Embraer Contribution to DPW-8/AePW-4: Buffet WG

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Embraer

Drag Prediction Workshop 8, 6-7 June 2026

Volcano ScaLES

- **Spatial discretization**: Finite Difference 4th order (inviscid) + 2nd order (viscous)
- **Time integration**: Explicit (3rd order Runge-Kutta)
- **Initialization method**: Freestream / impulsive start for free air and grid-sequencing
- **Grid topology**: Octree Cartesian grids with immersed boundary
- **Typical mesh points**: up to 2 Billions (8 x Nvidia L40s)
- **Wall modeling**: Equilibrium Wall Modeling (Algebraic)
- **SGS closure**: Smagorinsky with Dynamic Procedure
- **Transition treatment**: None (numerical discretization controls it)
- **Typical time step normalized by CTU**: 2.2E-4
- **Aspect ratio range (tangential spacing/wall-normal):** 1
- **Wall model exchange location**: 1.5 x (Dx)
- **Relevant publication**:
  - Ashton et. al. “Immersed Boundary Wall-Modeled Large Eddy Simulations for the 5th High-Lift Prediction Workshop” AIAA 2025-0888

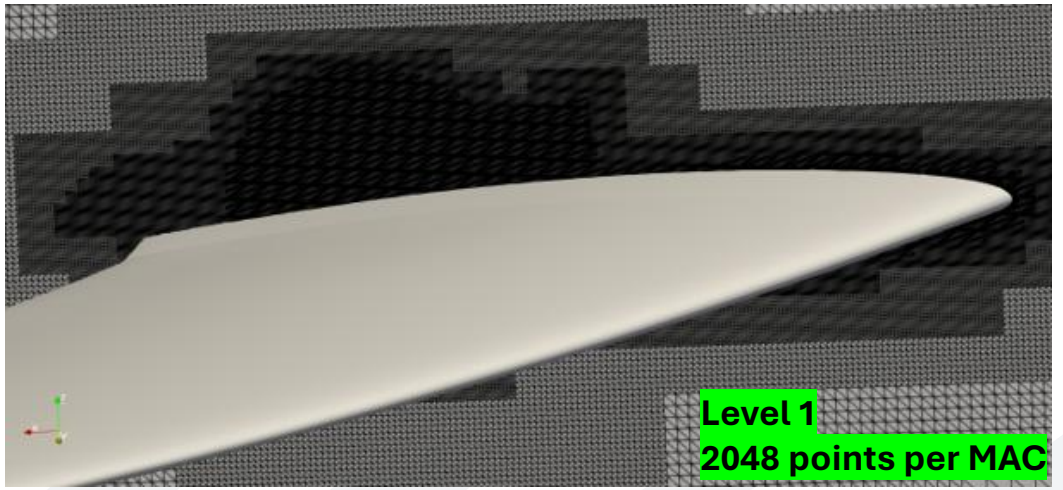
Simulation Setup

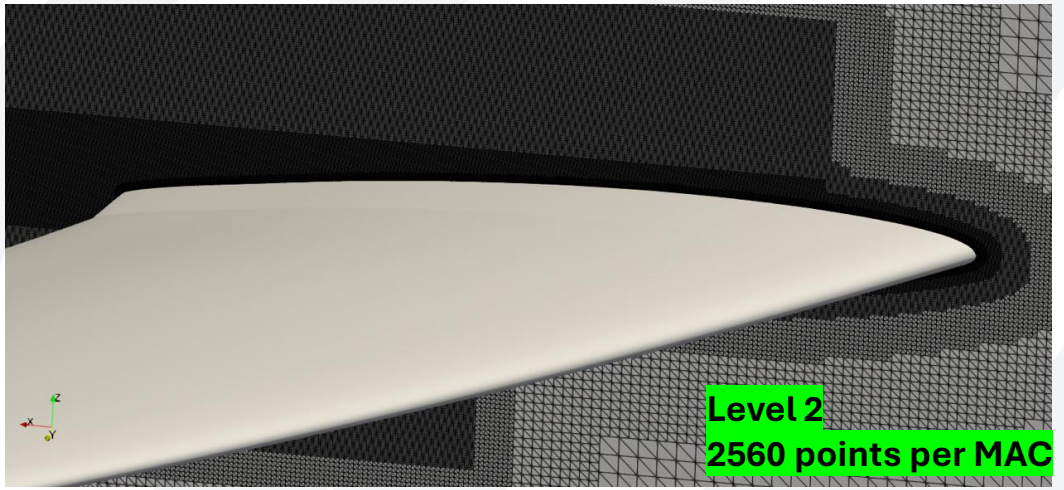
Mesh Generation

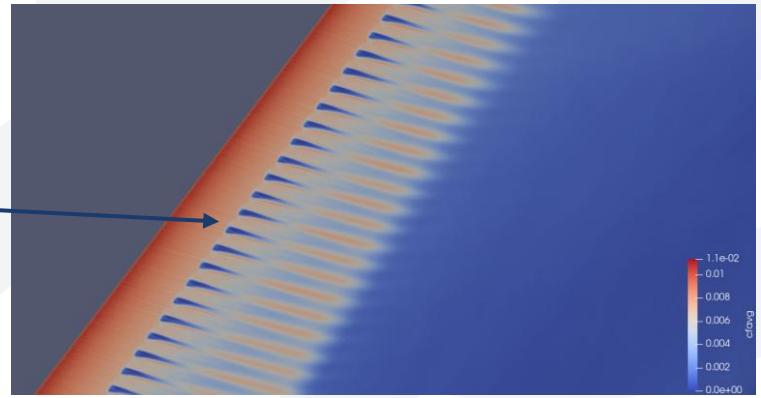
- Volume generated from wing deformed STL files.
- Two different grid strategies:
  - Localized refinement
  - Full wing surface and wake refinement.
- Numerical Transition Trip as close as the experimental data

Grid Level	2.16% NASA-CRM JAXA WT	
	Total Cells	Wall Time 10 CTUs [h] [8 x Nvidia L40S]
Level 1	490,936,330	2.93
Level 2	1,154,805,518	7.25

Grid Level	Transition Trip Information		
	Diameter [mm]	Distance [mm]	Height [mm]
Level 1	1.27	2.54	0.1477 [2dx]
Level 2	1.27	2.54	0.1182[2dx]
Experimental Test	1.27	2.54	0.0889-0.1143

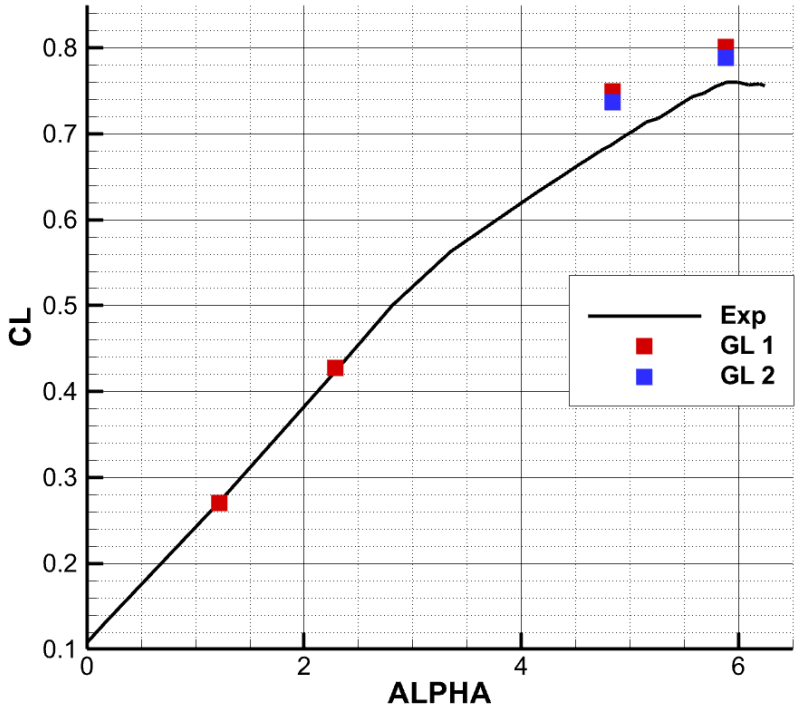


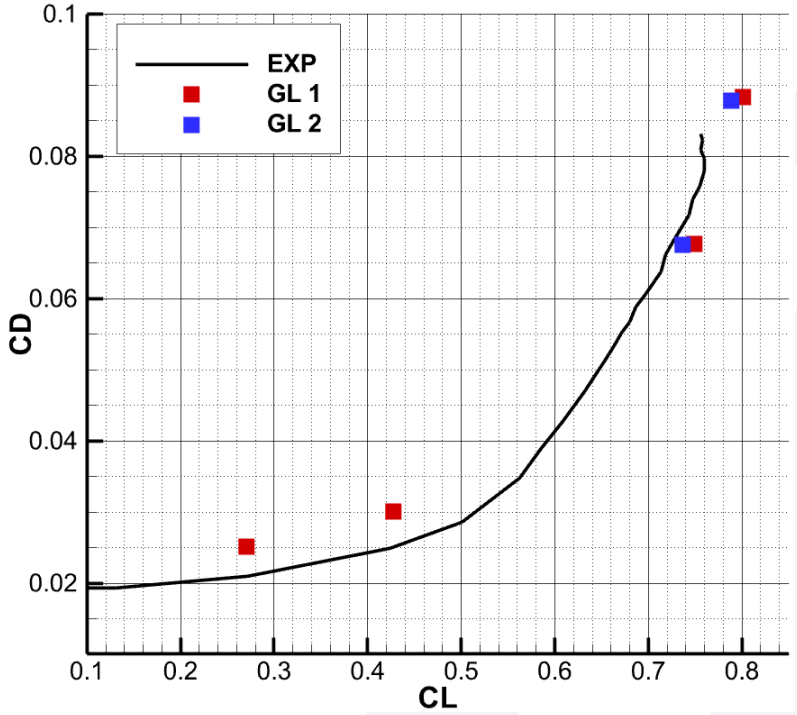


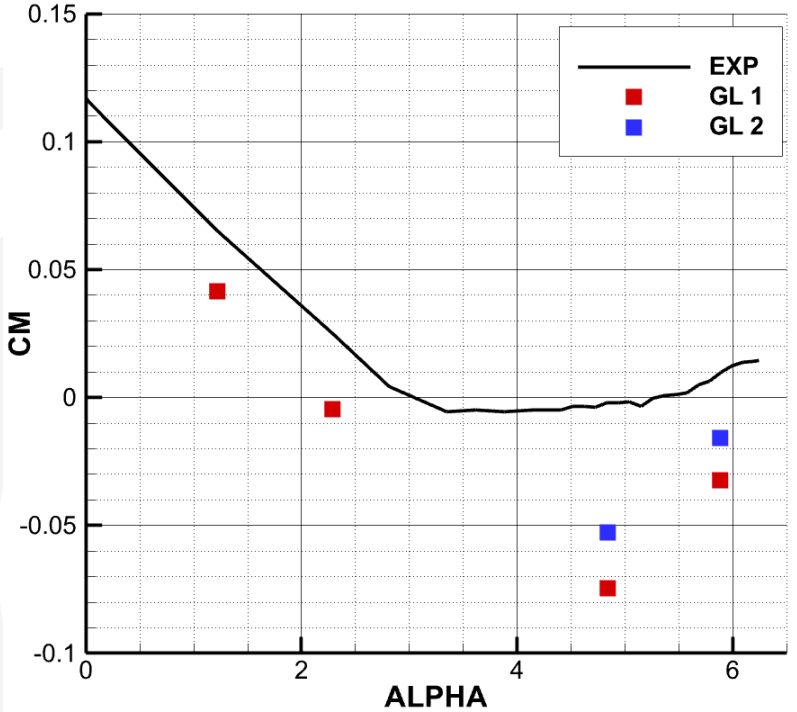


Results

Forces and Moments



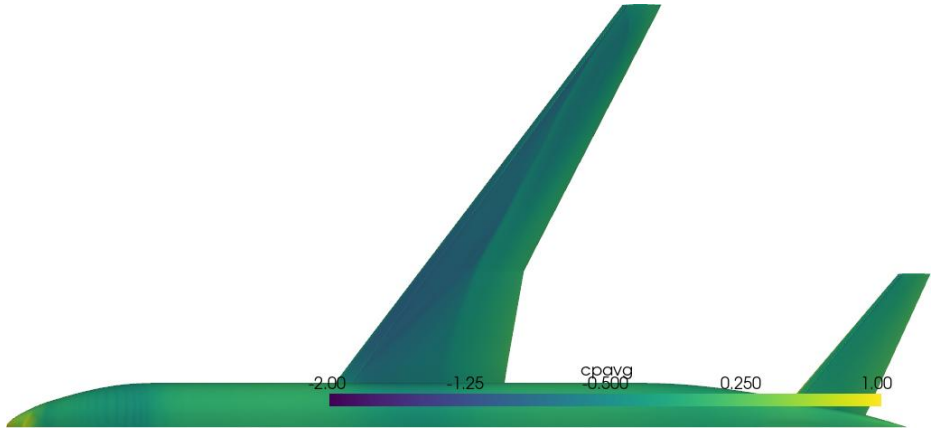


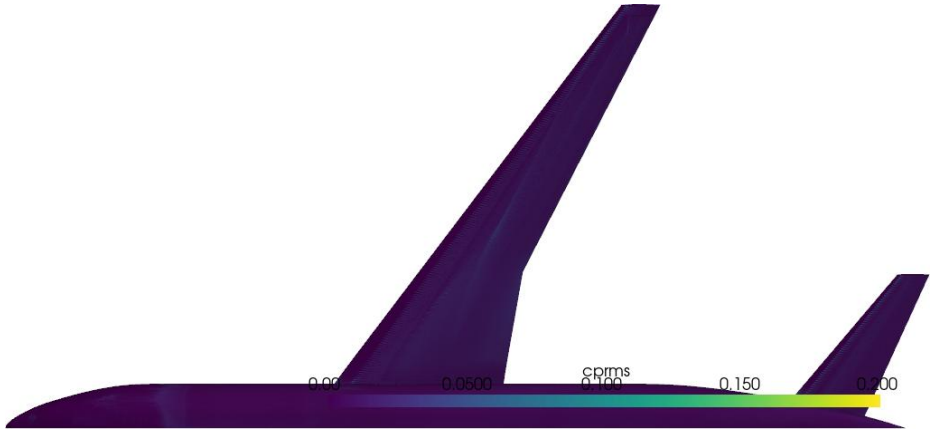


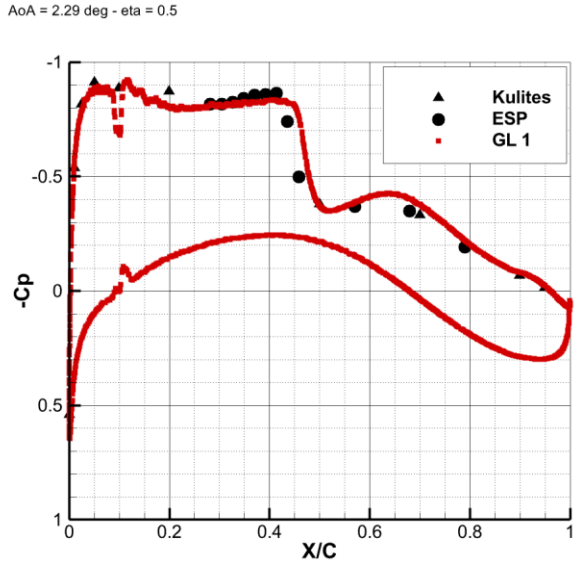
- Shock moves forward with grid refinement in the post-buffet region (AoA=4.84 and AoA=5.89deg).

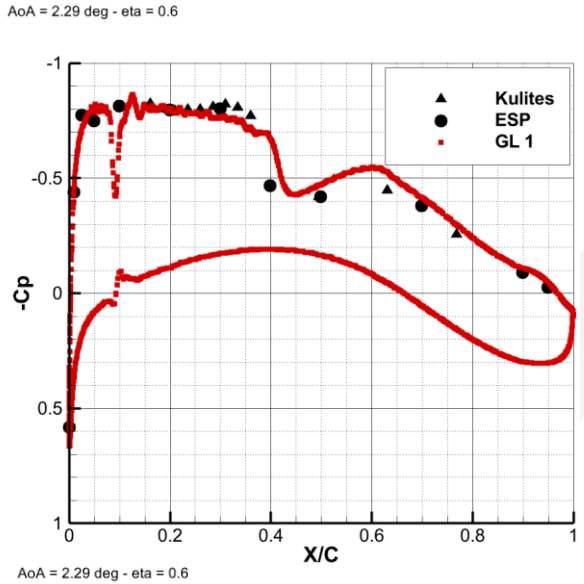
Results

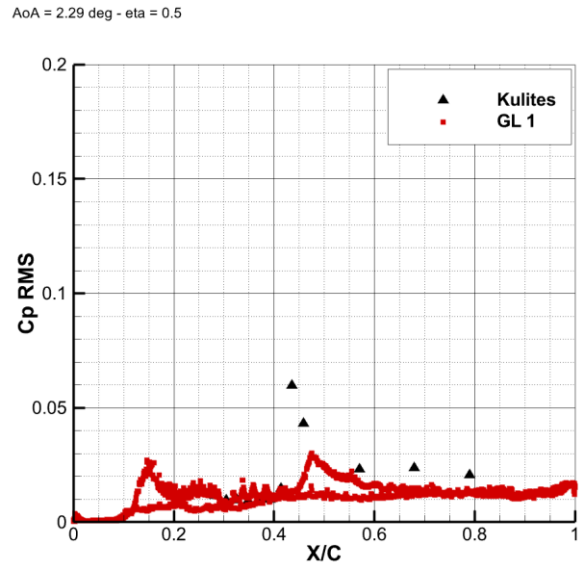
Pressure Coefficient at 2.29 deg

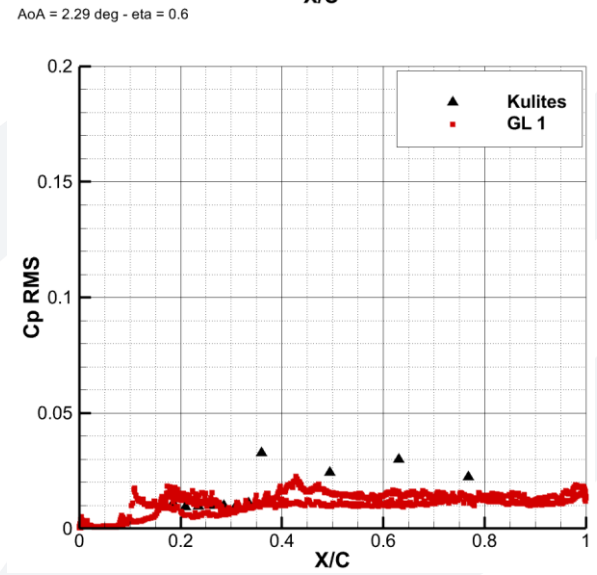






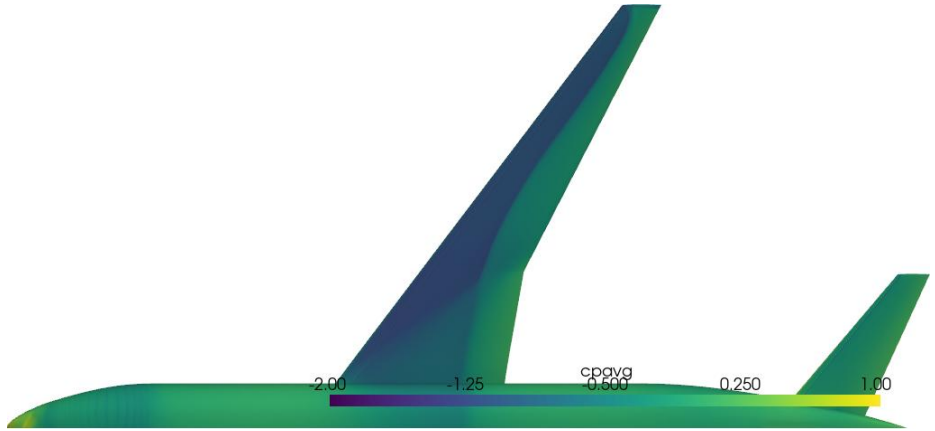


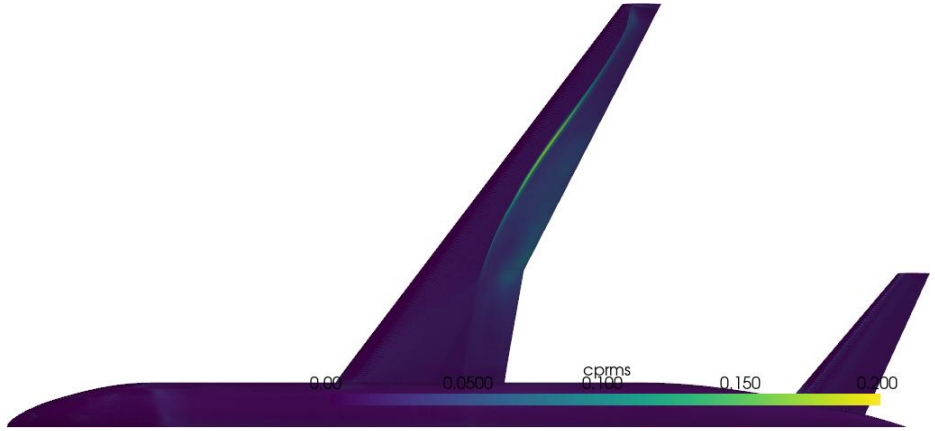


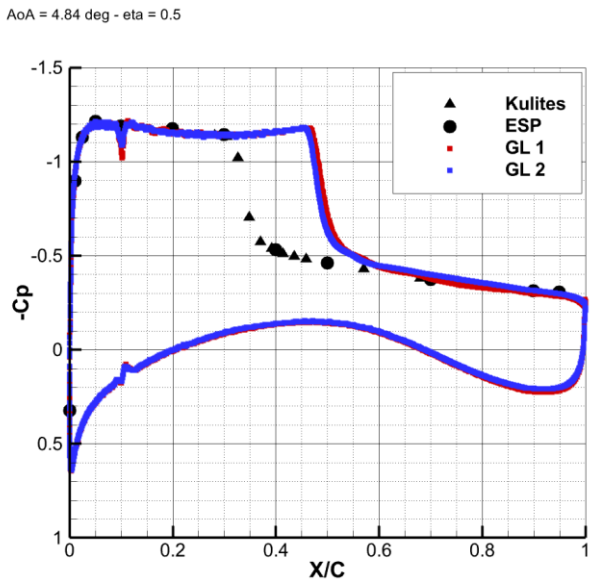


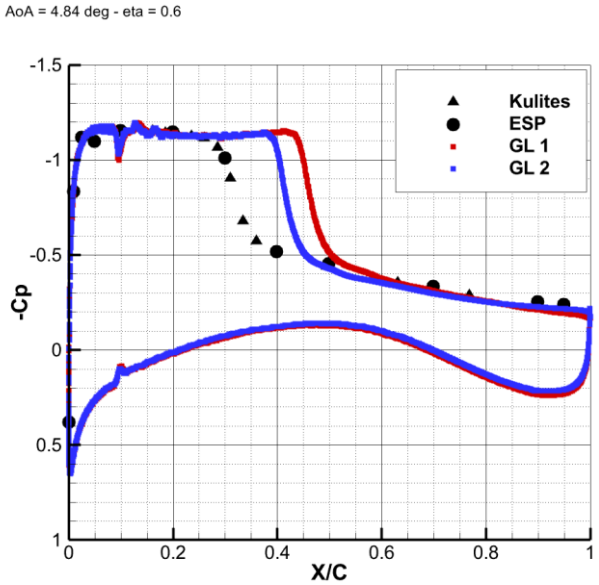
Results

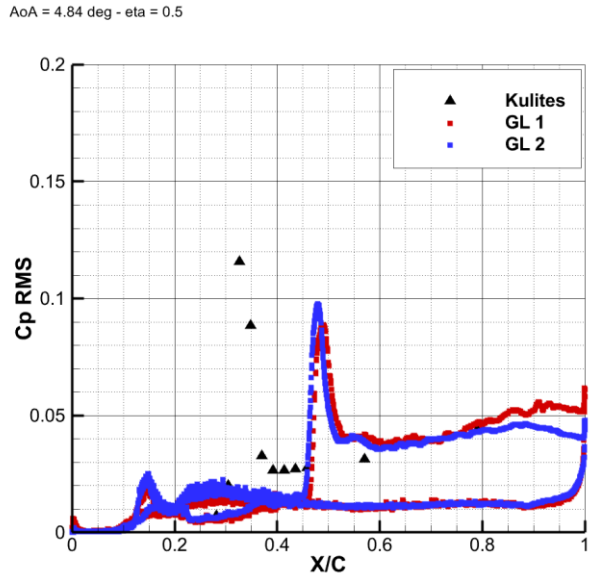
Pressure Coefficient at 4.84 deg

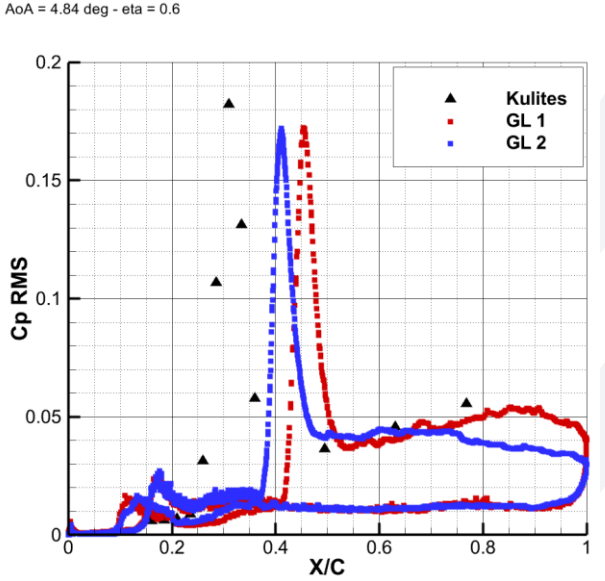






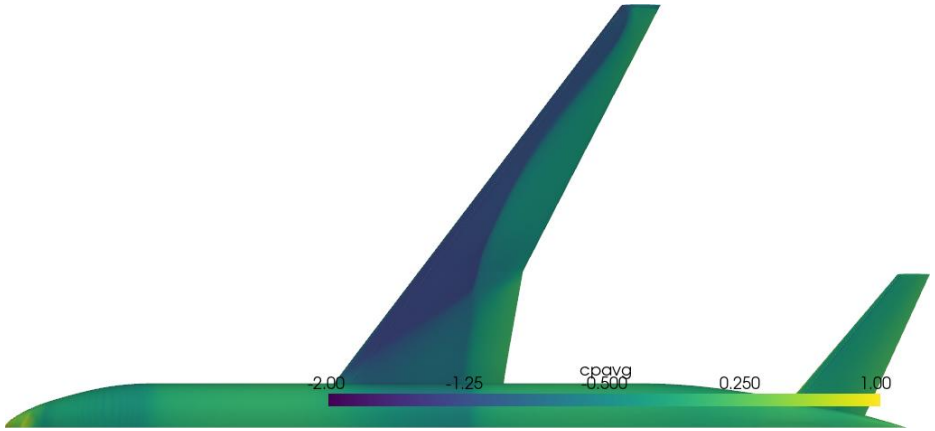


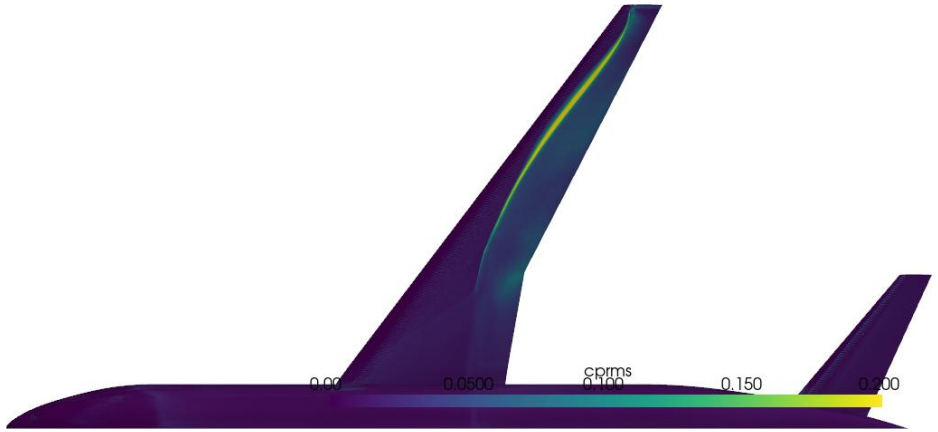


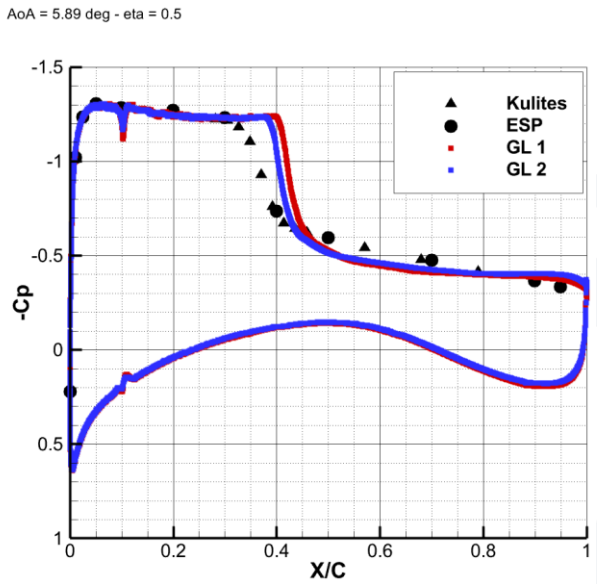


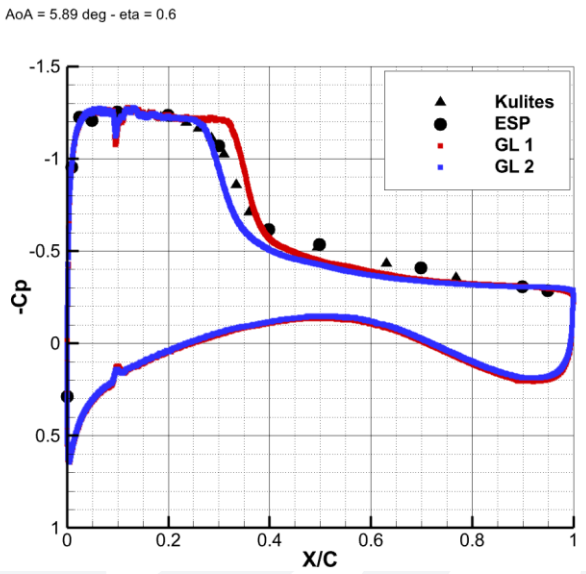
Results

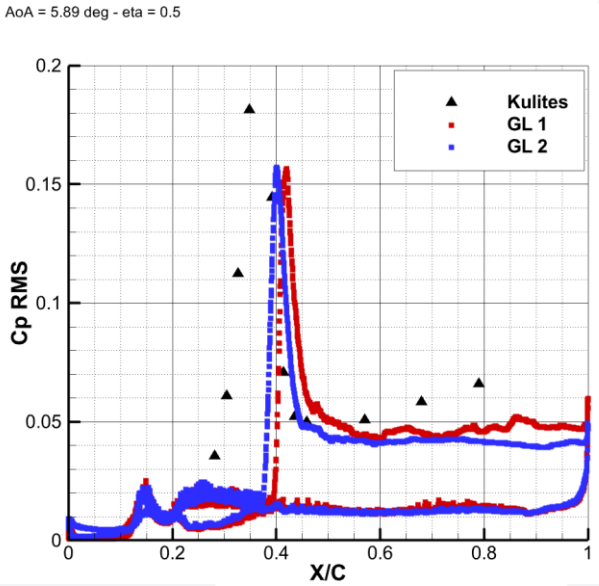
Pressure Coefficient at 5.89 deg

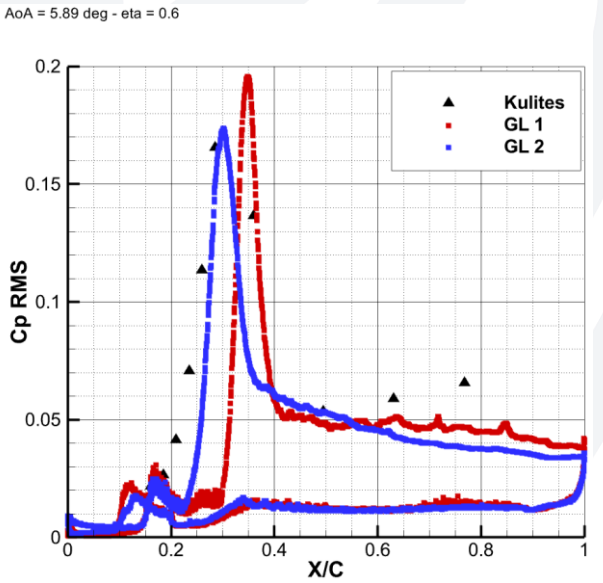






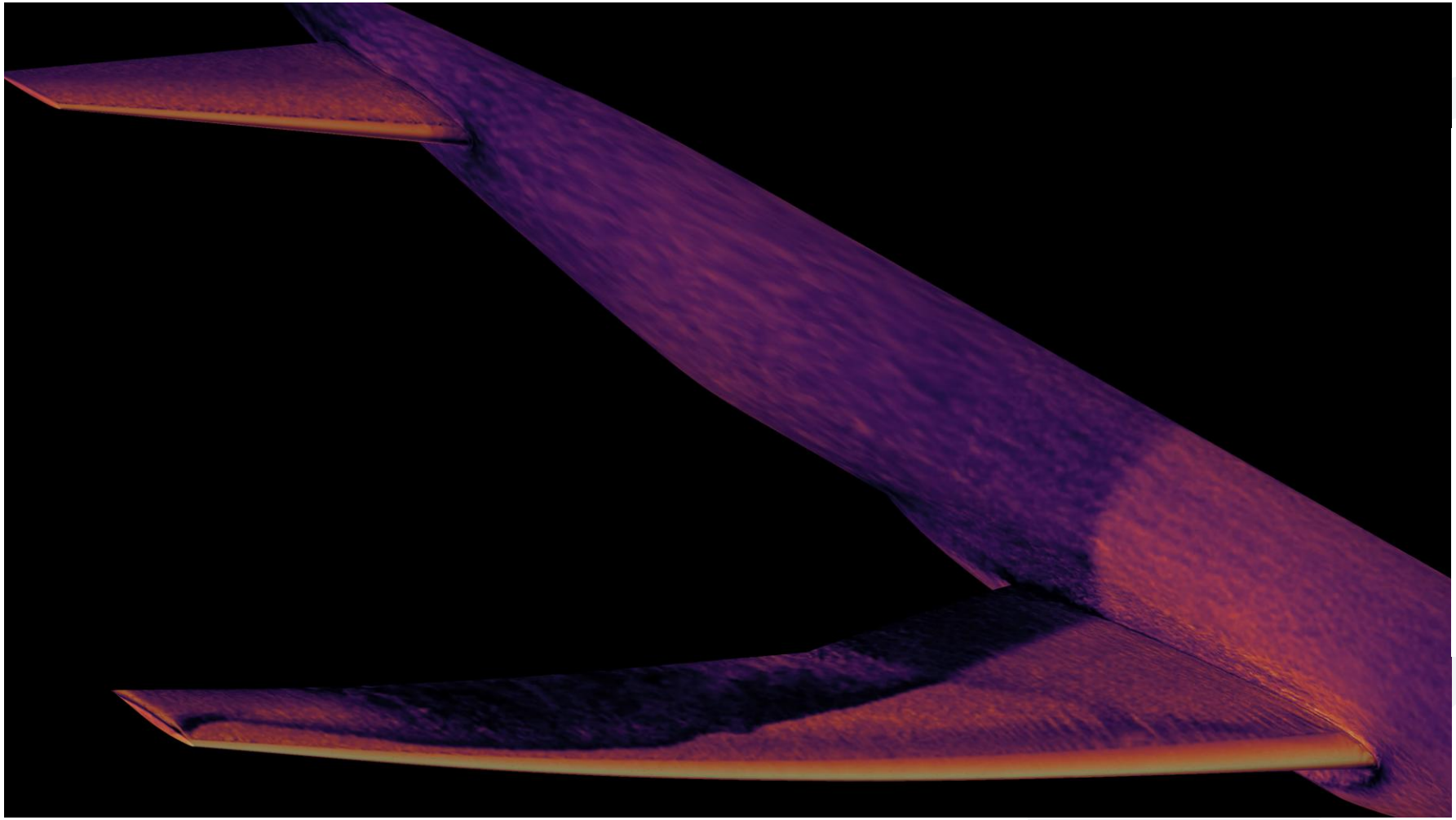


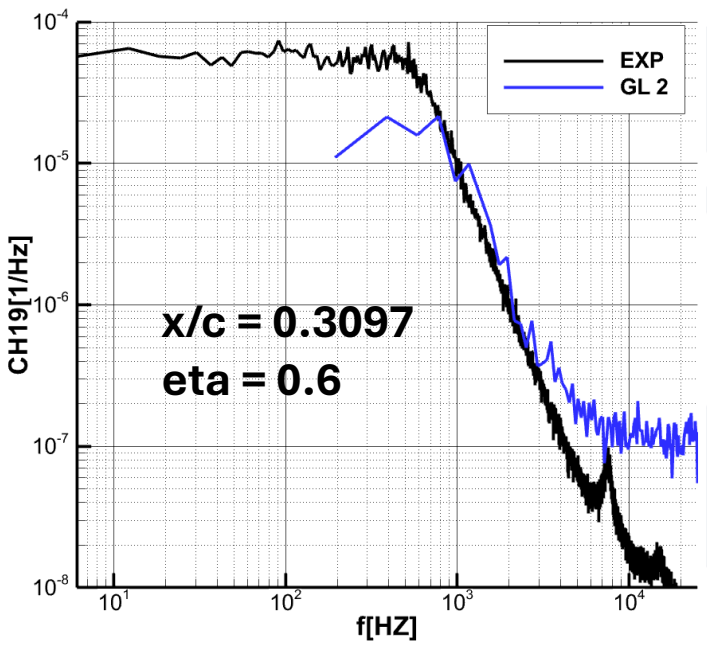




Results

Instantaneous skin-friction dynamics





Spectra computed from ~100CTUs

Summary

- The present work demonstrated the capability of **WMLES** to capture key aerodynamic features of the NASA CRM JAXA model in both **pre- and post-buffet** regimes.
- Grid refinement revealed a systematic upstream movement of the shock in the post-buffet conditions, highlighting a strong sensitivity of buffet dynamics to spatial resolution and indicating that **additional grid refinement/topology studies are required.**
- The instantaneous skin-friction field clearly shows the **highly unsteady nature of the shock-boundary layer interaction and the evolution of buffet cells**; reinforcing the need for **scale-resolving simulations**.
- Accurate spectral characterization of buffet requires **long time integration**: while **~100 CTUs** were used in this study, **more than 500 CTUS are necessary** to properly resolve low-frequency content, leading to **significant computational cost**, even with highly optimized finite-difference GPU code.

Thank You