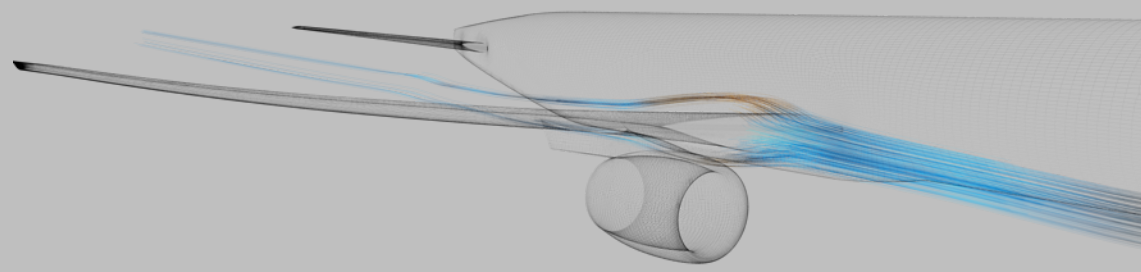


Contributions to HighLiftPW-3

The Centre for Modelling & Simulation (Bristol, United Kingdom)
Andrei Cimpoeru (CFD Engineer), 3-4 June 2017

Outline

- Participant overview
- Summary of Cases
- Flow solver and Numerics
- Grid Generation
- Results
- Conclusions

Overview CFMS

- Not for profit and independent based in Bristol, UK
- Founded in 2007 as a collaboration between the UK primes in the automotive and aerospace industry
- Current:
  - HPC Access (CRAY CS400, Intel Broadwell and NVIDIA K80)
  - Modelling and Simulation Services
  - Collaborative Research Projects
    - Aerospace, Automotive, Civil & Renewables
    - MBSE
    - Industrialization of HO-DG methods

Overview Zenotech

- Founded in 2012
- Based in Bristol, UK
- Background in Computational Engineering research for Aerospace
- Current:
  - Develops cloud HPC and CFD technology for aerospace, automotive, civil and renewable energy sectors

Summary of cases

CASE NASA HL-CRM	Alpha=8, Fully turb, grid study	Alpha=16, Fully turb, grid study	Other
1a (full gap)	**YES**	**YES**	

CASE JAXA JSM	Polar, Fully turb, Ongoing	Other
2a (nacelle off)	4.36 and 10.47 computed	
2c (nacelle on)	4.36 and 10.47 computed	
Other	**NO**	

CASE	2D Verification study	Other
3	**YES**	
Other	**NO**	

- Full polar study for Case 2a/2c is ongoing

Flow Solver and Numerics

- Unstructured cell-centered density based, fully coupled
- Finite volume RANS, High Order DG Flux Reconstruction
- HLLC Riemann Solver with Vanalbada flux limiter
- SST-VSUST turbulence model using, fully turbulent
- Low Mach number precondition
- Geometric multigrid technique
- Explicit local time-stepping and Non-Linear Implicit LU-SGS
- GPU-MPI-OpenMP accelerated

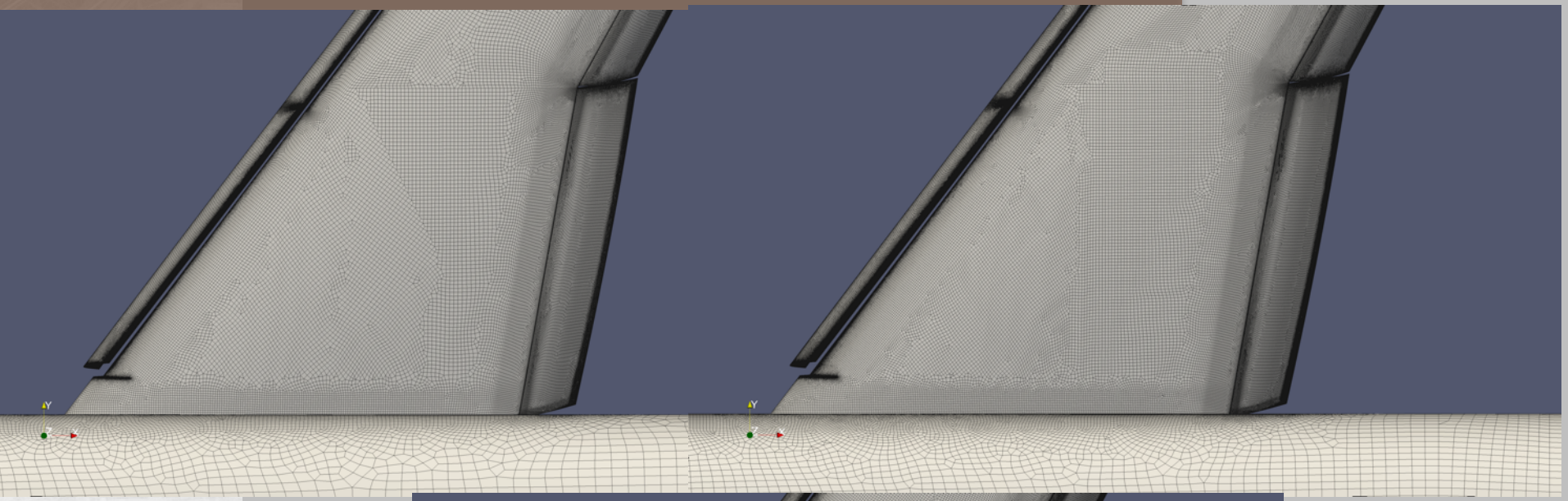
Grid Generation - SOLAR

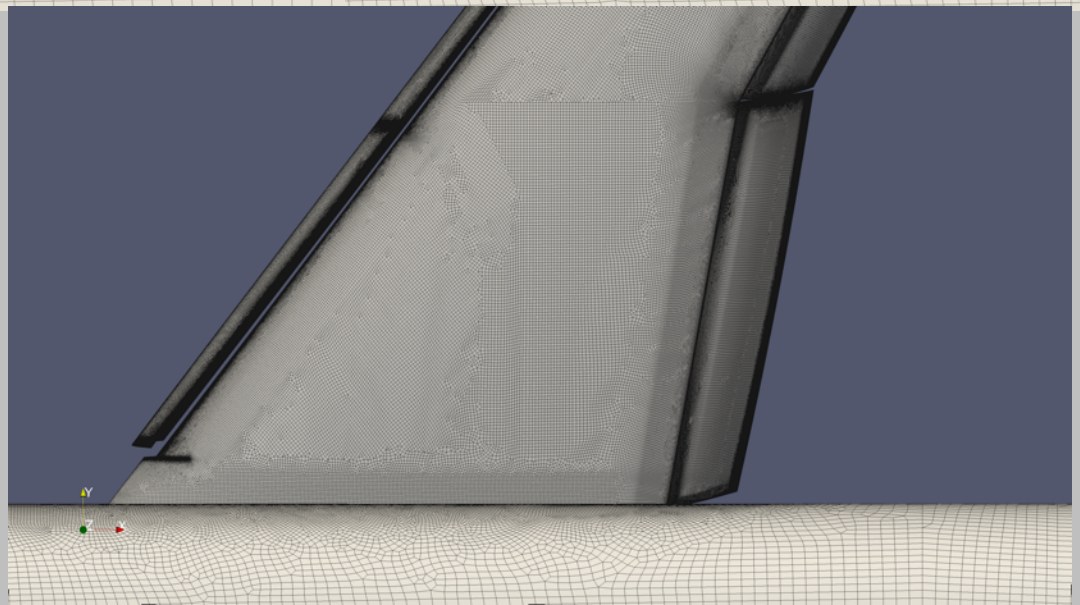
- Anisotropic quad dominant surface mesh based on local refinement
- Anisotropic boundary layer mesh
- Top-down cartesian-octree with cut cells
- Meshes generated
  - HL-CRM (C-M-F)
  - JSM model (M)

Grid Generation – HL-CRM

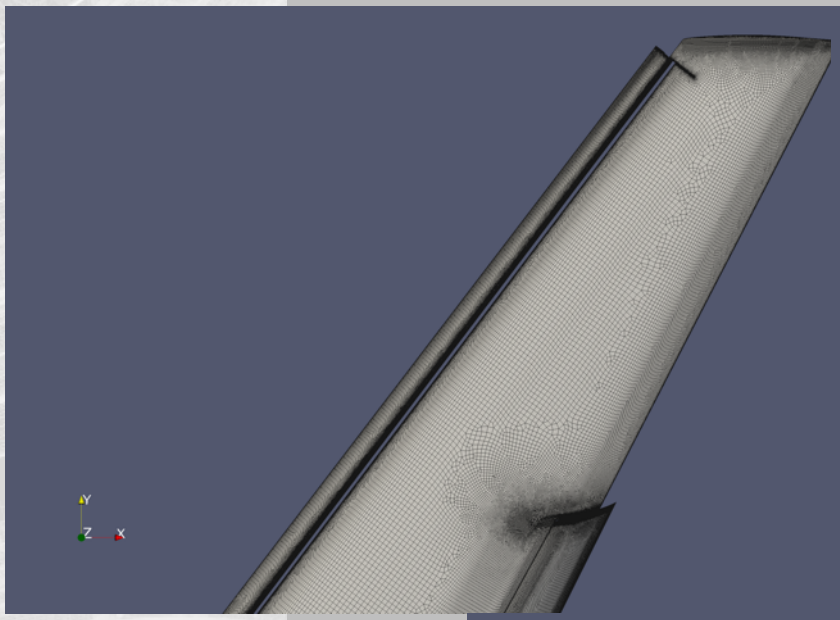
Case	Coarse	Medium	Fine
Surface Mesh	1.01M 0.91% non-quad	1.9M 0.75% non-quad	3.17M 0.64% non-quad
Boundary Layer	19.7M	35.2M	65.4M
Volume Volume	49.07M	99.2M	209M
Elements on Trailing Edge	3 dy = coarse	5 dy = medium	6-8 dy = fine

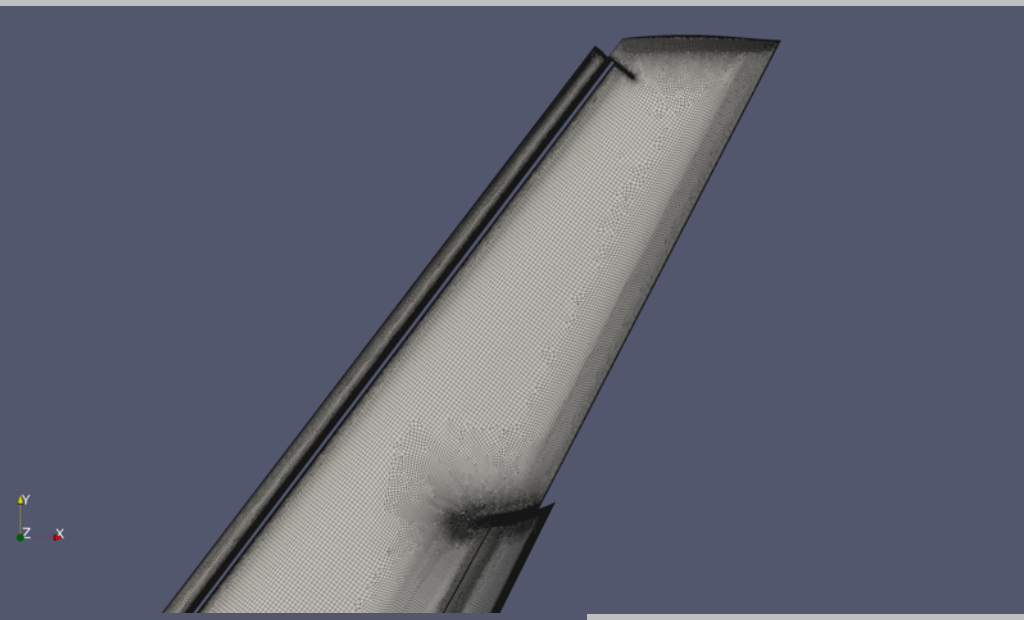
Grid Generation – HL-CRM

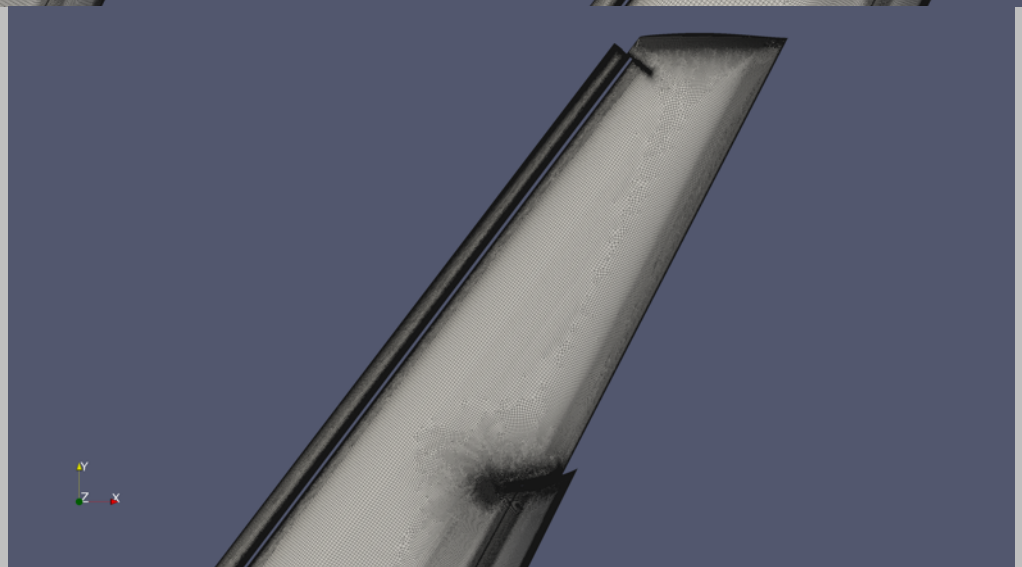




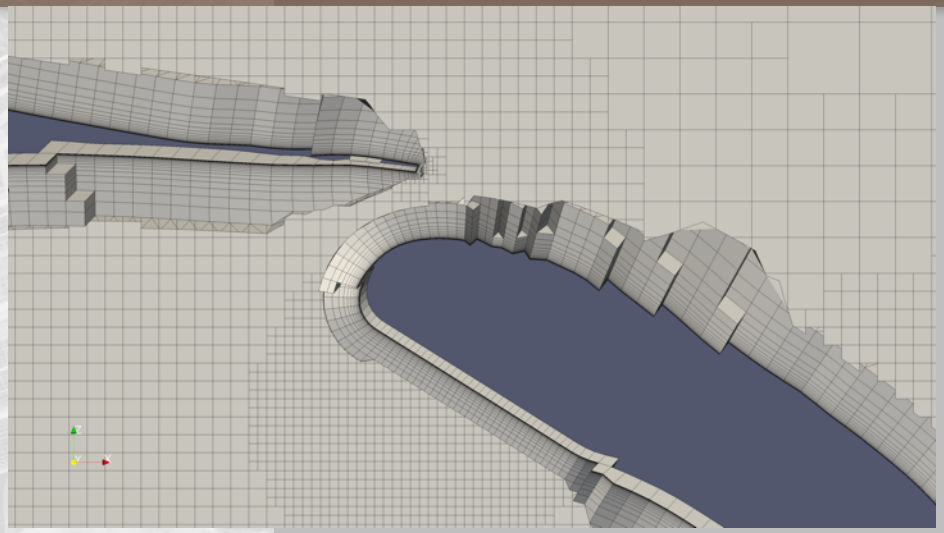
Grid Generation – HL-CRM

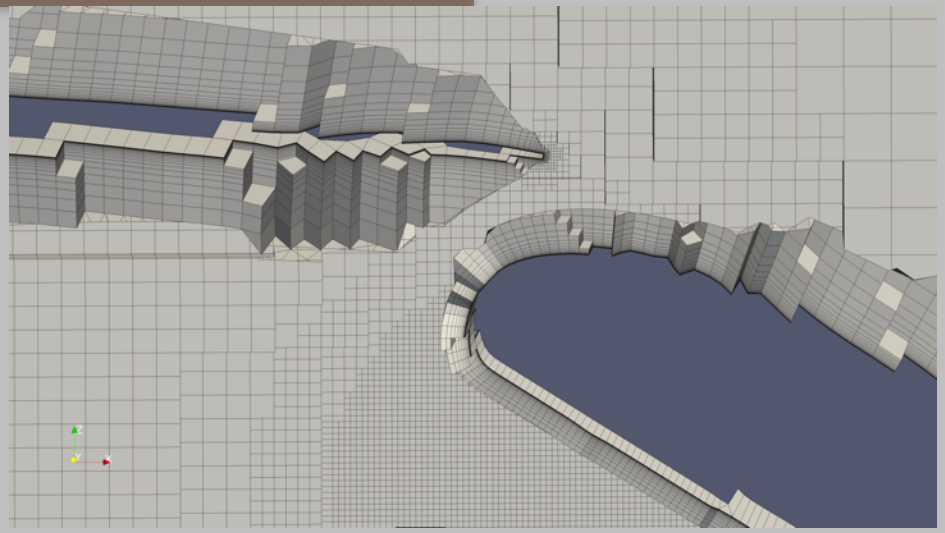


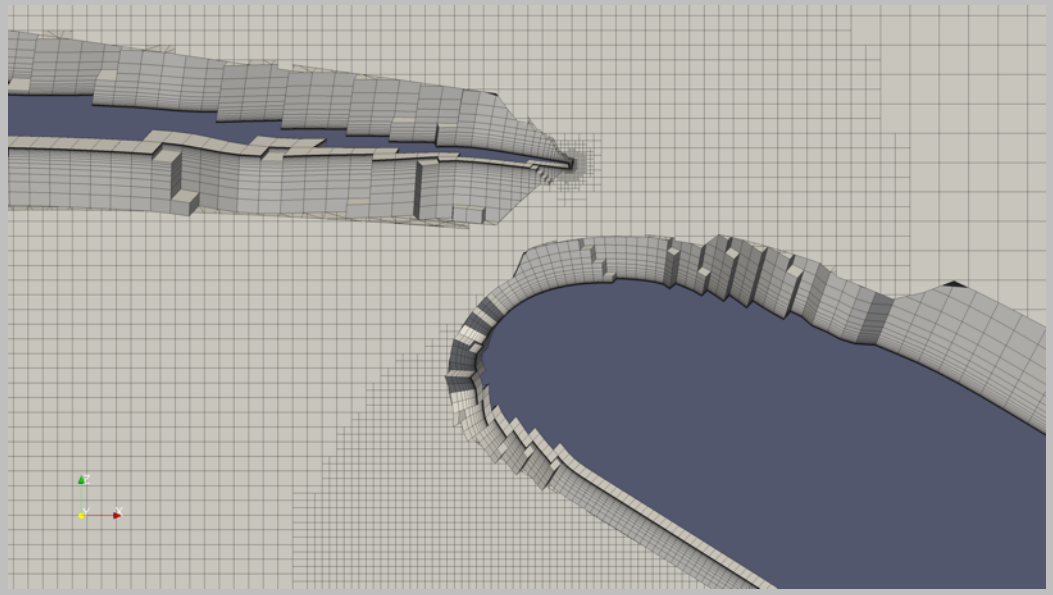




Grid Generation – HL-CRM



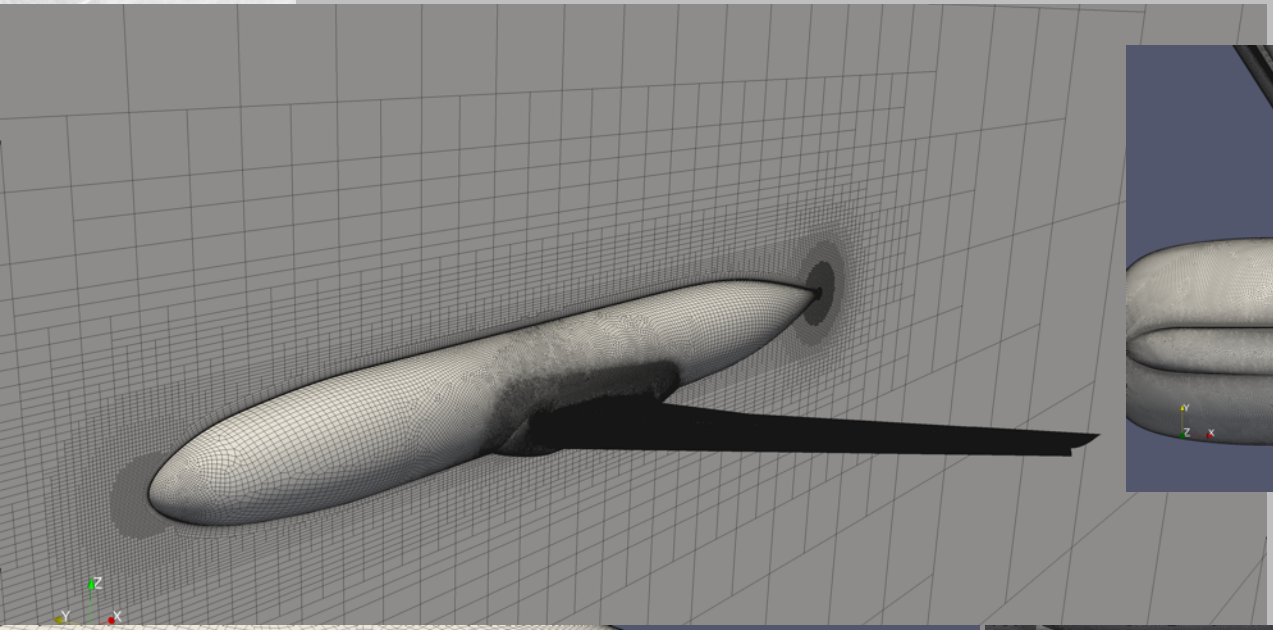


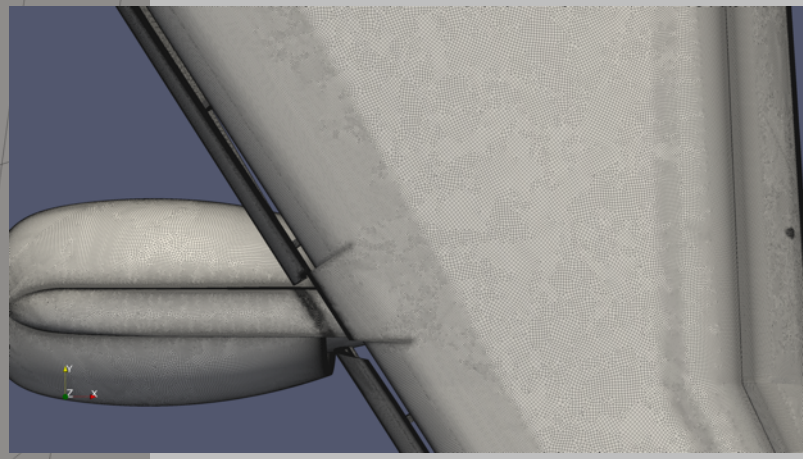


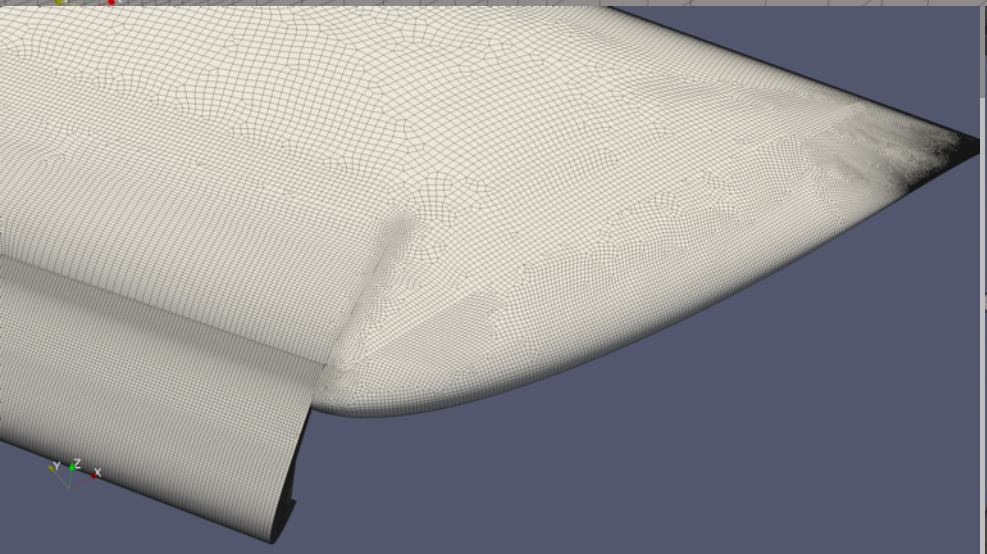
Grid Generation – JSM

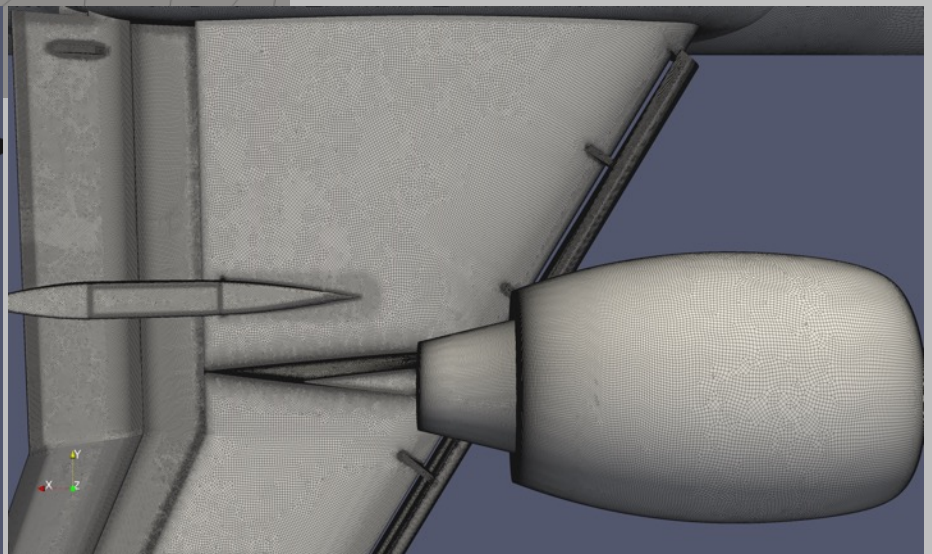
Case	Nacelle Off	Nacelle On
Surface Mesh	1.8M 0.35% non-quad	2.34M 0.39% non-quad
Boundary Layer	39.1M	50.6M
Volume Total	110.1M	133.2M
Elements on Trailing Edge	5	5

Grid Generation – JSM

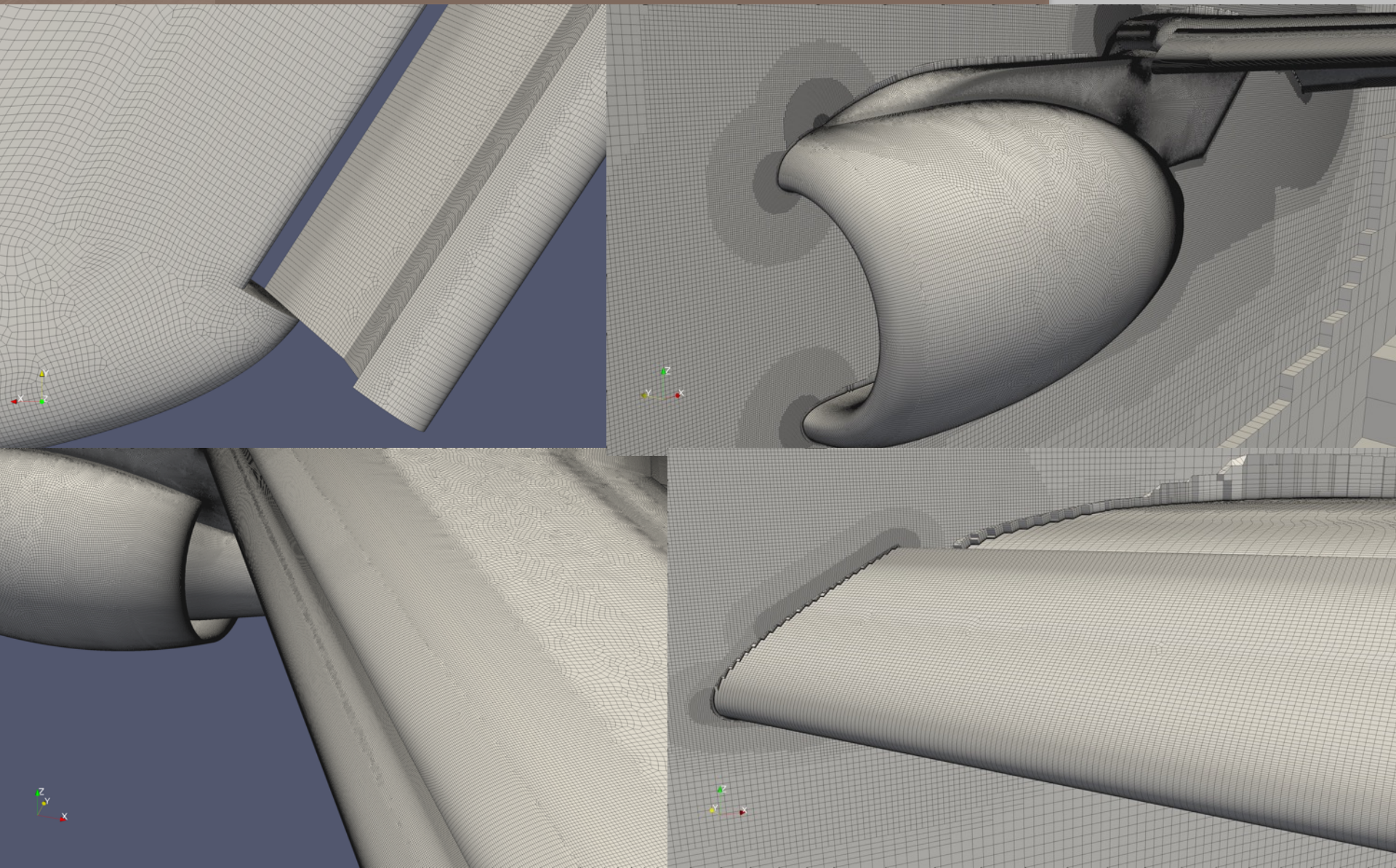




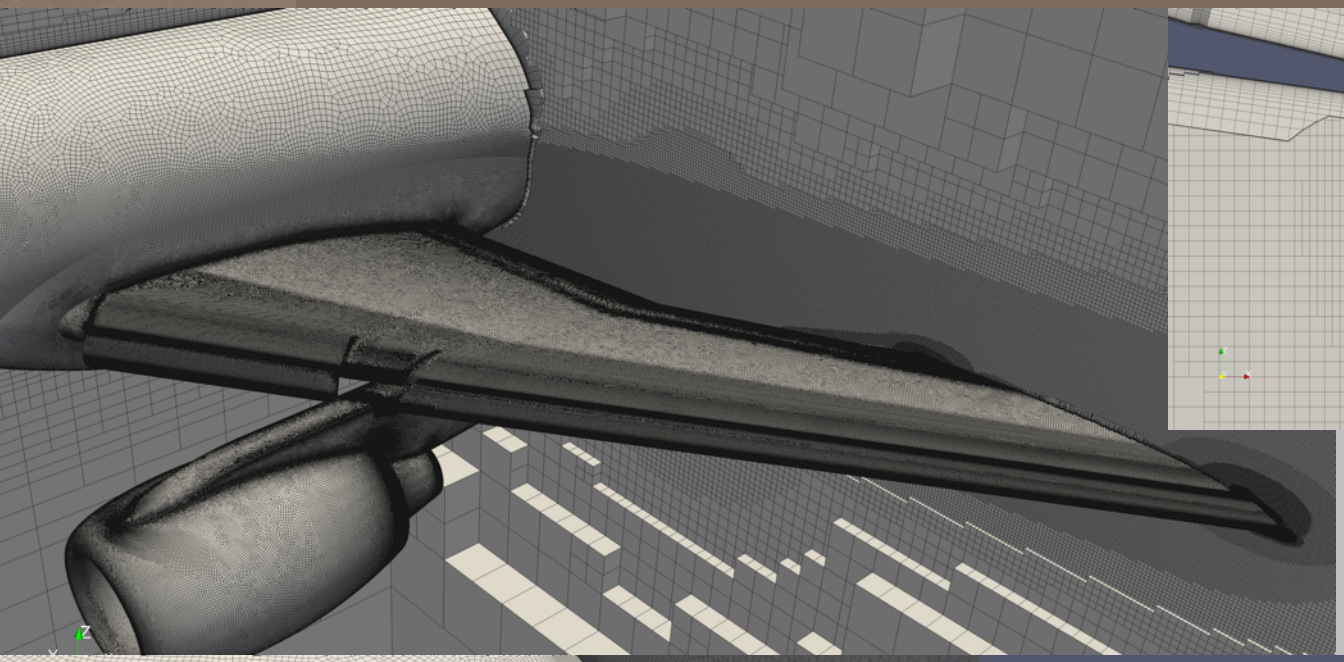


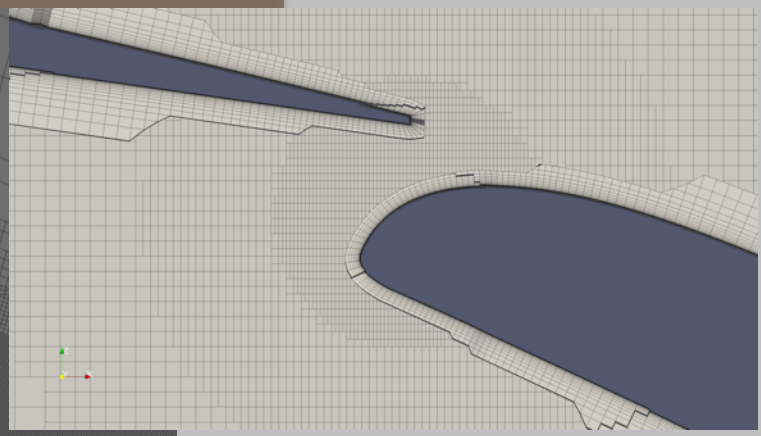


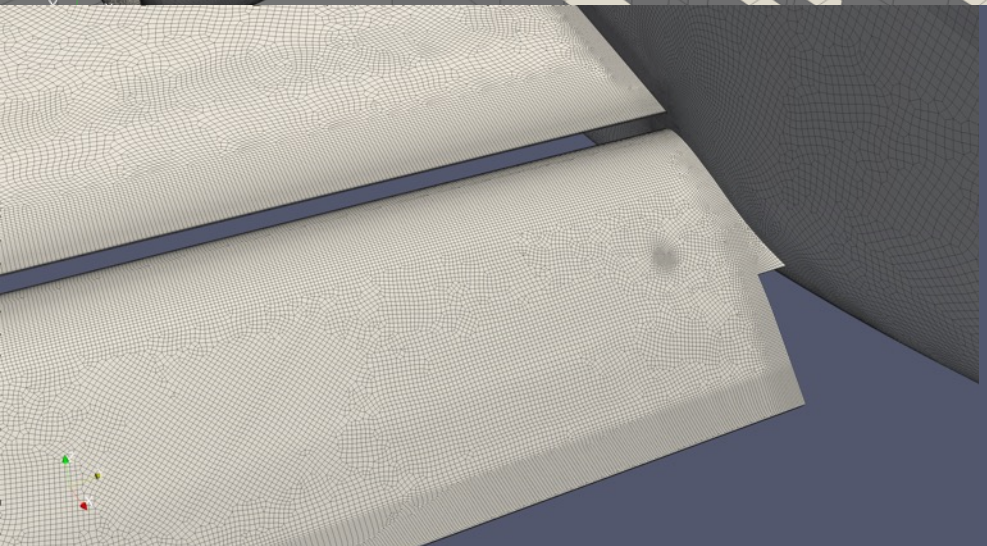
Grid Generation – JSM



Grid Generation – JSM



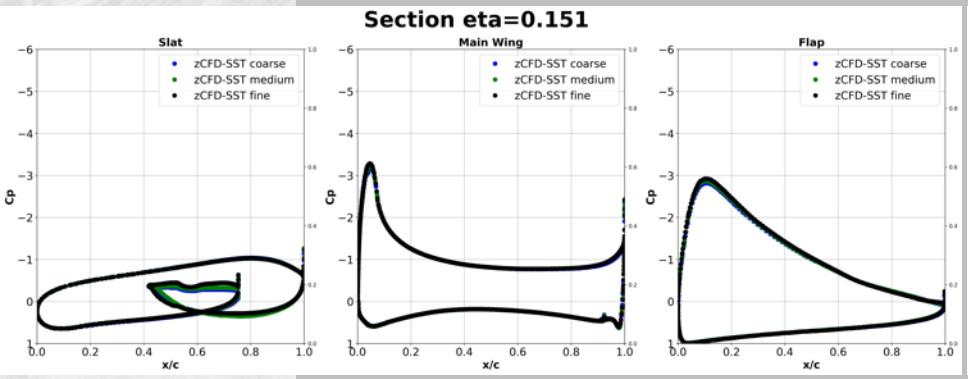


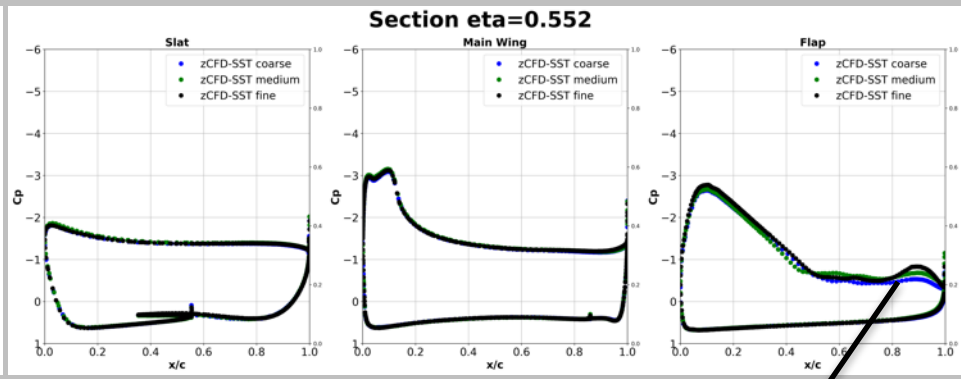


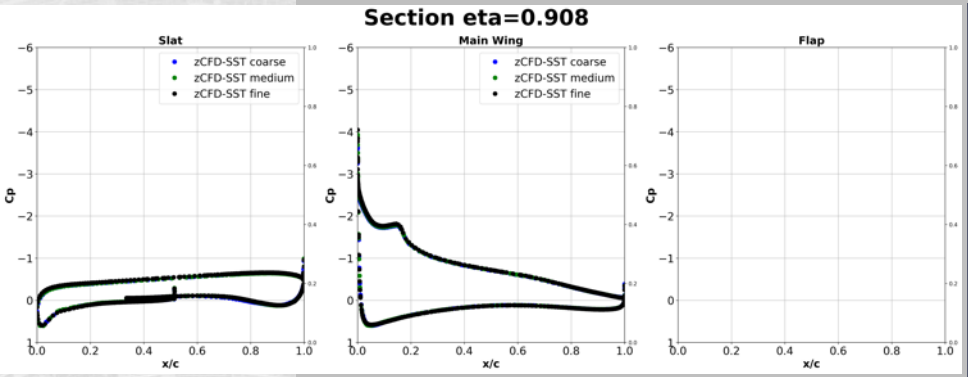
HL-CRM Results

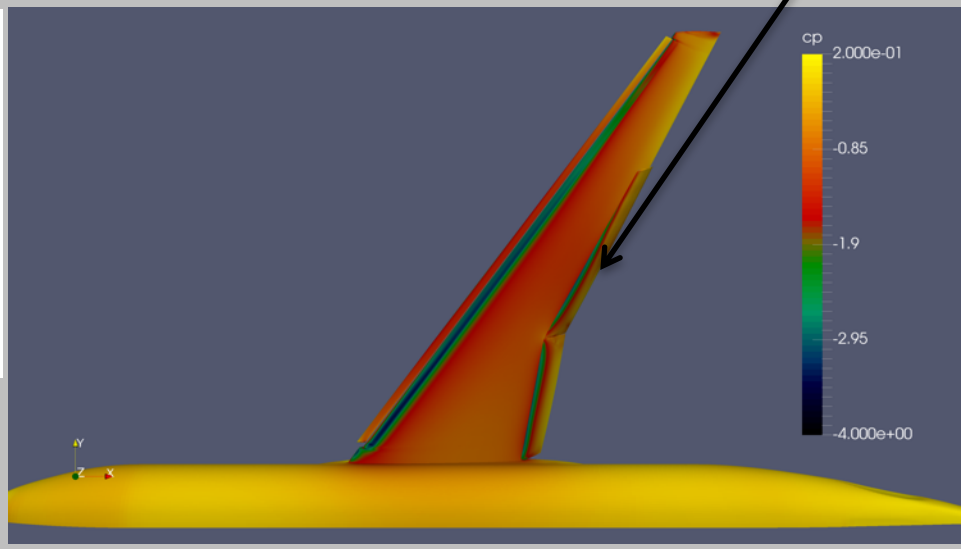
HL-CRM Results

- Cp plots (AoA = 8º)



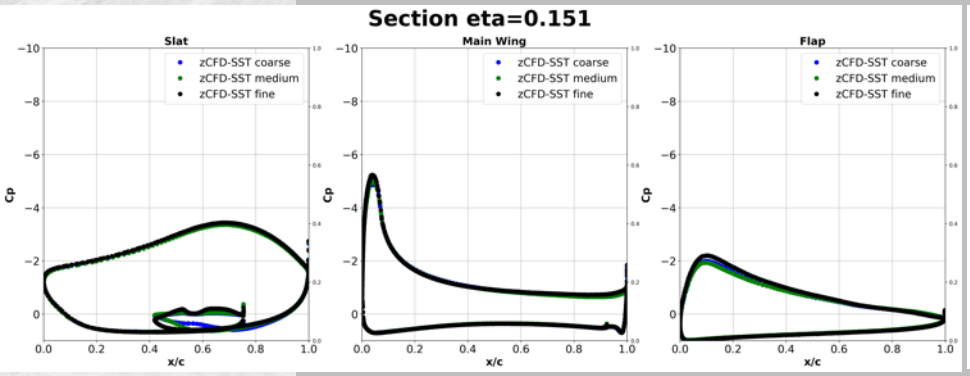


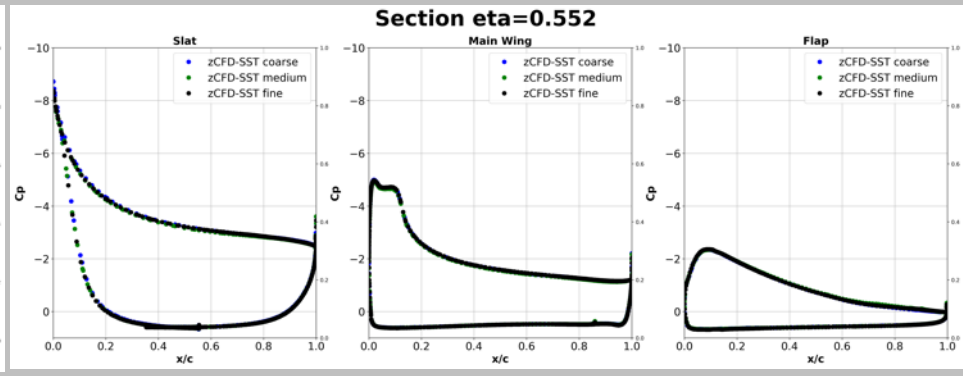


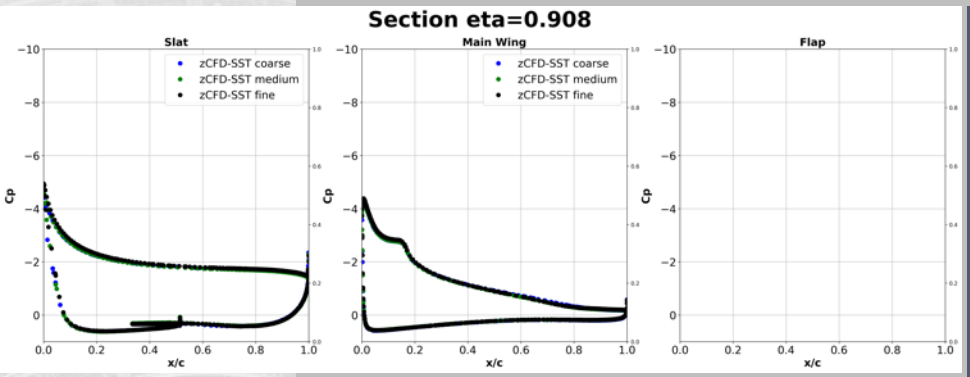


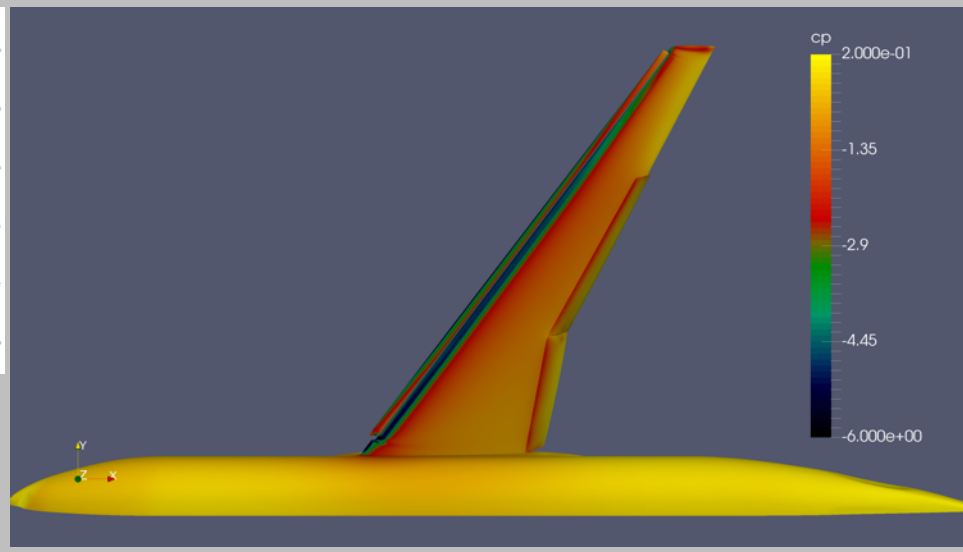
HL-CRM Results

- Cp plots (AoA= 16) restarted from 8°



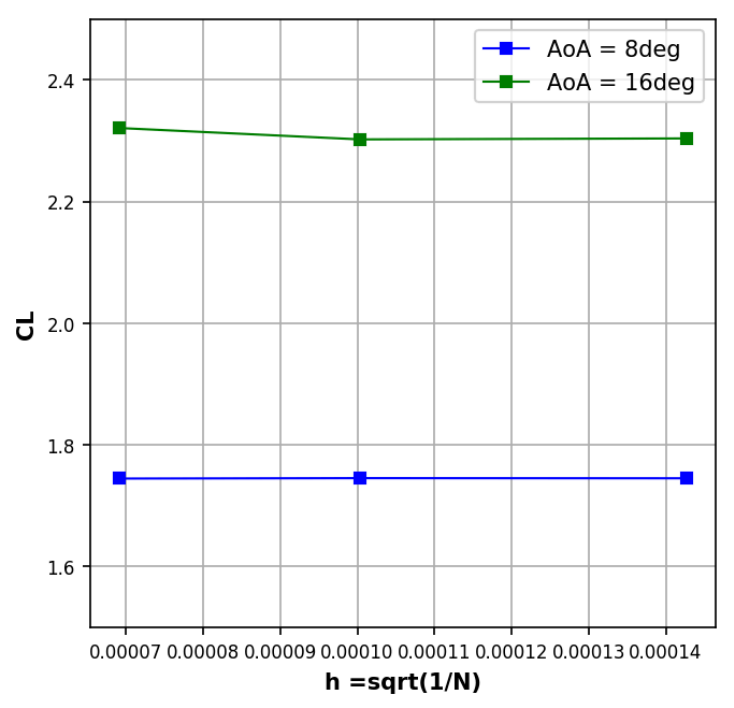


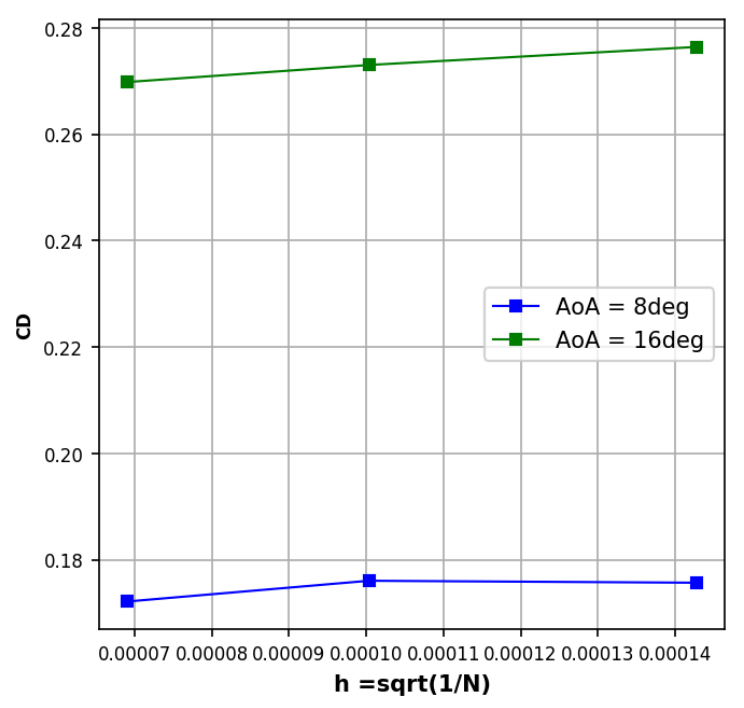




HL-CRM Results

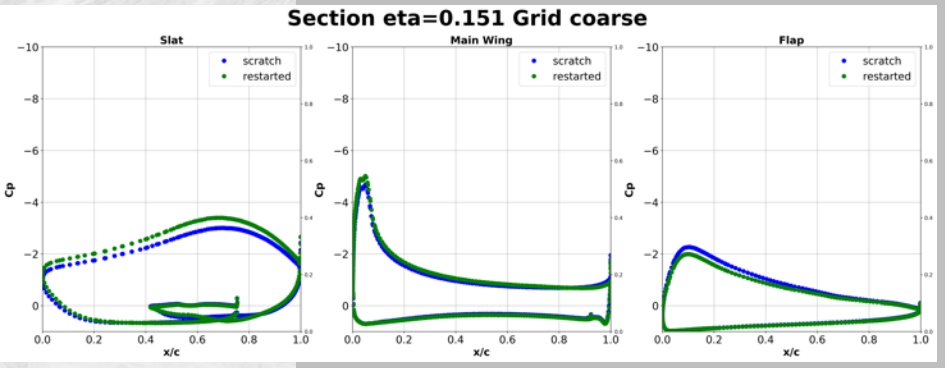
- Forces

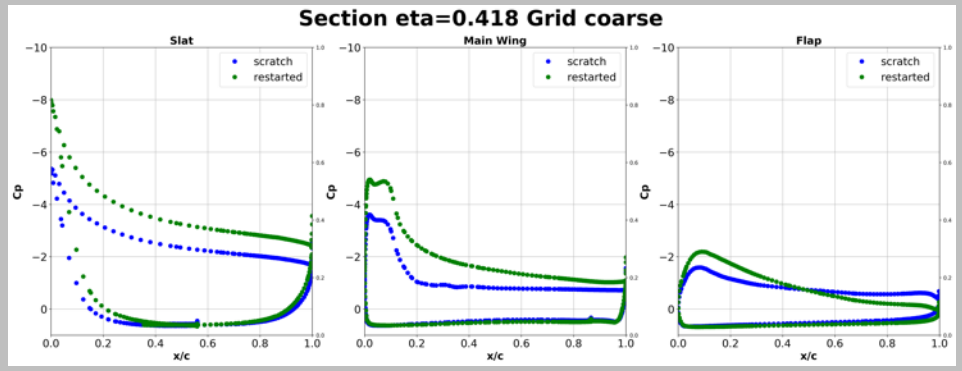


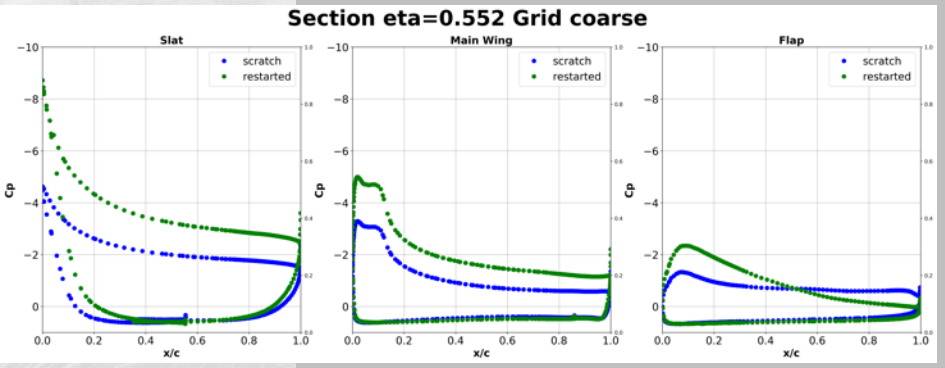


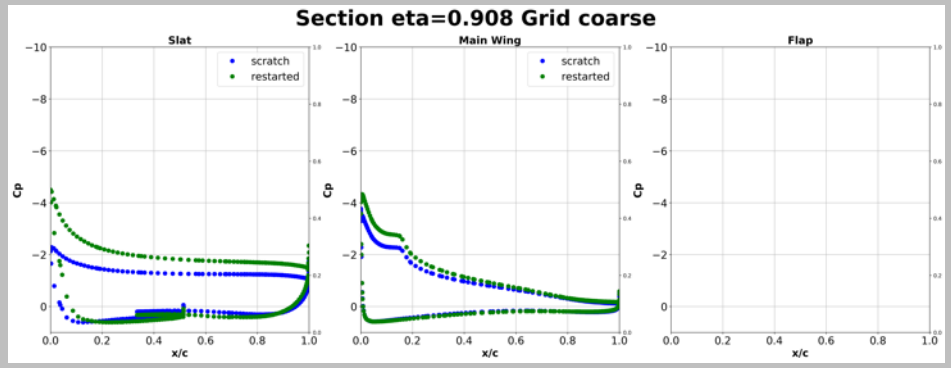
HL-CRM Results

- Restarted vs from Scratch, AoA = 16°



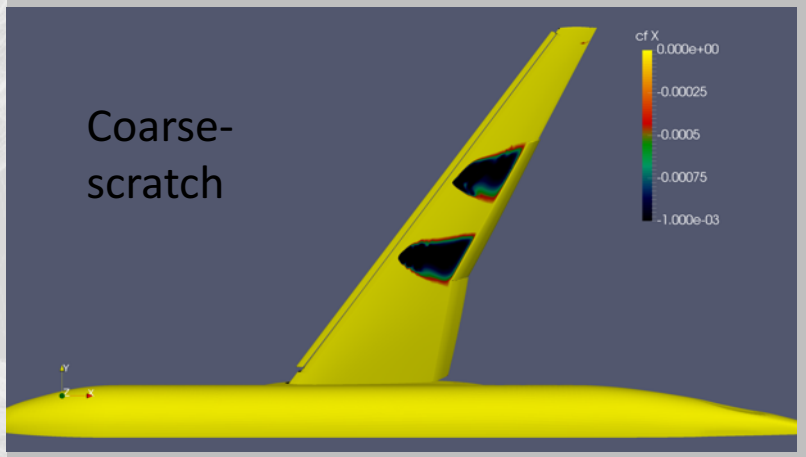


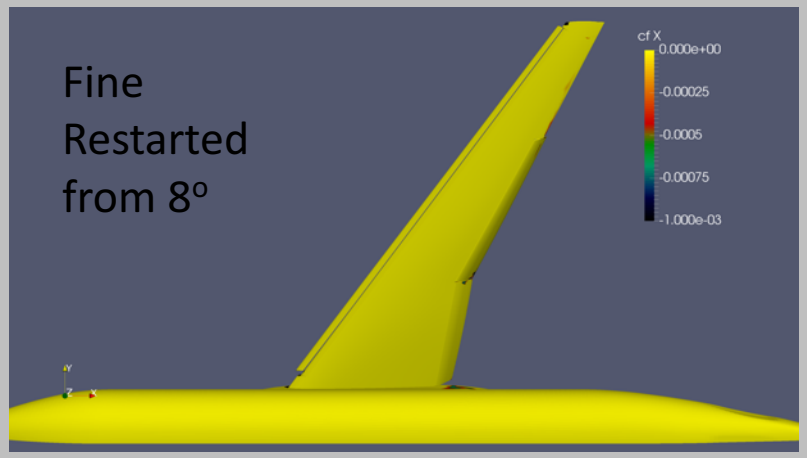


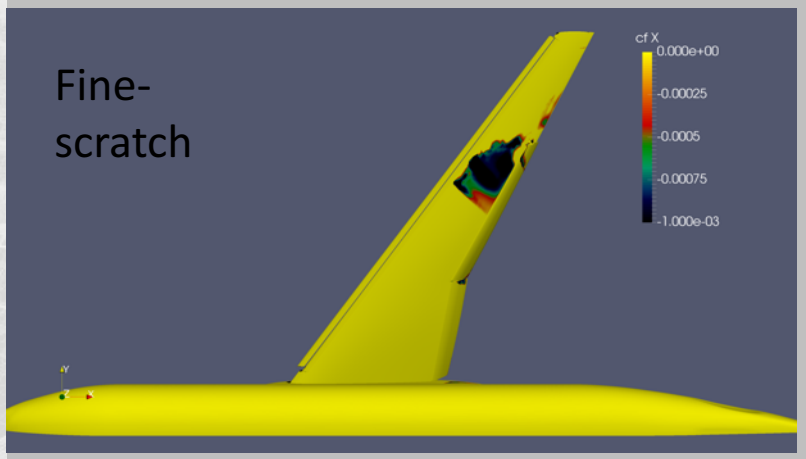


HL-CRM Results

- Restarted vs from Scratch, AoA = 16°

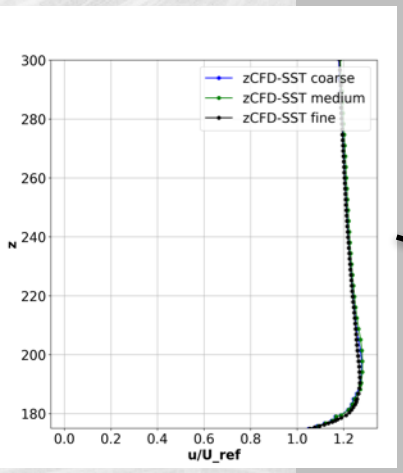


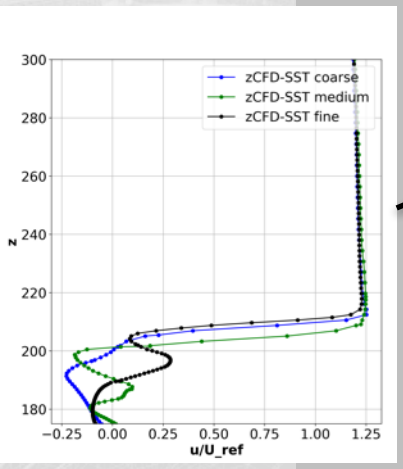


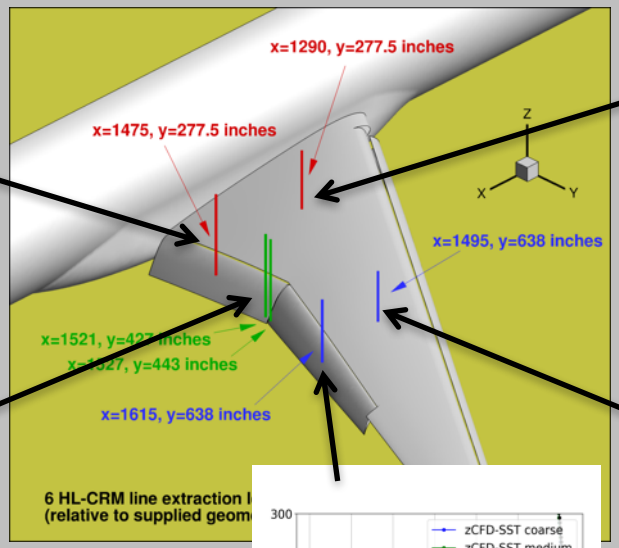


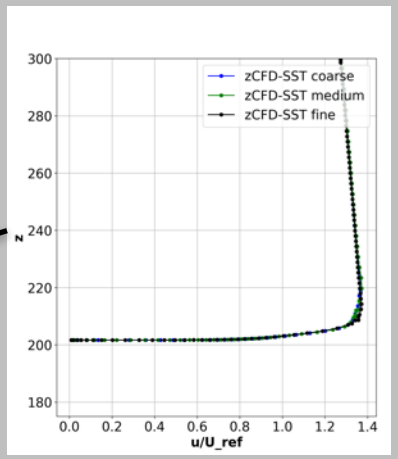
HL-CRM Results

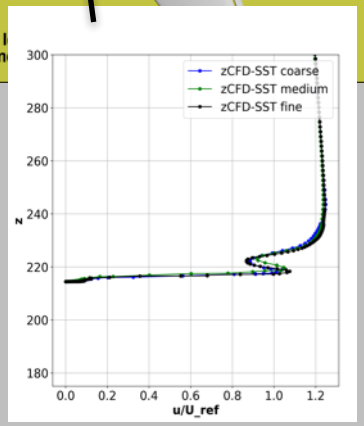
- Velocity profiles, AoA = 8°

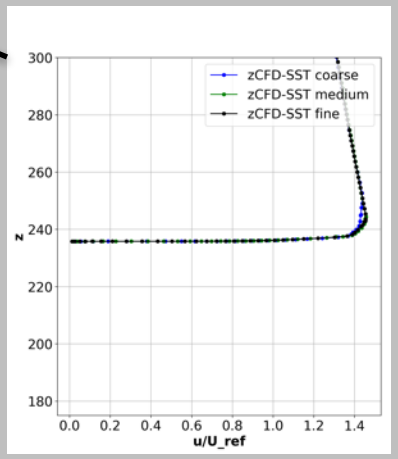








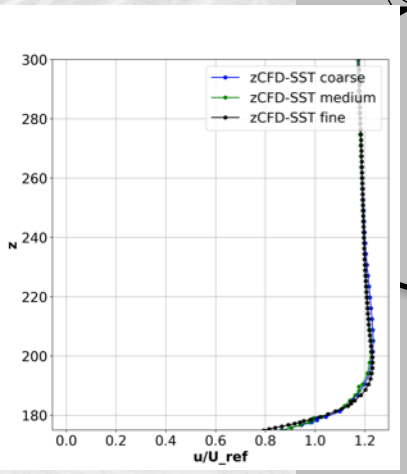


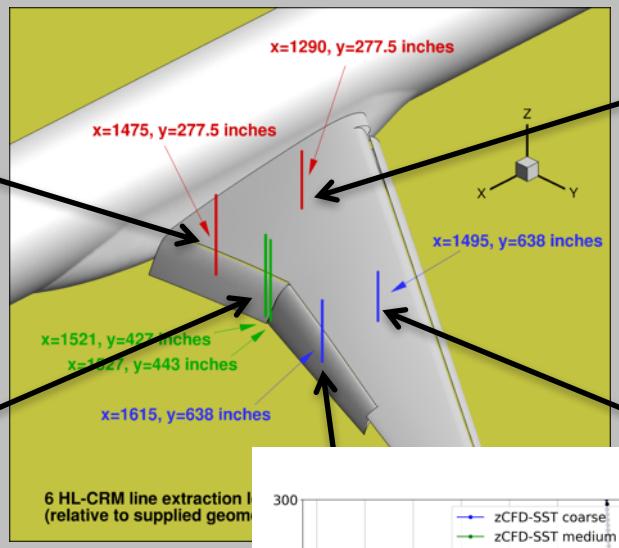


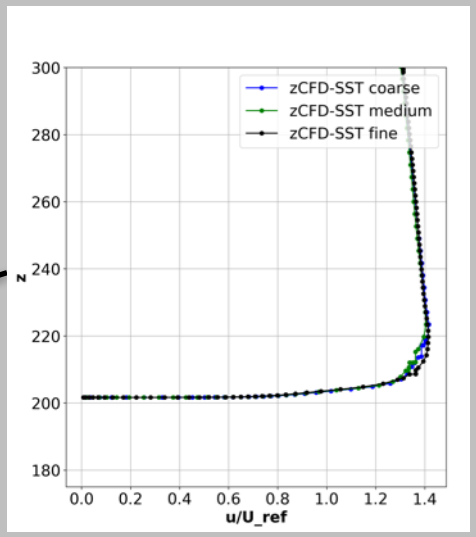
Unsteadiness in gap region

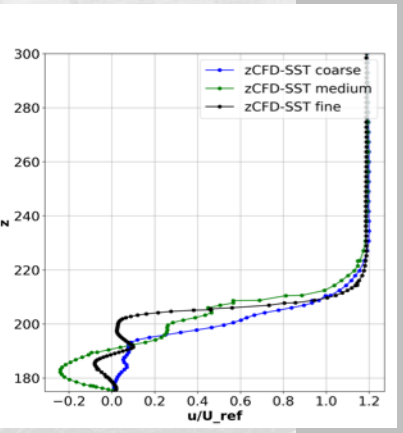
HL-CRM Results

- Velocity profiles, AoA = 16°

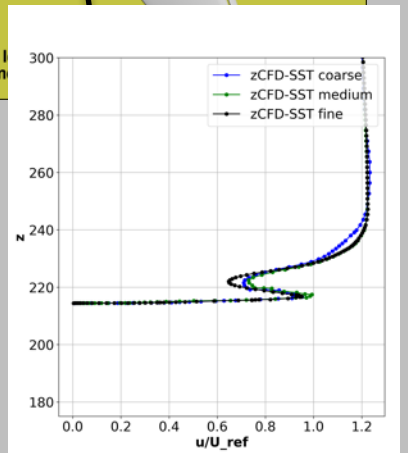


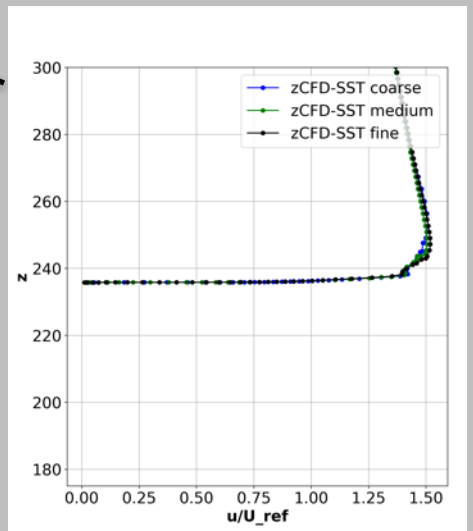






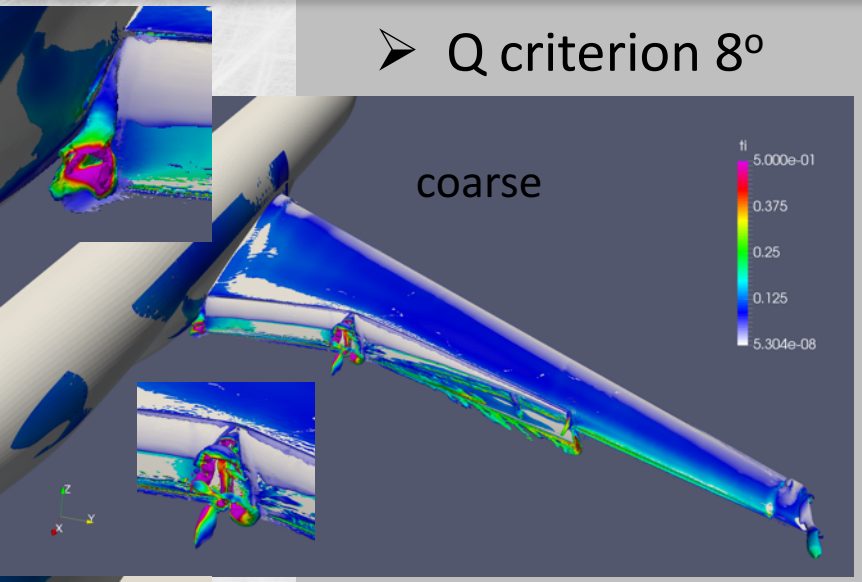
Unsteadiness in the gap region

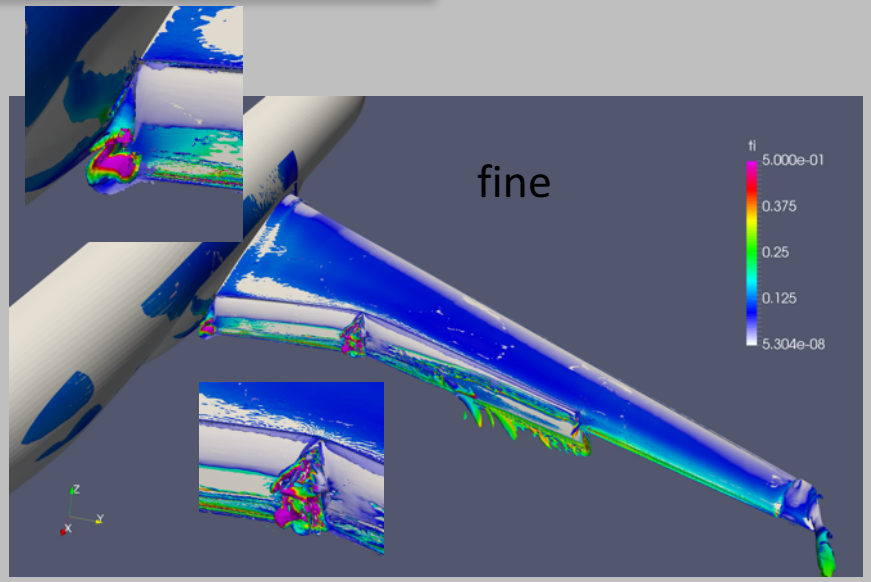




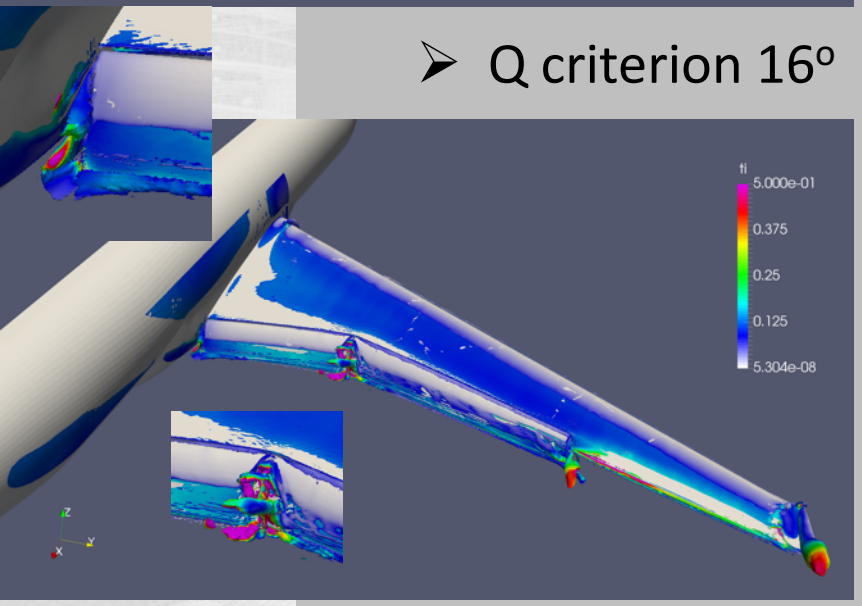
HL-CRM Results

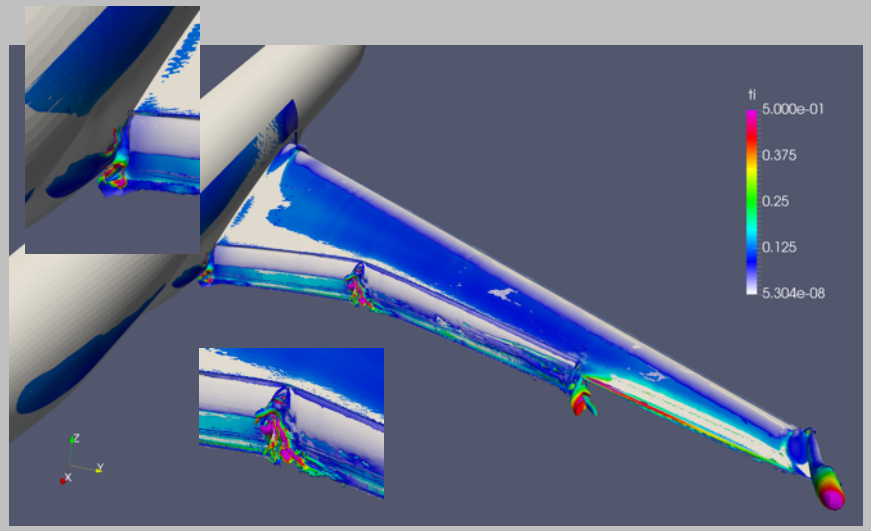
- Q criterion 8º





- Q criterion 16º



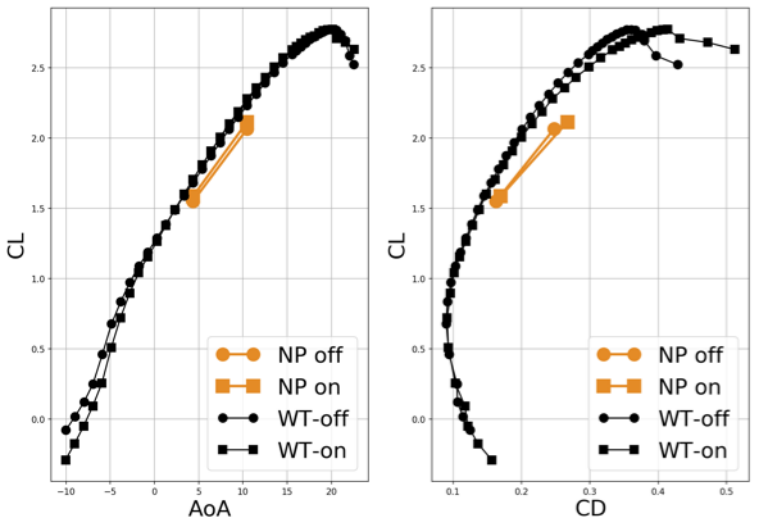


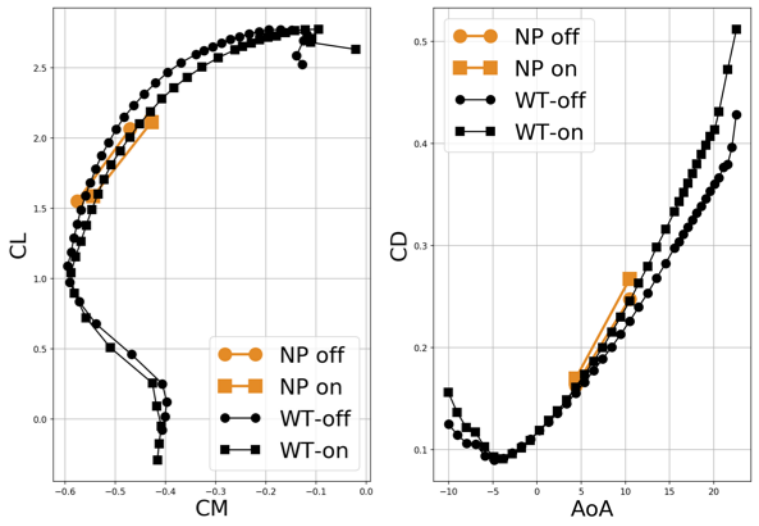
JSM Results

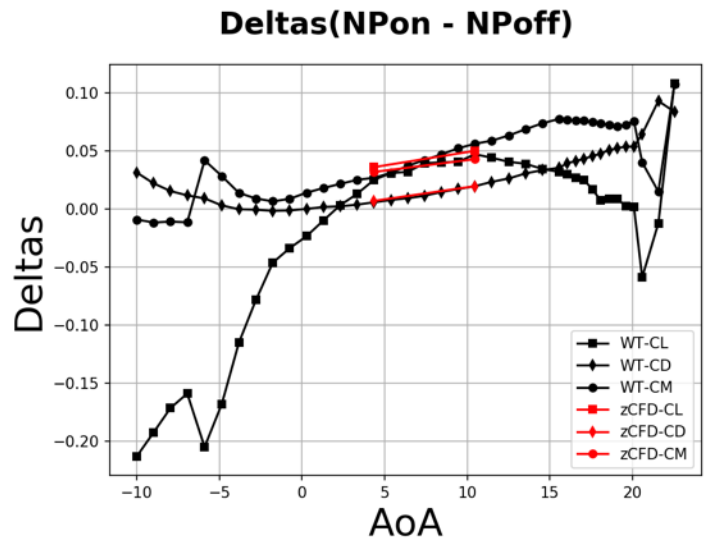
- Computed 4.36^{o} and 10.47^{o} from scratch for Case2a and Case2c

JSM Results

Forces



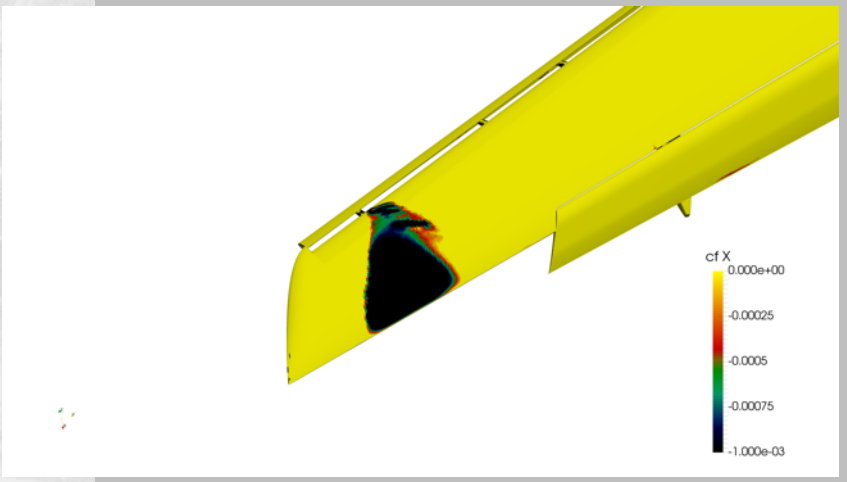


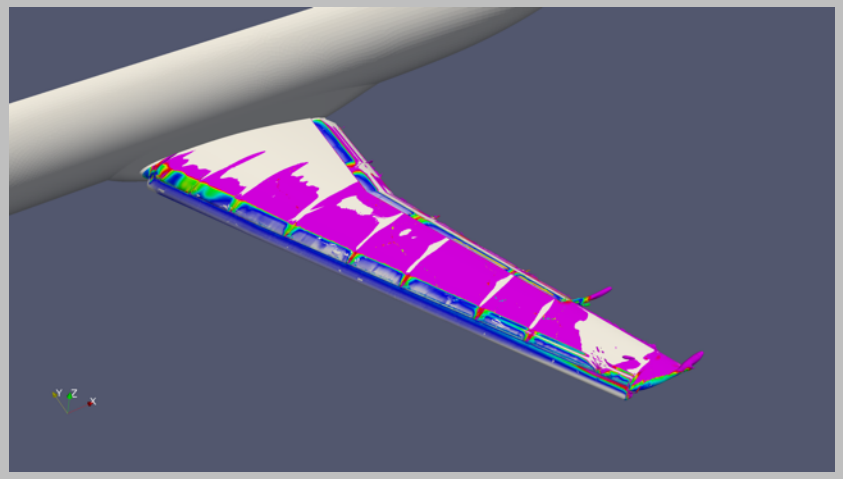


JSM Results

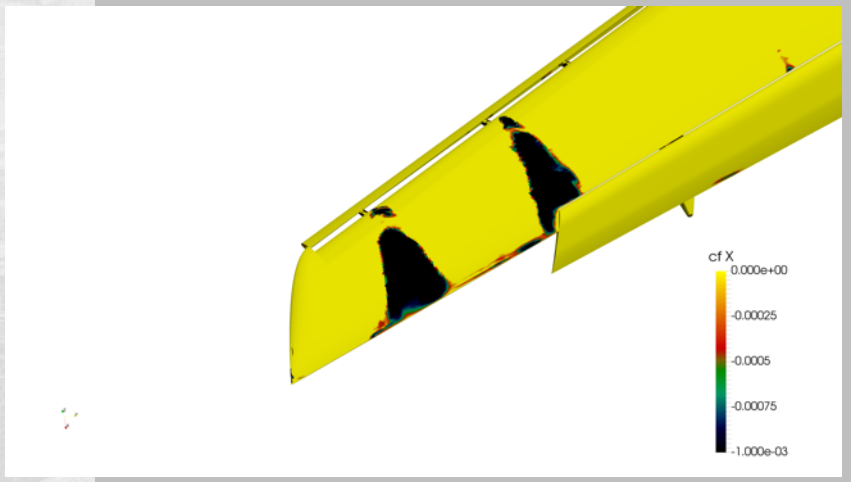
- Free Decay vs Controlled Decay (Sustainment), 10.47°

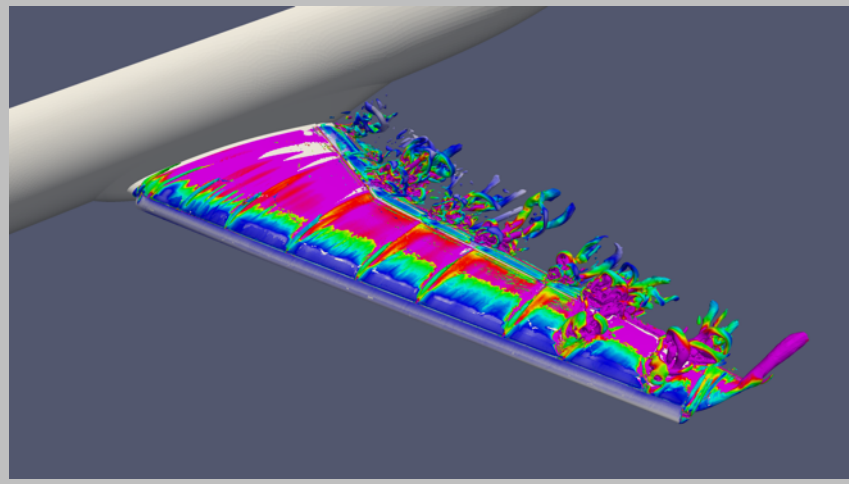
SUST On



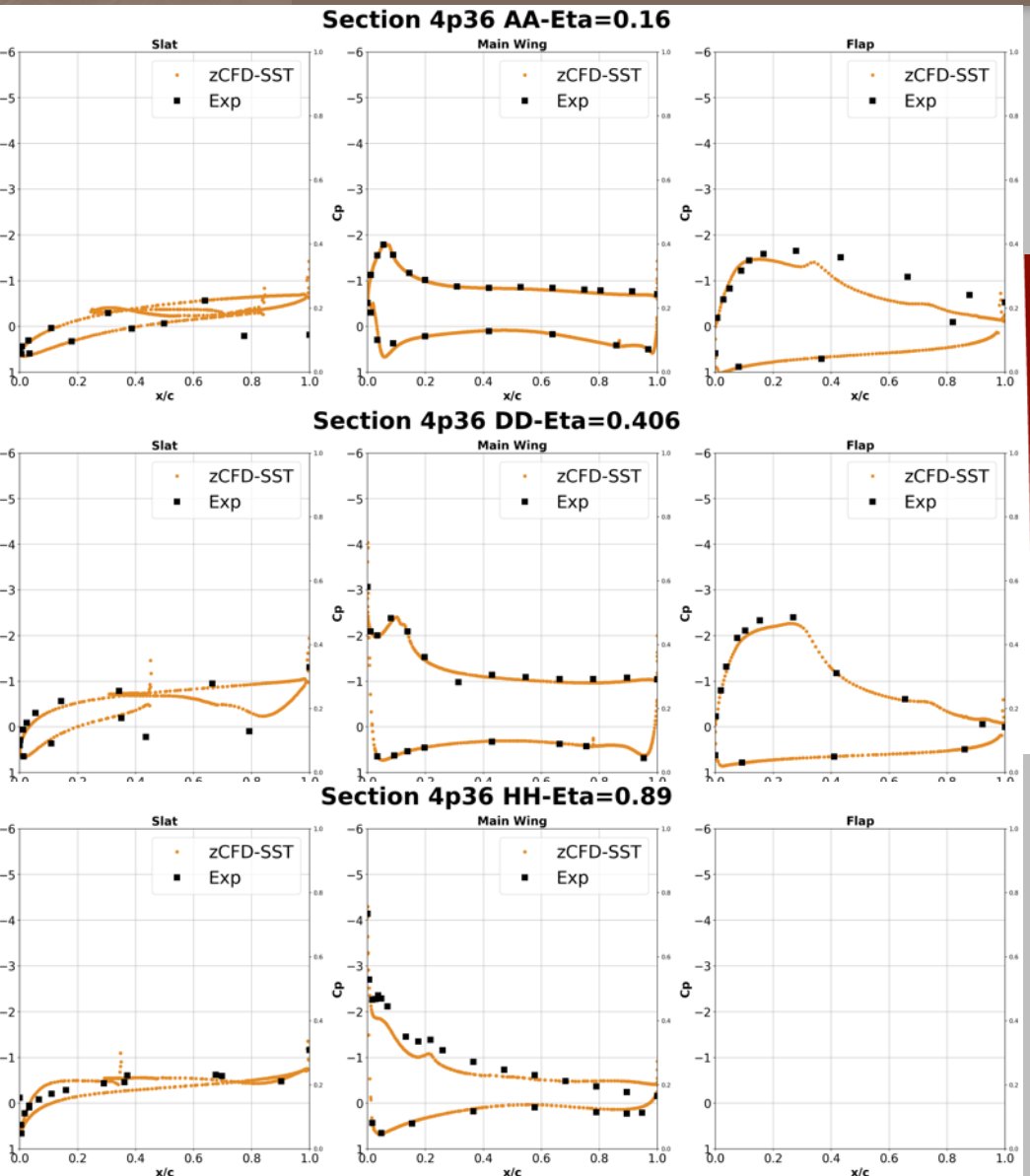


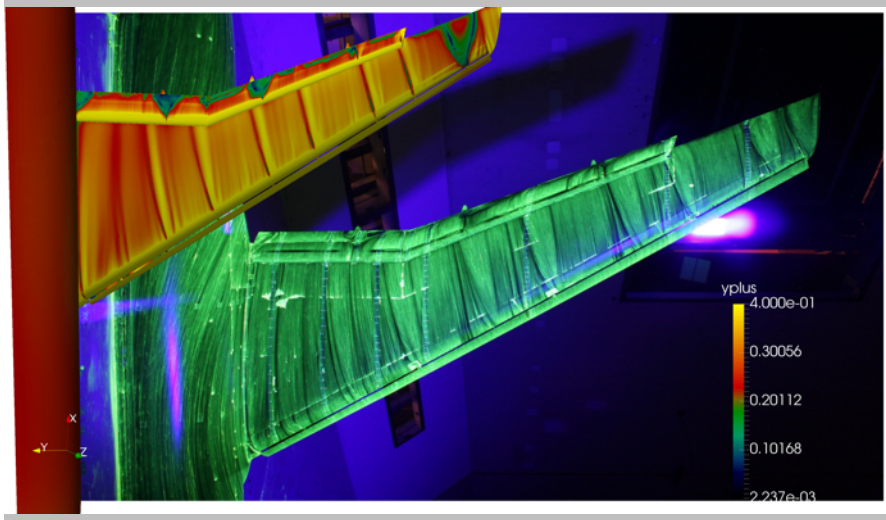
SUST off



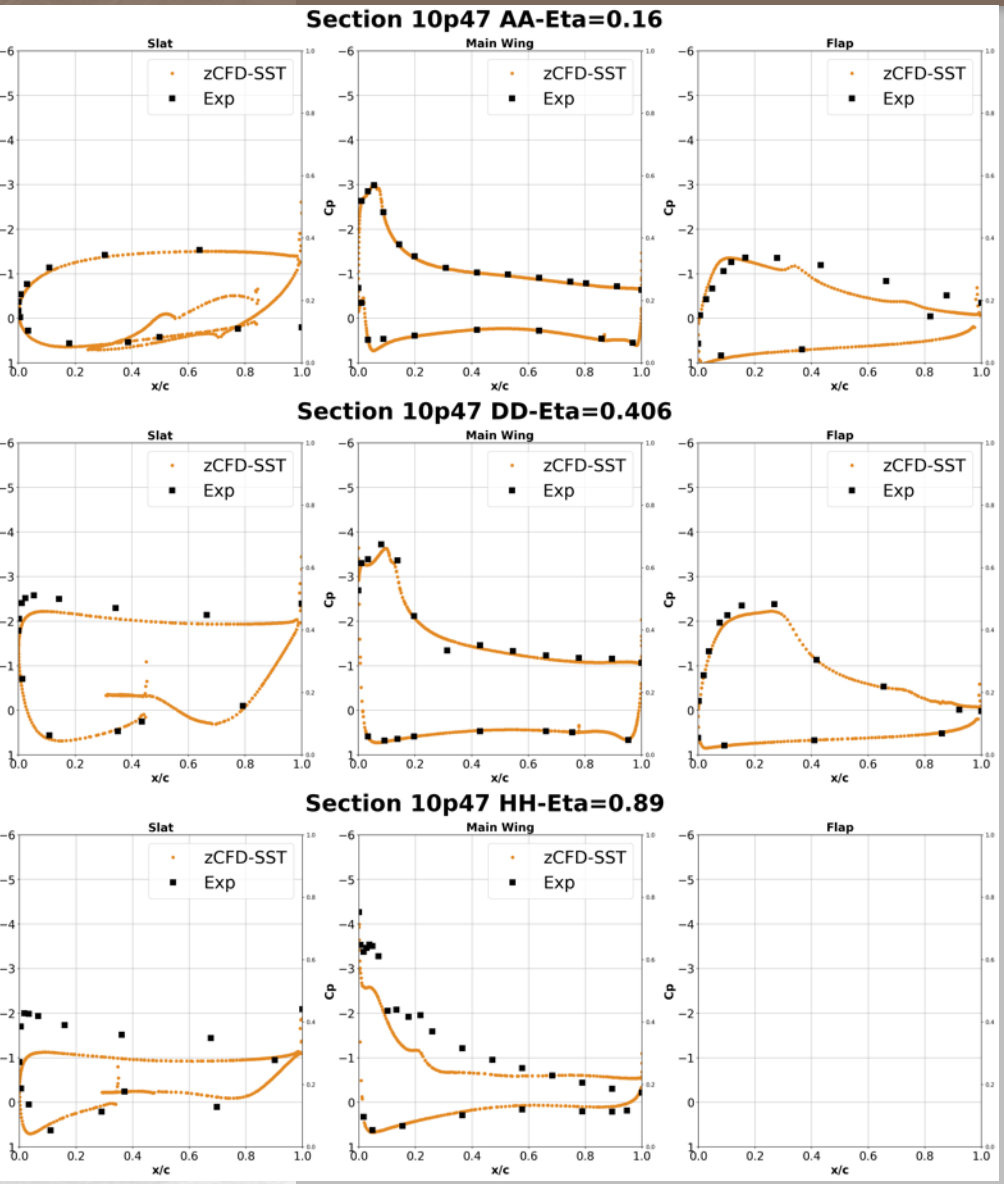


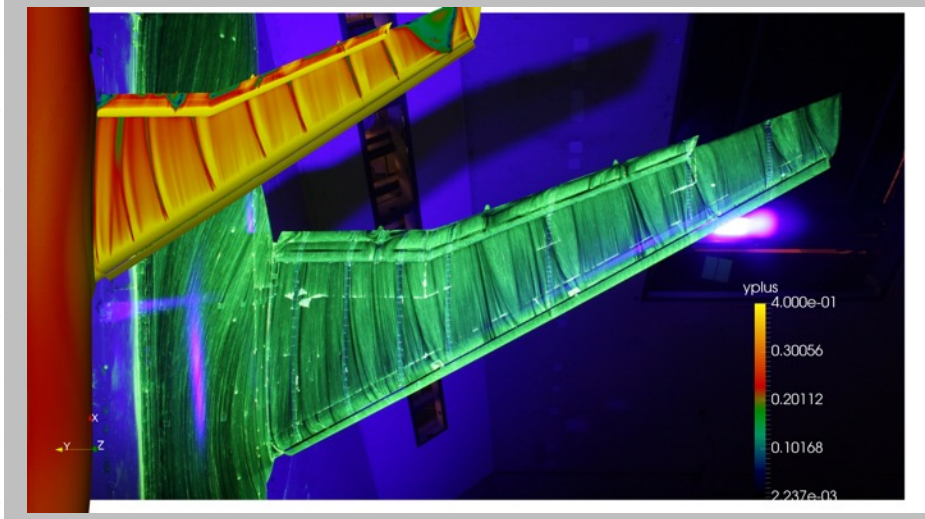
JSM Results


Section 4p36 AA-Eta=0.16
Slat
Main Wing
Flap
zCFD-SST
Exp
Cp
x/c
Section 4p36 DD-Eta=0.406
Section 4p36 HH-Eta=0.89

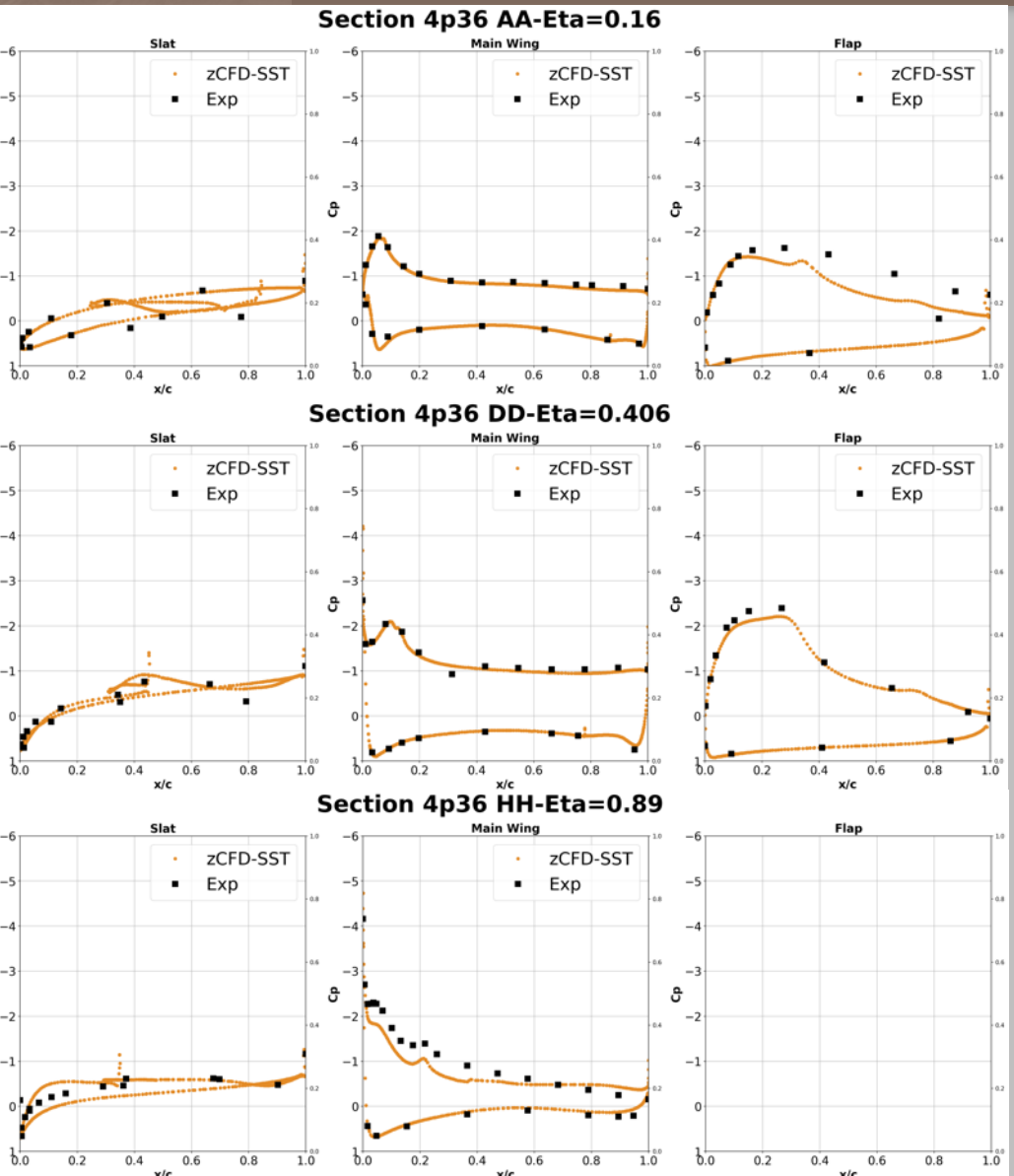

yplus
4.000e-01
0.30056
0.20112
0.10168
2.237e-03

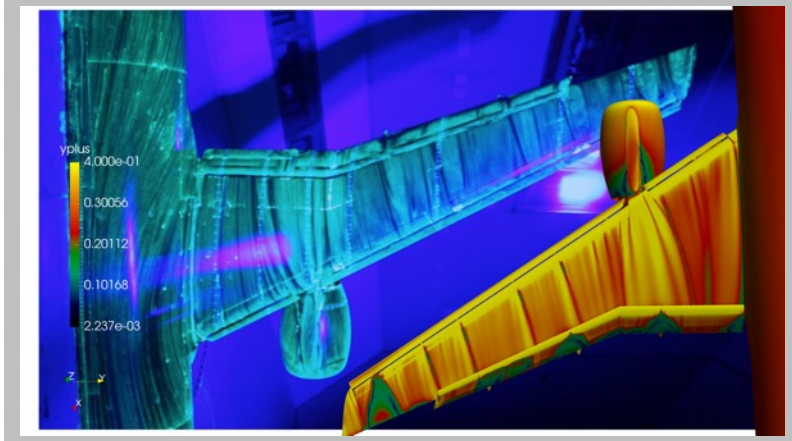
JSM Results

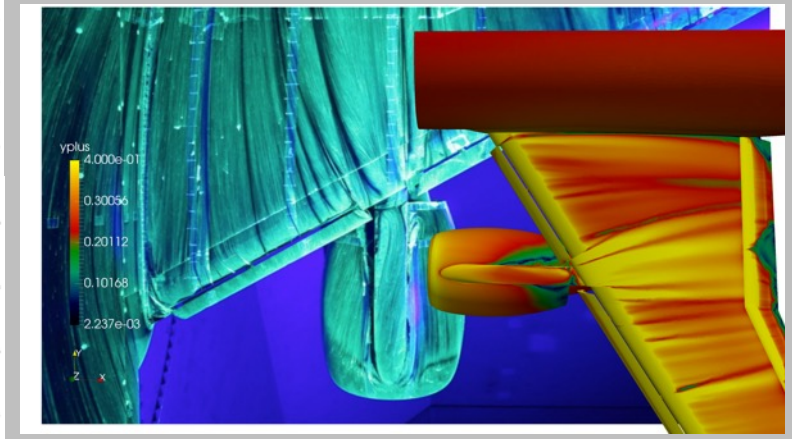

Section 10p47 AA-Eta=0.16
Slat
Main Wing
Flap
zCFD-SST
Exp
Cp
x/c
Section 10p47 DD-Eta=0.406
Section 10p47 HH-Eta=0.89


yplus
4.000e-01
0.30056
0.20112
0.10168
2.237e-03

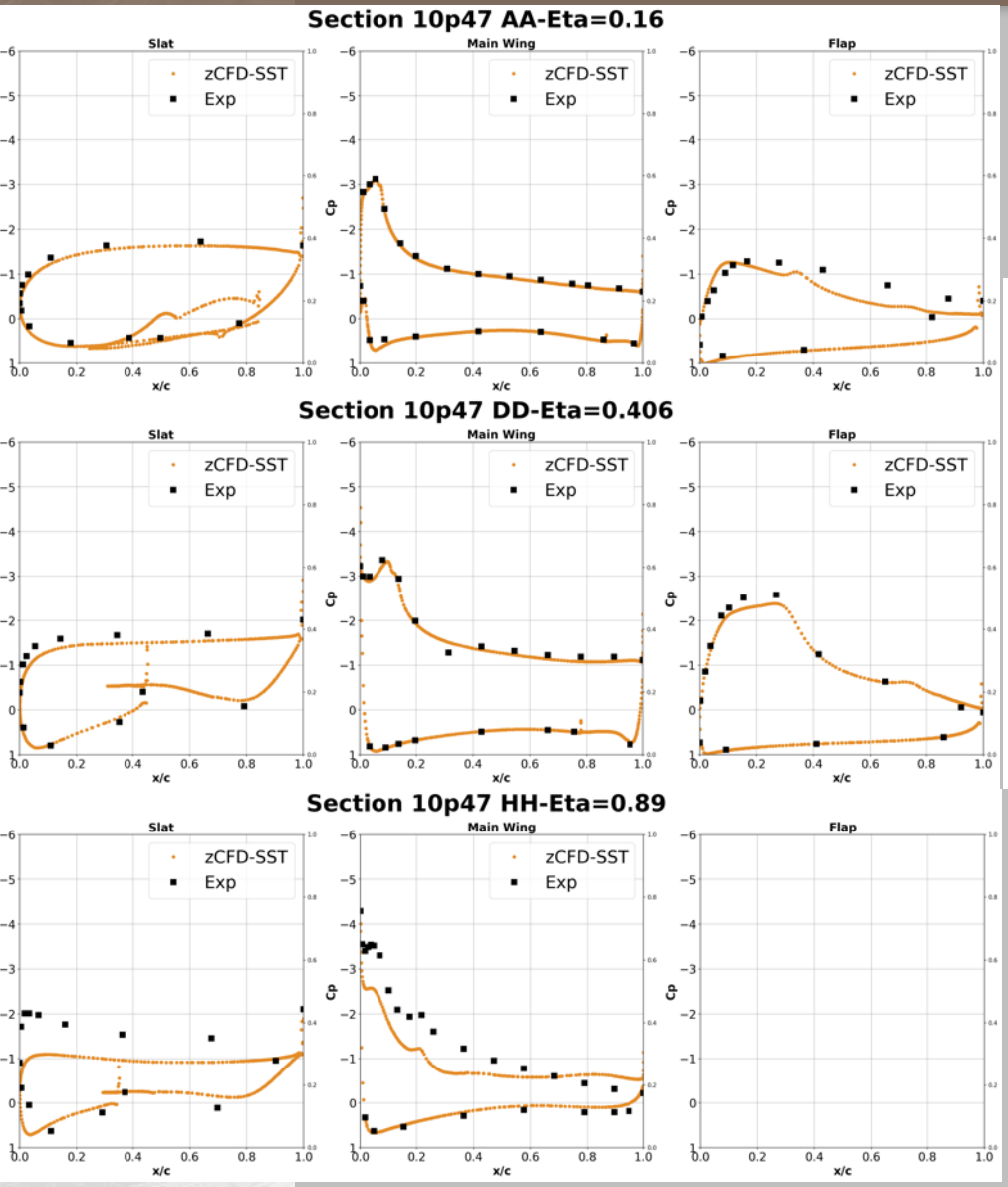
JSM Results


Section 4p36 AA-Eta=0.16
Section 4p36 DD-Eta=0.406
Section 4p36 HH-Eta=0.89
Slat
Main Wing
Flap
zCFD-SST
Exp
Cp
x/c


yplus
4.000e-01
0.30056
0.20112
0.10168
2.237e-03


yplus
4.000e-01
0.30056
0.20112
0.10168
2.237e-03

JSM Results


Section 10p47 AA-Eta=0.16
Slat
Main Wing
Flap
zCFD-SST
Exp
Cp
x/c
Section 10p47 DD-Eta=0.406
Section 10p47 HH-Eta=0.89

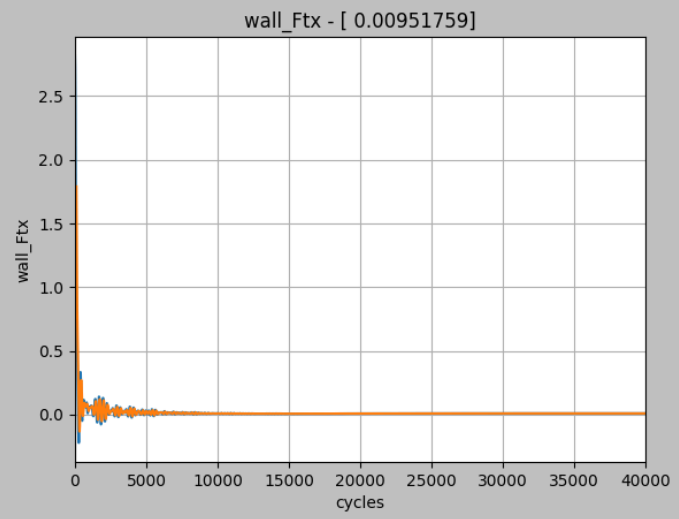
yplus
4.000e-01
0.30056
0.20112
0.10168
2.237e-03

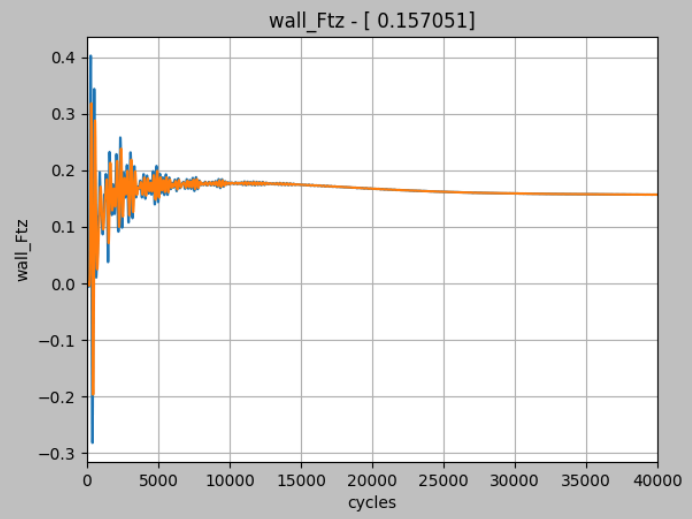
Case 3 Verification Study

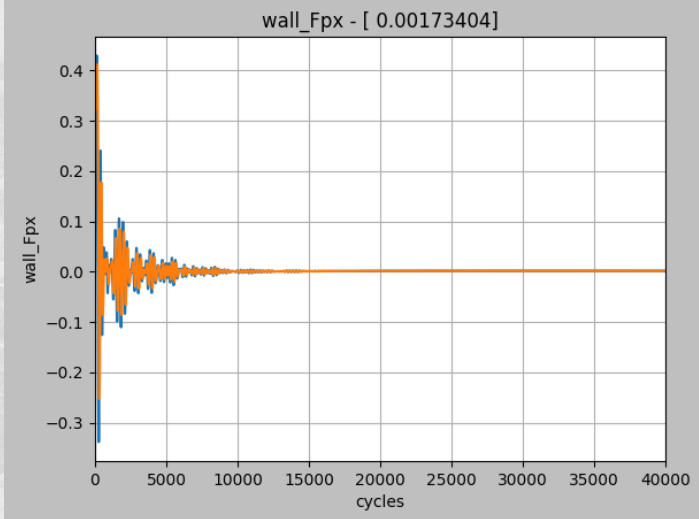
- Used the grids available on TMR website, L1-L5
- EVR = 0.09 (using 0.009 increased the convergence time), Ti = 0.088%, SUST term on (Controlled Decay)
- Production term based on vorticity magnitude (SST-VSust, TMR website)

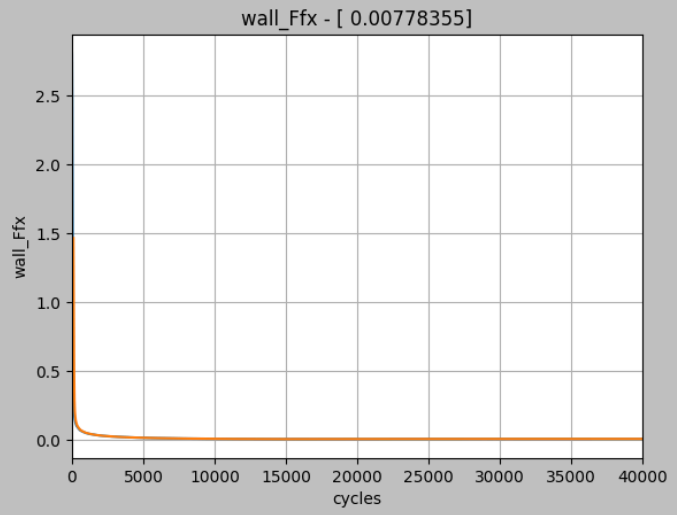
Case 3 Verification Study

- L5 Mesh

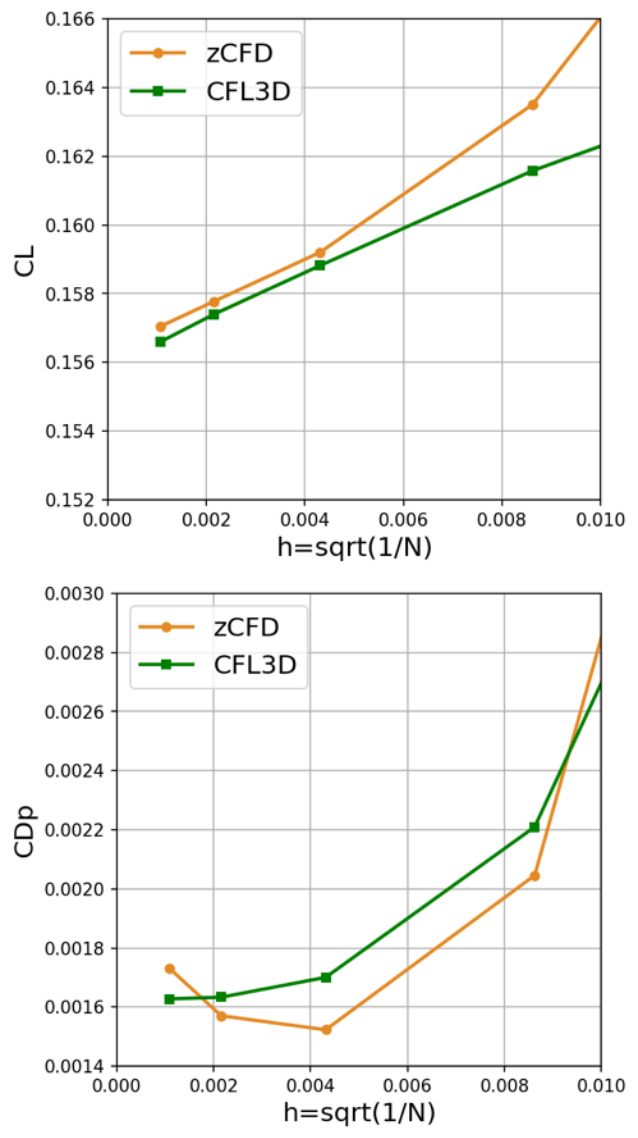


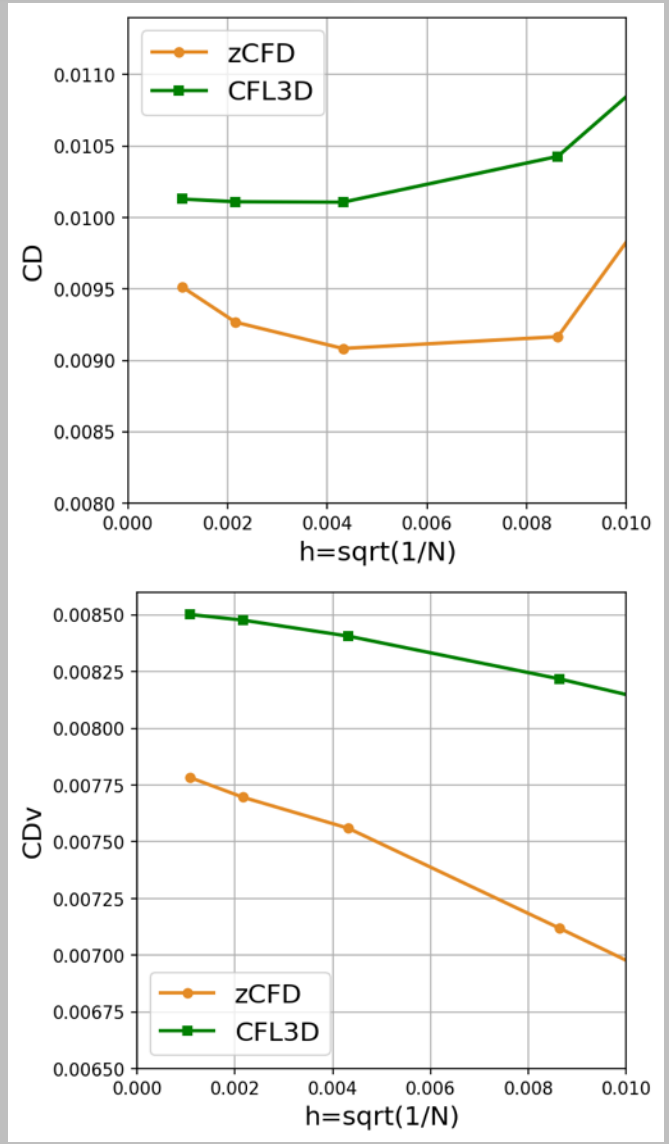




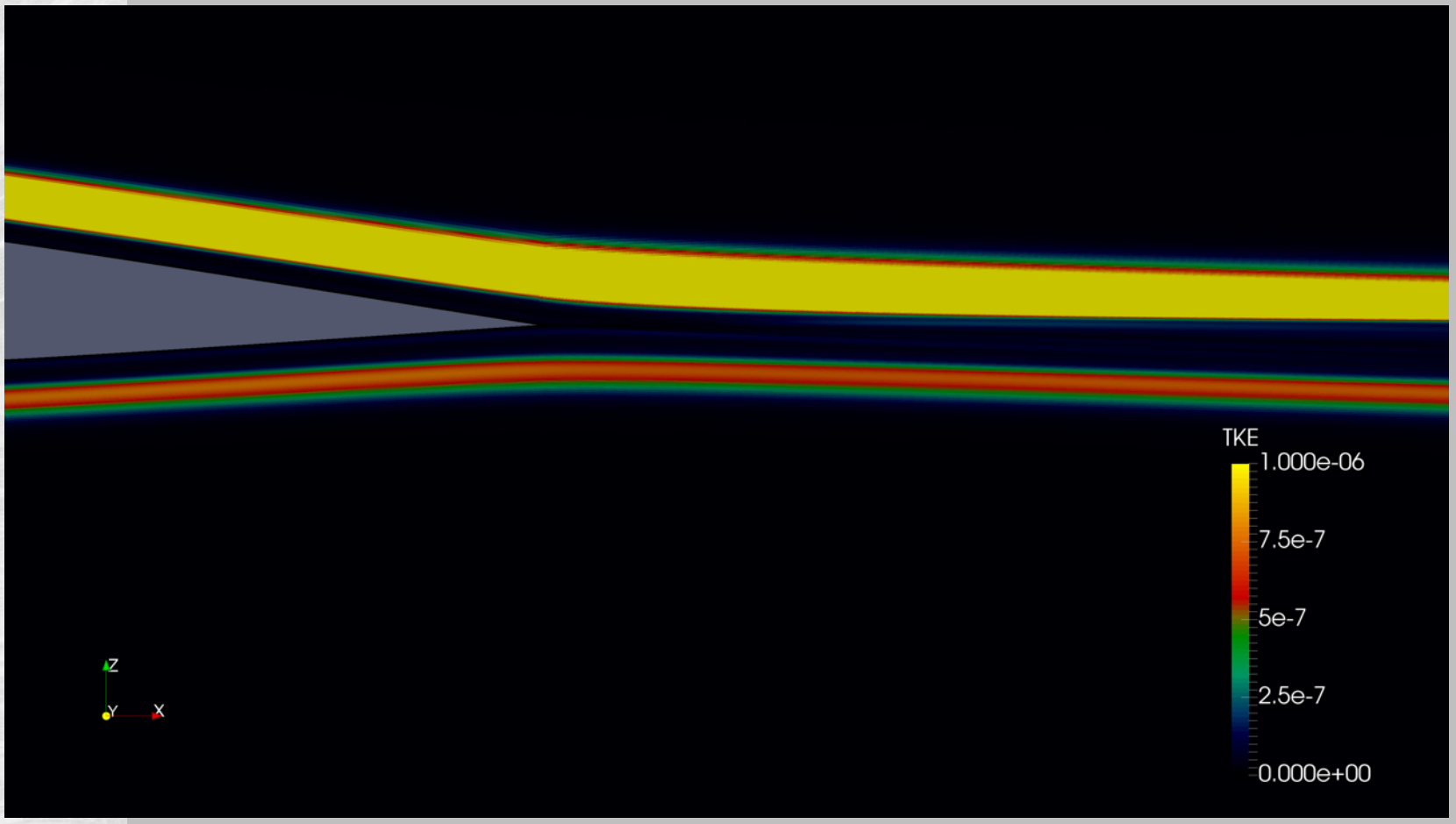


Case 3 Verification Study

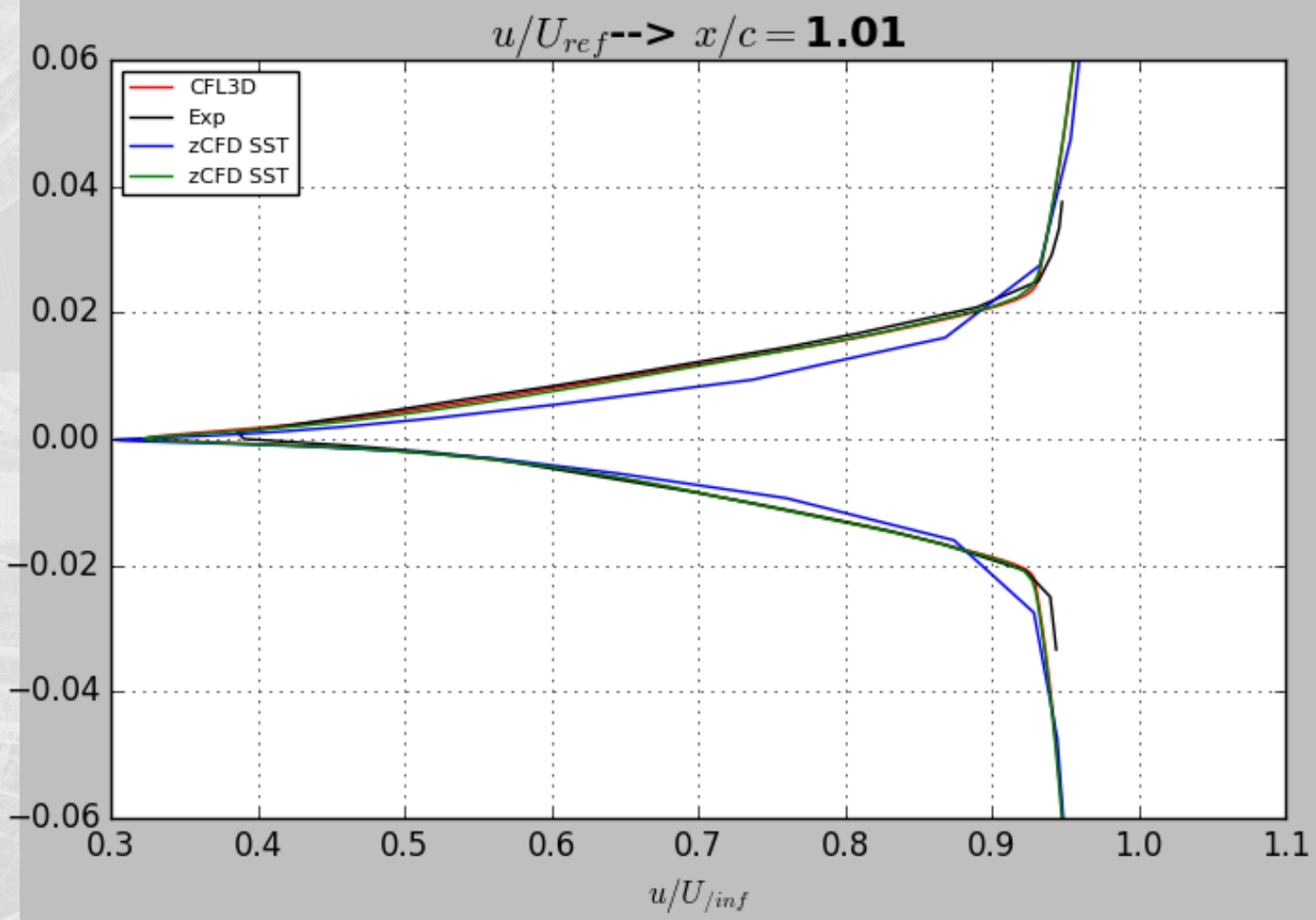




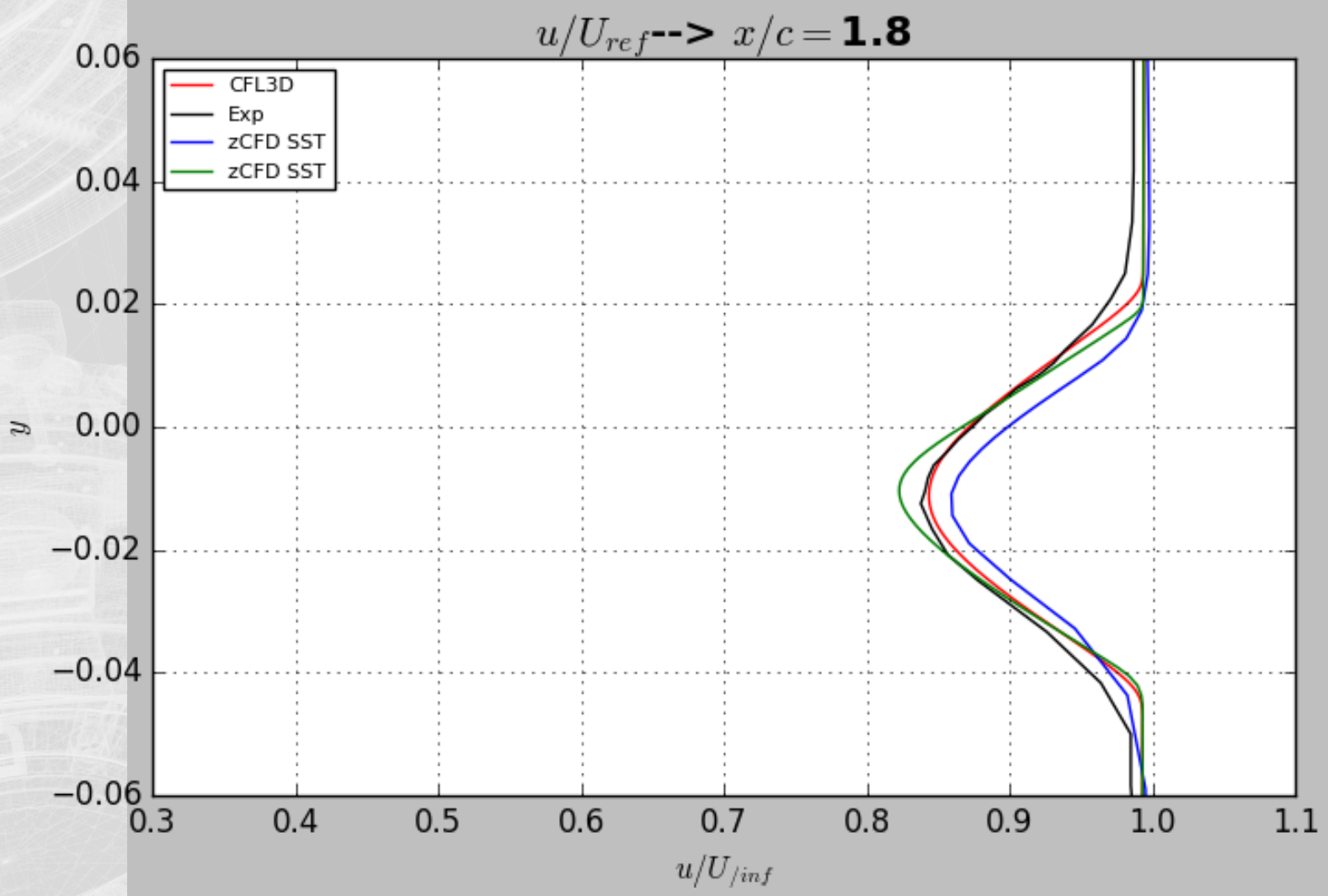
Case 3 Verification Study



Case 3 Verification Study



Case 3 Verification Study



Summary

- Restarting the solution from low alphas to high alphas is recommended in order build the flow field. Also it would be interesting to work backwards as well
- Consistent grid convergence study for the HL-CRM
- zCFD predicted flow features when compared with oil flow images for the JSM model
- Controlled decay can help in maintaining the flow attached