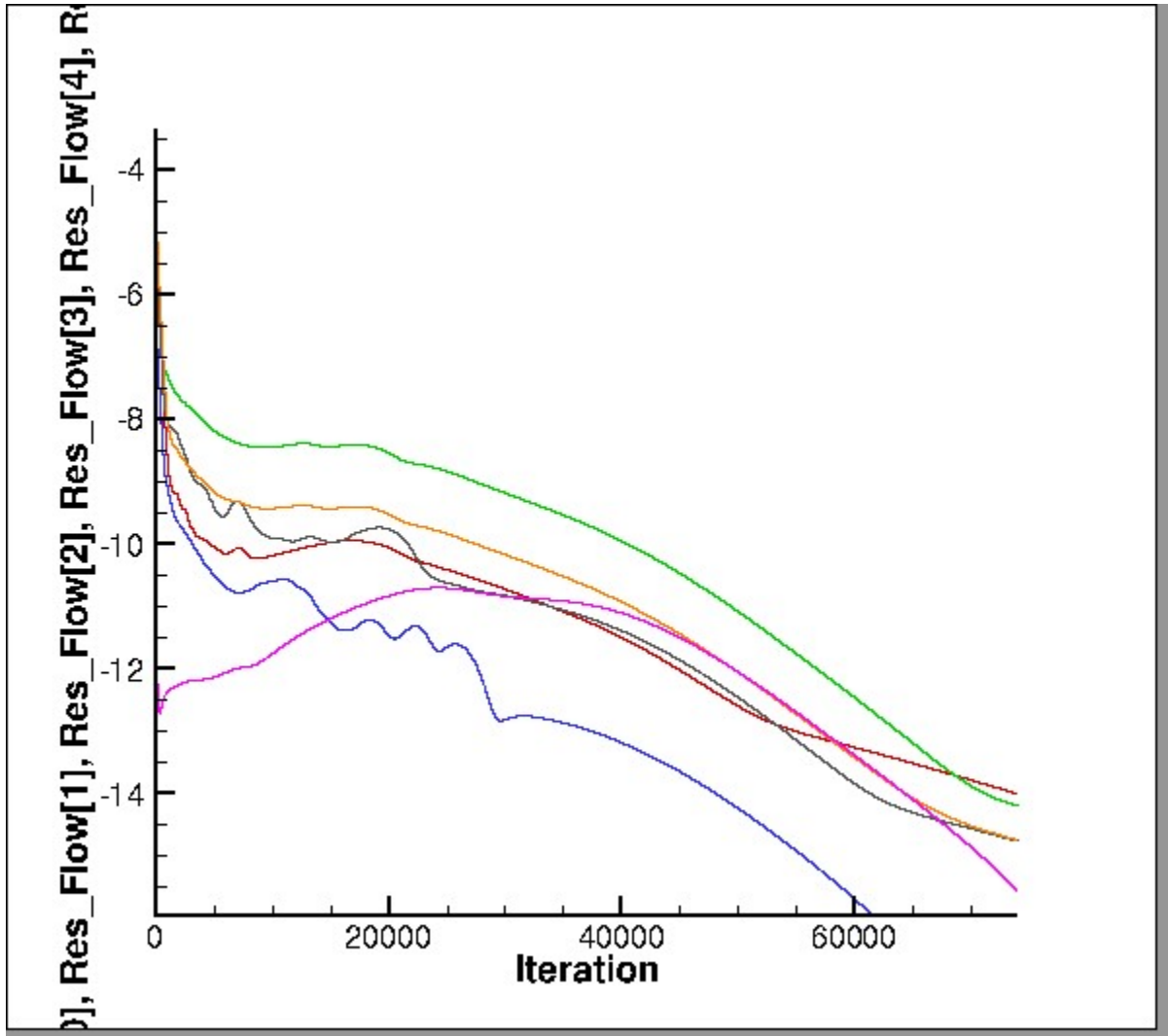
HL-CRM

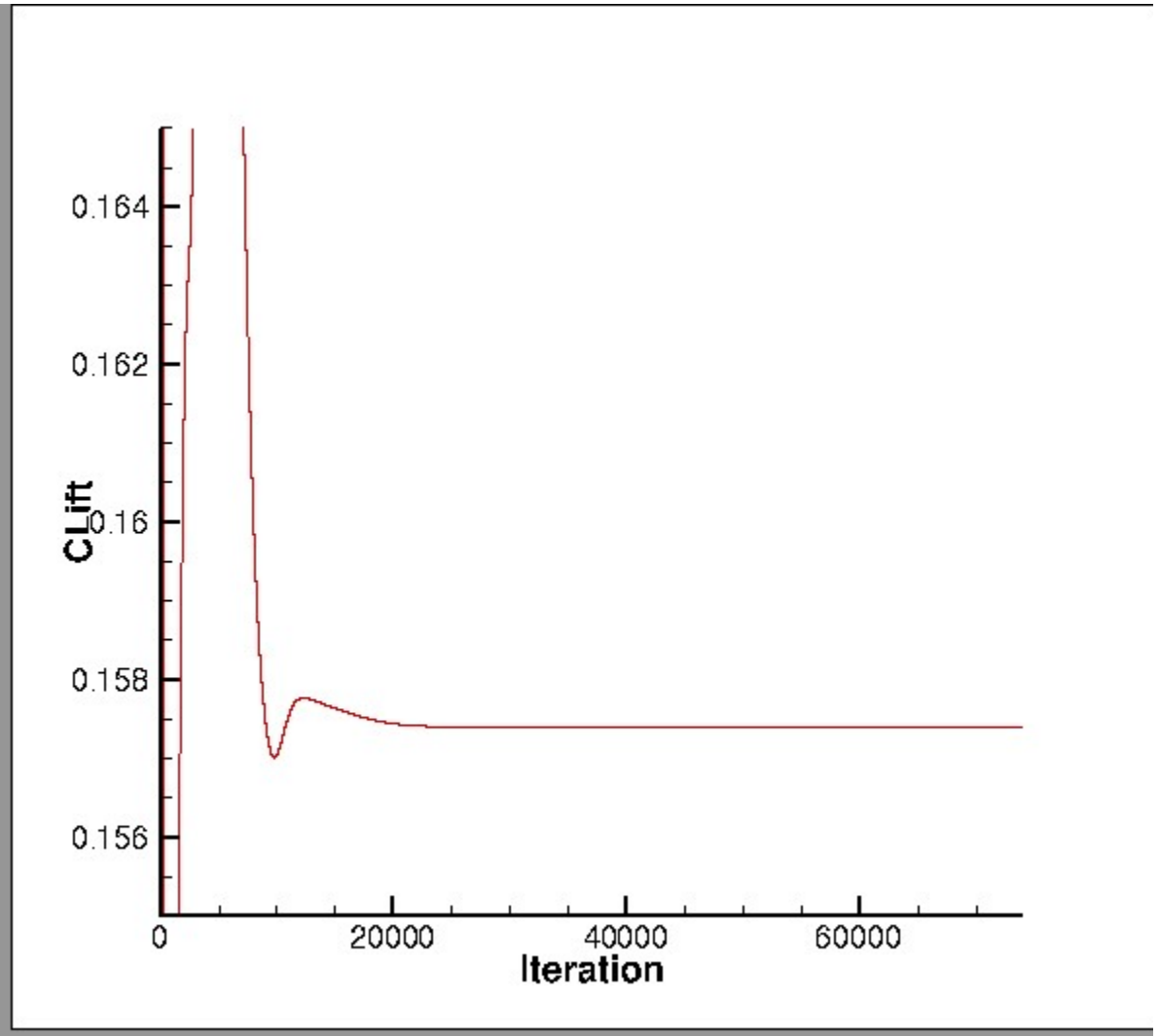




Convergence

Verification case





Computational resources

Universidad de Los Andes	Case 1a	Description
		17 HP blade servers ProLiant BL460c Gen8. 192 GB RAM, two Intel(R) Xeon(R) CPU E5-2695 v2 @ 2.40GHz (12 Cores) processors, 4 HD 279 GB in RAID 1 , Infiniband network architecture (40gbps).

Universidad de San Buenaventura	Case 3	Dell Precision T5610 running Ubuntu 15, with an Intel® Xeon® E5-2600v2, 36 GB of RAM
	Case 1a	Dell Precision R5500 running Rocks 6.2., with a Dual Intel Xeon X5675, 3.06 GH z, 12M Cache, 6.40 GT/s Intel QPI, and 96GB DDR3 ECC RDIMM

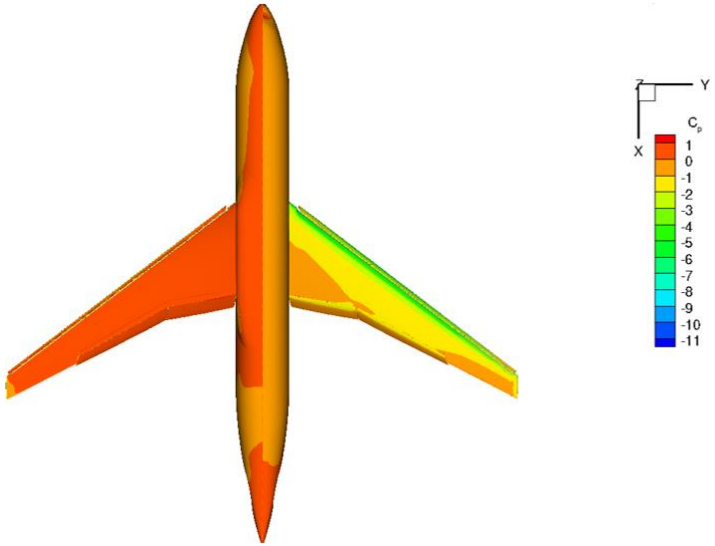
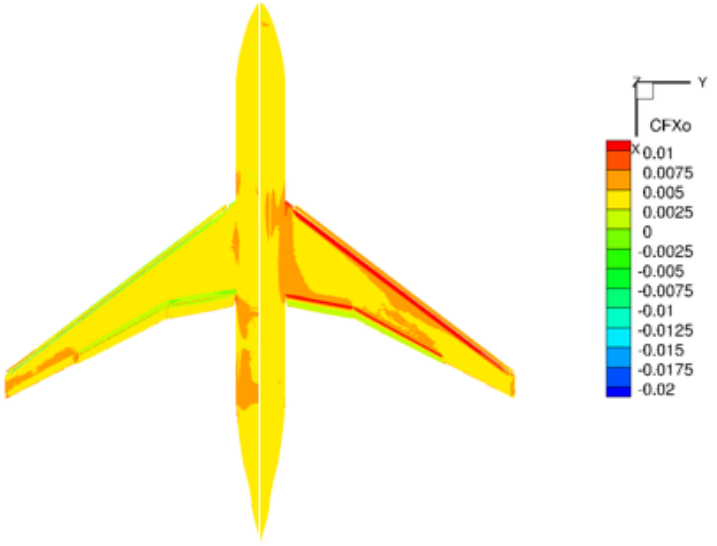
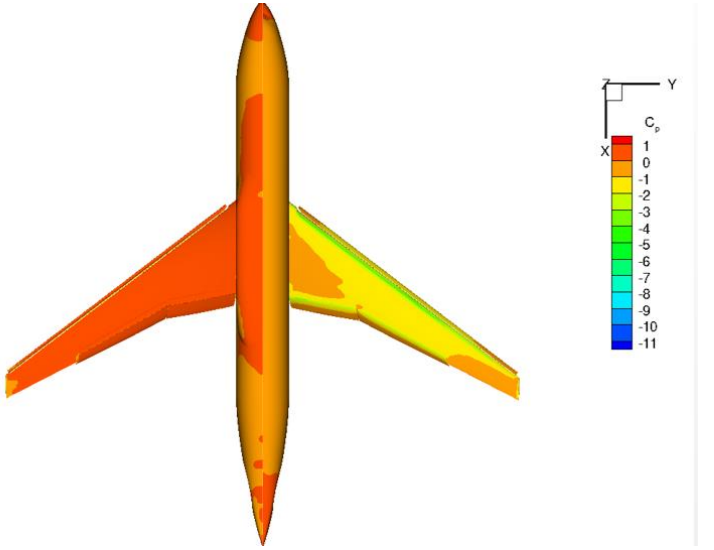
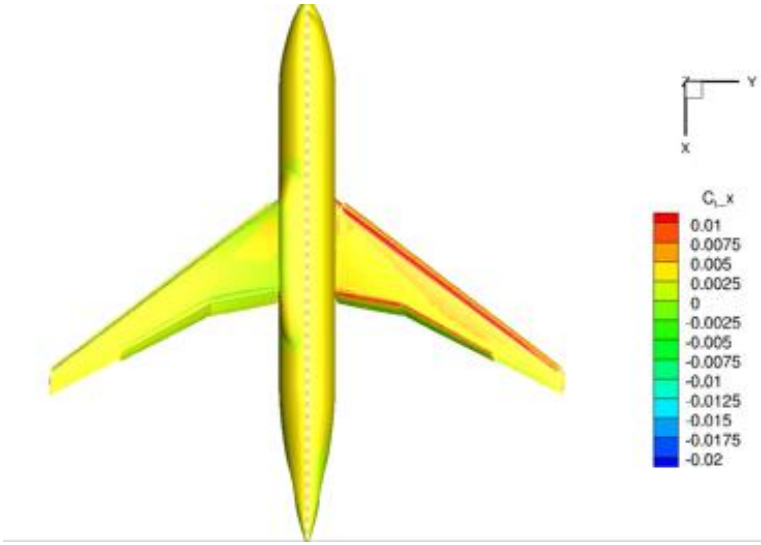
Sabalcore Computing Inc.	Case 1a	Intel® Xeon E5-2600 Series, up to 3.1Ghz highest performing Bare-metal cores, up to 8GB of RAM per core, Infiniband network architecture (56Gbp), blazing fast 40Gbps Data Network and Parallel File System (1.5Gbps of I/O)

Computational resources

	Universidad de los Andes		Universidad de San Buenaventura		Sabalcore
Grid	B3 Medium (alpha = 8º)	B3 Fine (alpha = 8º)	Airfoil (2 x 2,241 x 385)	B3 Coarse (alpha = 16º)	B3 Medium (alpha = 16º)
Cells	47,557,044	118,774,267	860,160	18,011,980	47,557,044
Processor	Intel	Intel	Intel	Intel	Intel
Nodes	4	1	1	1	4
Cores	64	32	12	12	64
RAM	157 Gb	480 Gb	10.7 Gb	62.8 Gb	200 Gb
Time/iter (min)	1.25	3	0.26	1.39	0.43
Number of iterations	25,838*	1,035*	154,000	49,500*	3,500*

*Not fully converged

Contours of Cfx

Grid: Coarse Alpha: 8º	 
Grid: Medium Alpha: 8º