CREATE
COMPUTATIONAL RESEARCH AND ENGINEERING ACQUISITION TOOLS AND ENVIRONMENTS

HPCMP CREATE™-AV Kestrel Simulations for the DPW-8/AePW-4 Buffet Working Group

DPW-8/AePW-4: Buffet Working Group

Sunday, 7 June 2026

HPC MODERNIZATION PROGRAM

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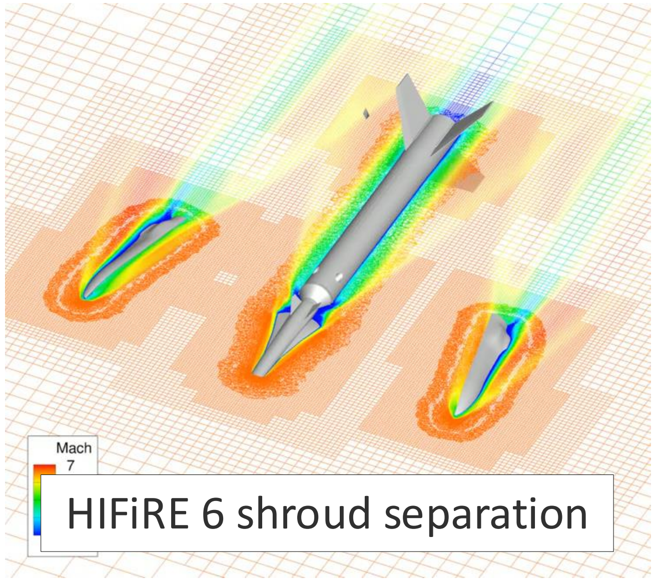
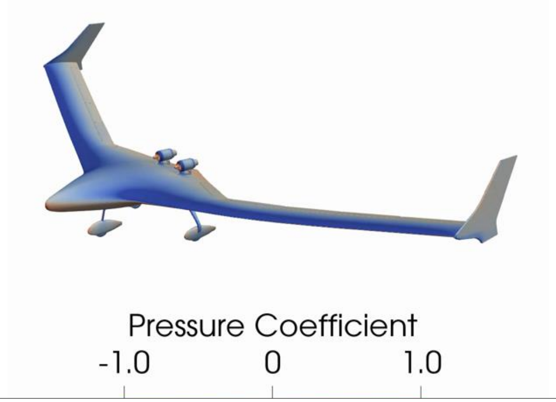
HPCMP CREATE™-AV Kestrel

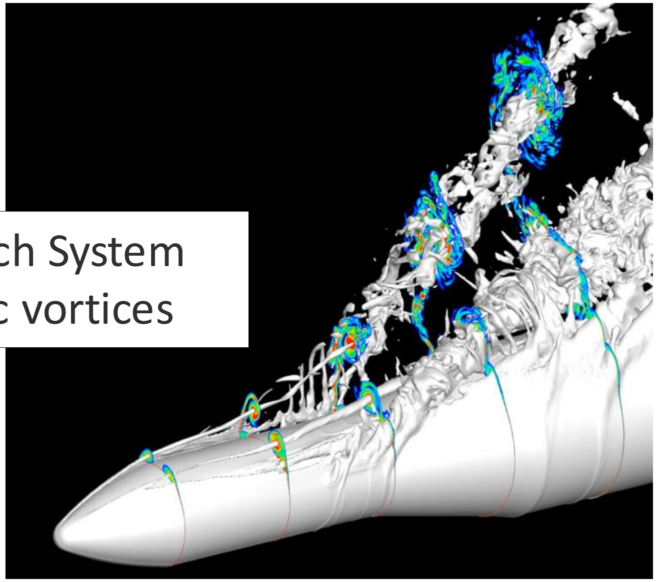
- **Multiphysics simulation code supporting US DoD programs of record**
  - Key application areas include hypersonics, store-separation, and tunnel support
  - Full spectrum of flight conditions, missions, and vehicle types
  - Coupled physics: **aerodynamics**, thermochemistry, aero-heating, **structural dynamics**, propulsion, flight controls, 6-DoF motion w/ generalized constraints, separation/contact/collision
  - Easy for users to learn, use, customize, and extend



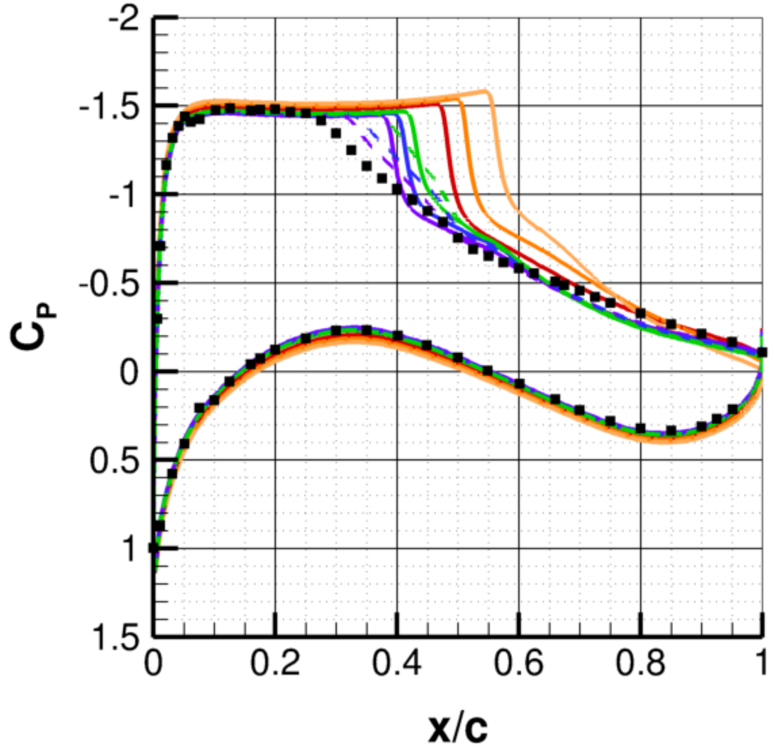
HIFiRE 6 shroud separation

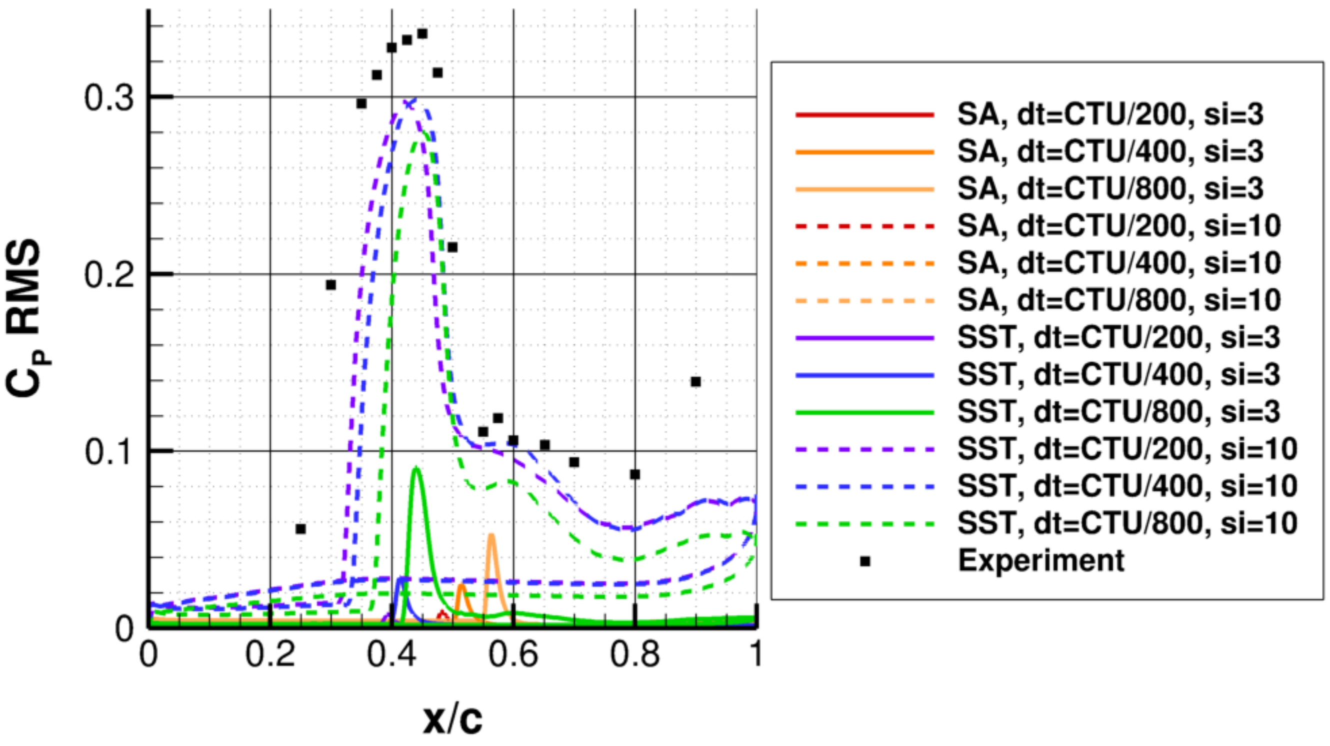


X-56A Body-Freedom Flutter


Space Launch System asymmetric vortices

Case 1 Key Findings



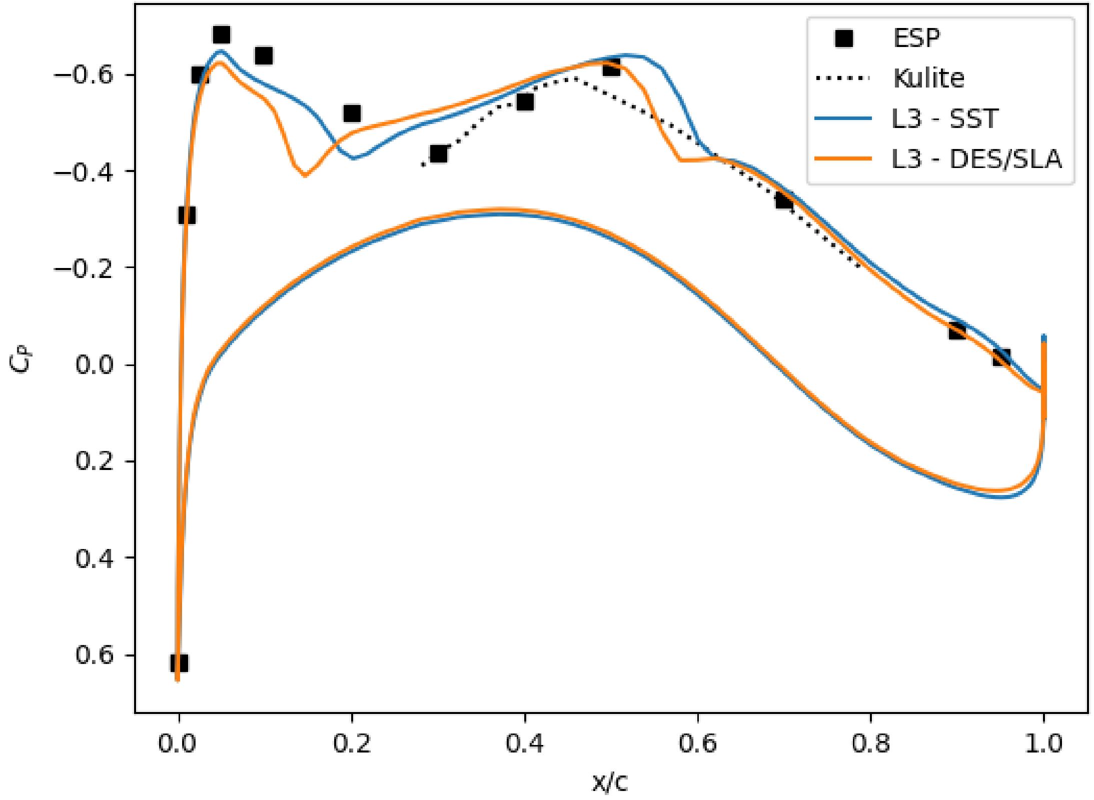


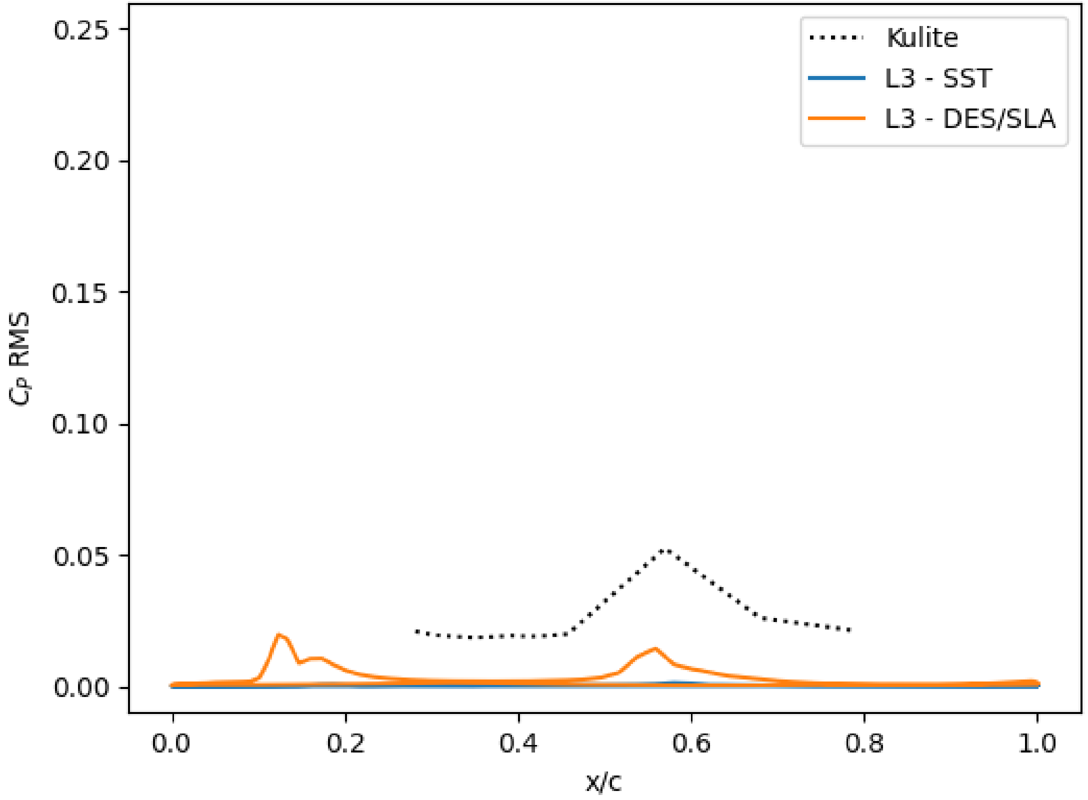
- **Using Kestrel on the Cadence grids, SST worked much better than SA on this problem.**

Case 2 Setup and Challenges

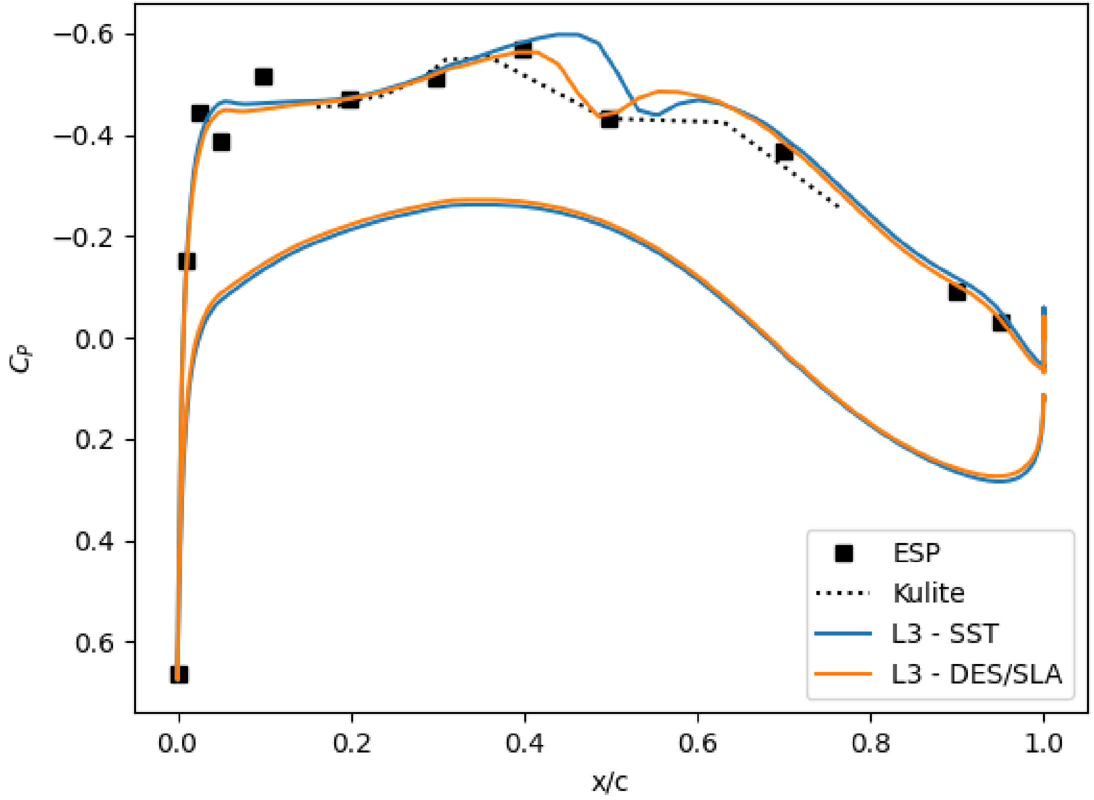
- **Kestrel Setup**
  - Use workshop-provided unstructured grids from Cadence
  - Look at both URANS and Hybrid RANS/LES
    - Menter SST with compressibility correction, rotational/curvature correction, and QCR 2020
    - “Shear Layer Aligned” formulation of DES
  - Using Kestrel’s “FN1+NN” expanded gradient stencil
  - 3rd Order MUSCL
- **Challenges**
  - URANS cases refused to go unsteady on grid levels L1 and L3
    - Tried different limiters, time steps, subiterations, 2nd Order, “kicking”, transition model
  - Hybrid RANS/LES went unsteady right away

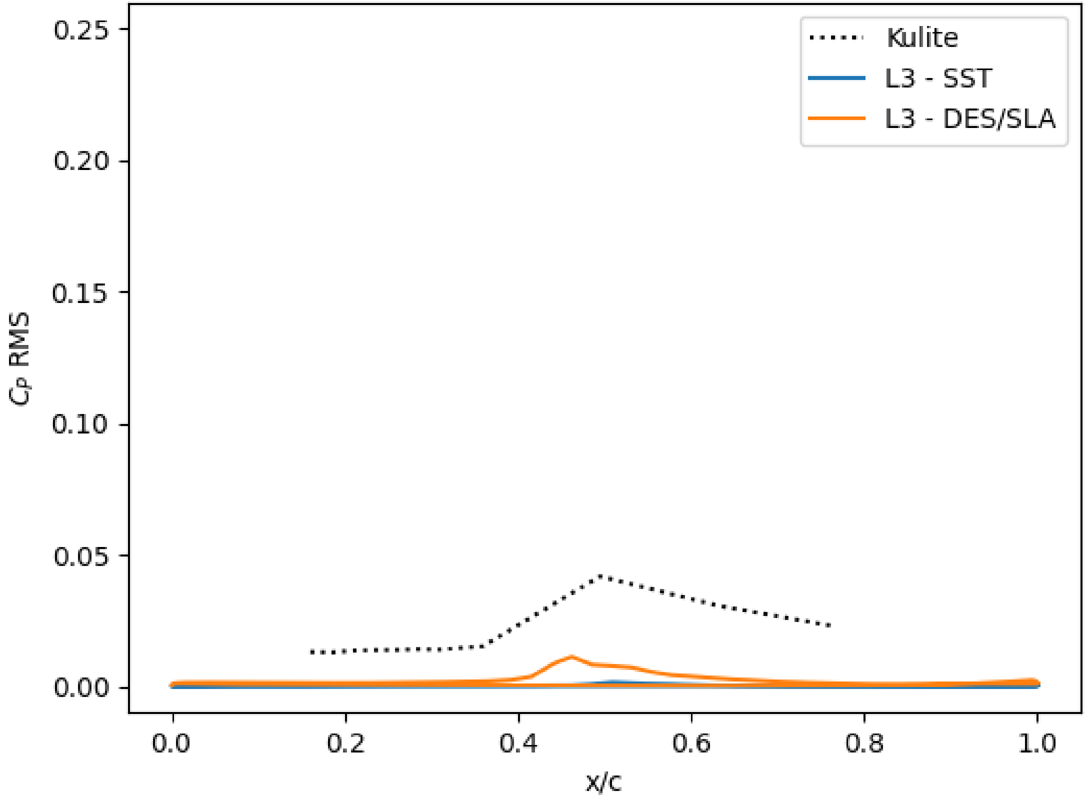
Case 2 Results – C_P and C_P RMS, α = 1.22°, η = 0.5



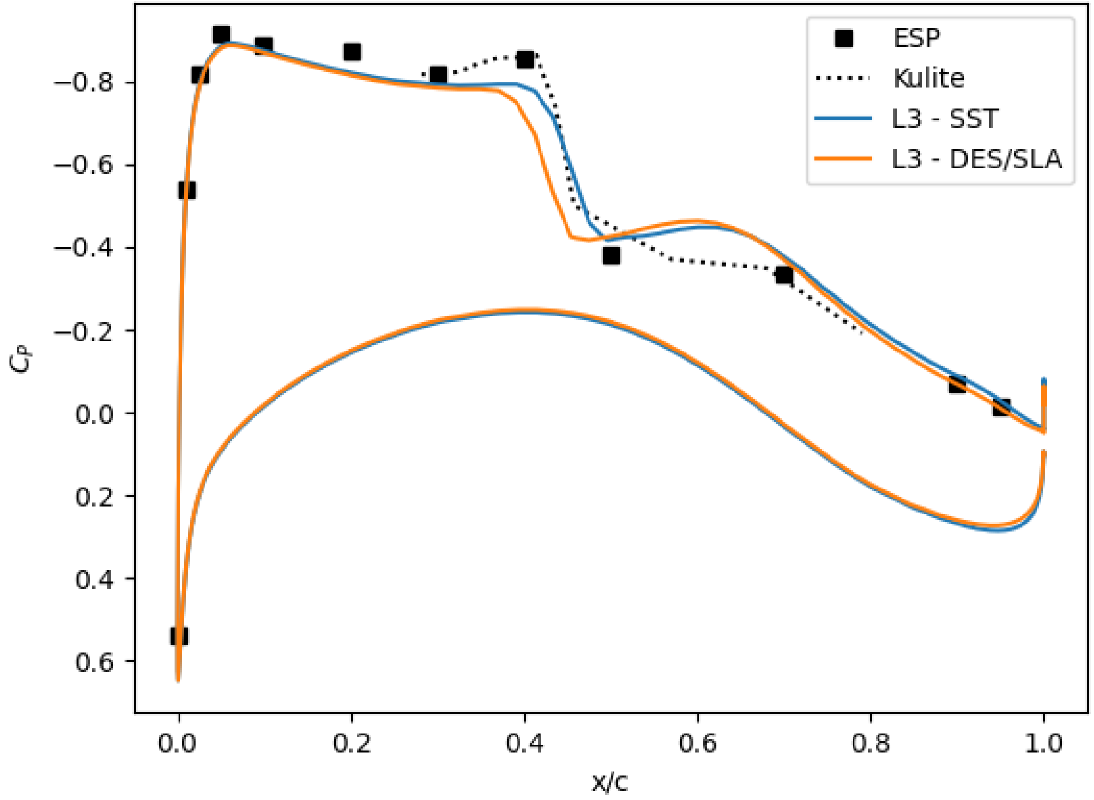


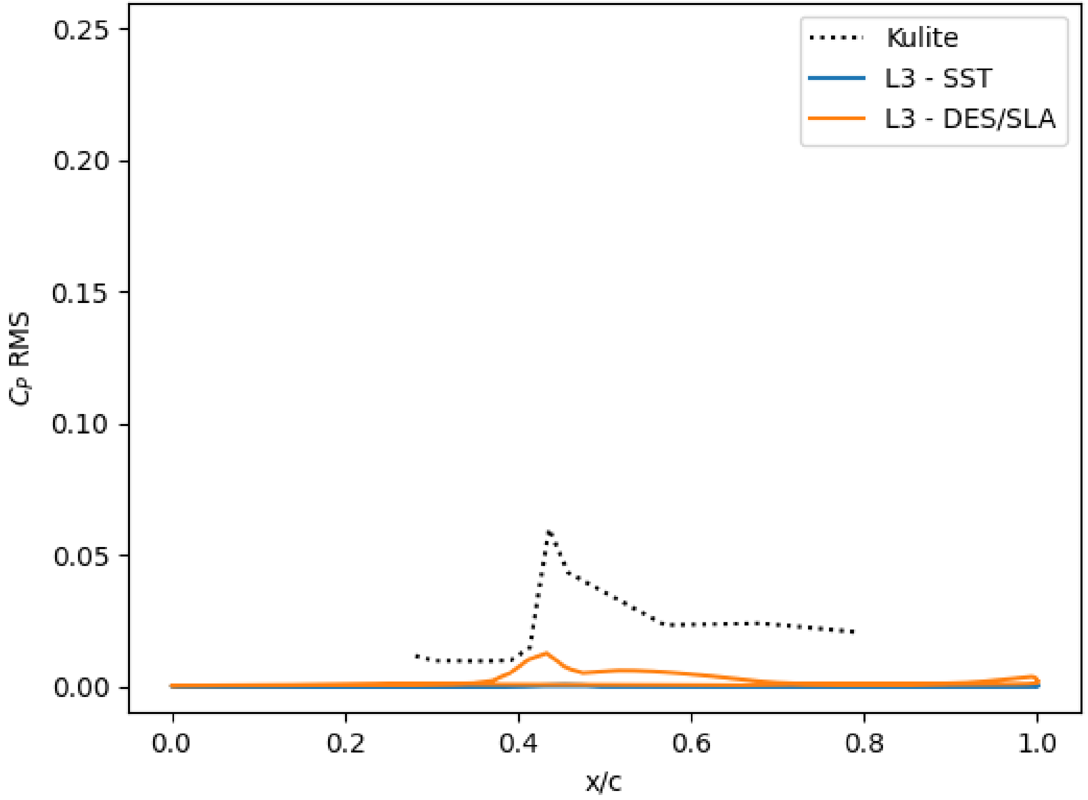
Case 2 Results – C_P and C_P RMS, α = 1.22°, η = 0.6



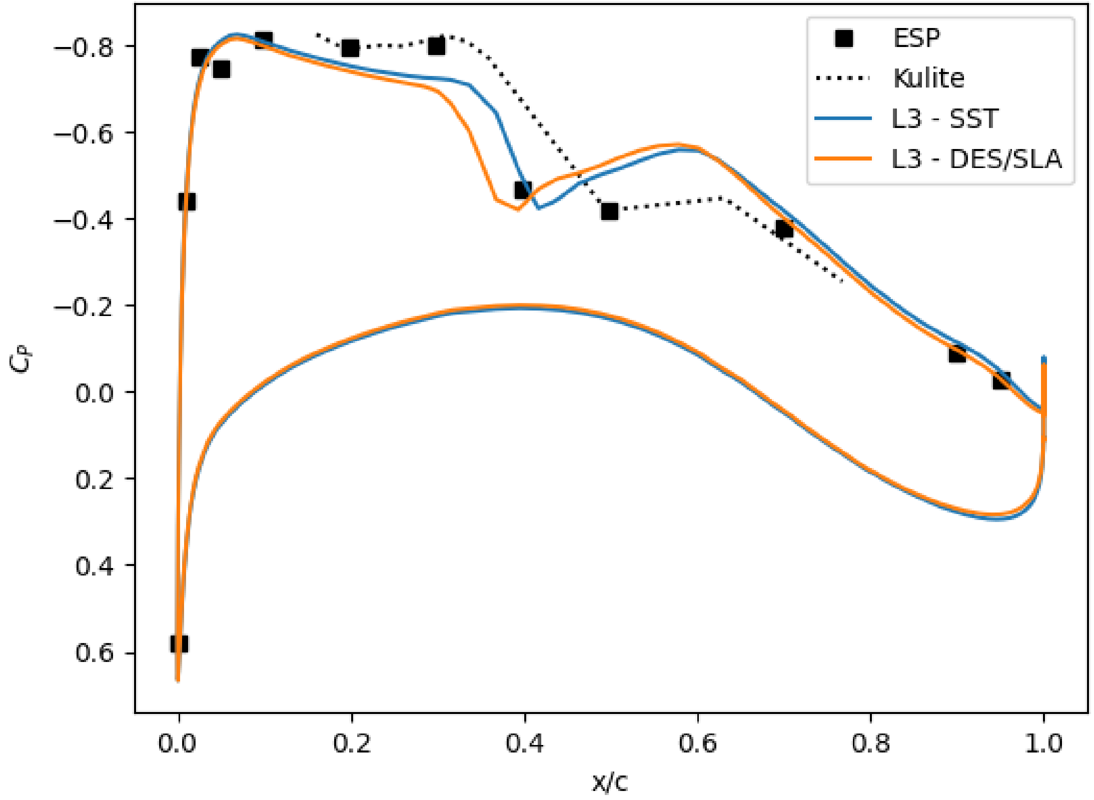


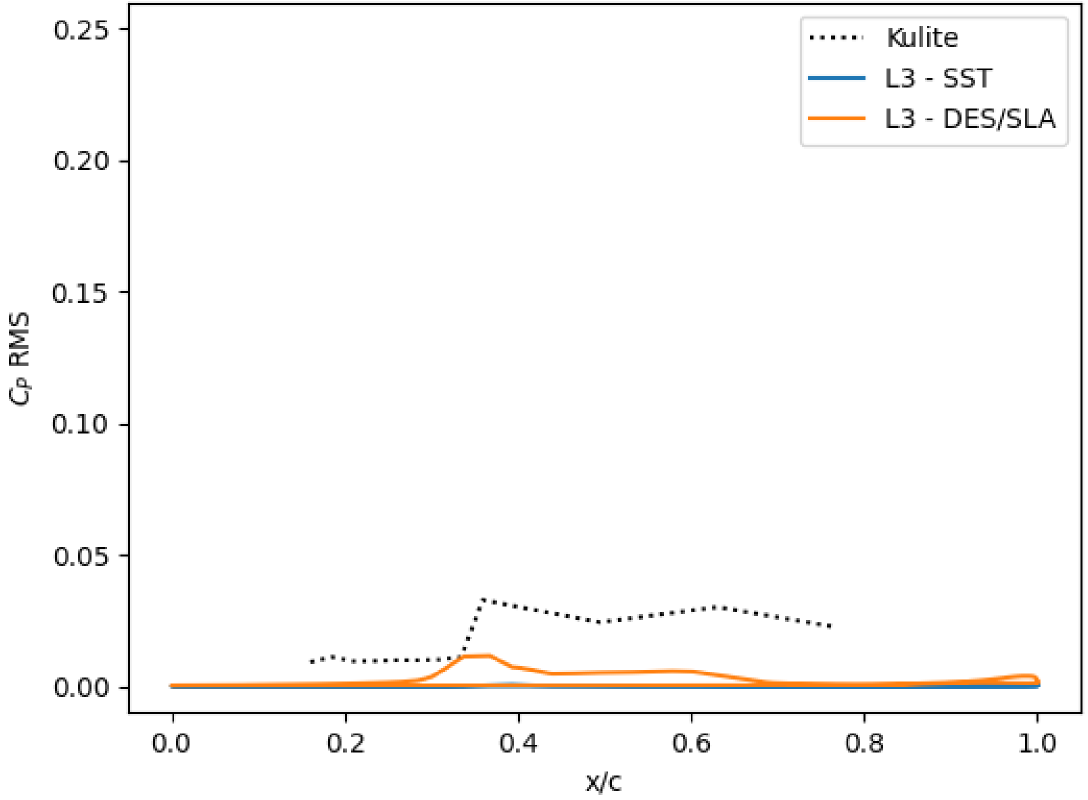
Case 2 Results – C_P and C_P RMS, α = 2.29°, η = 0.5



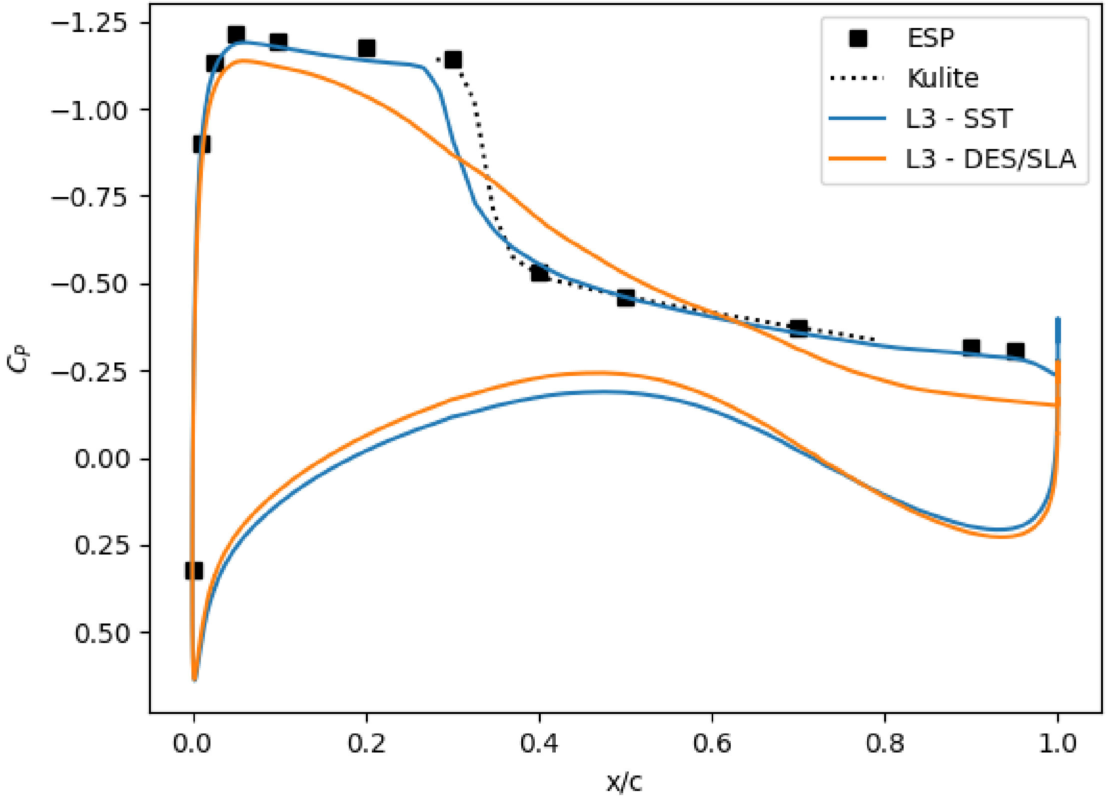


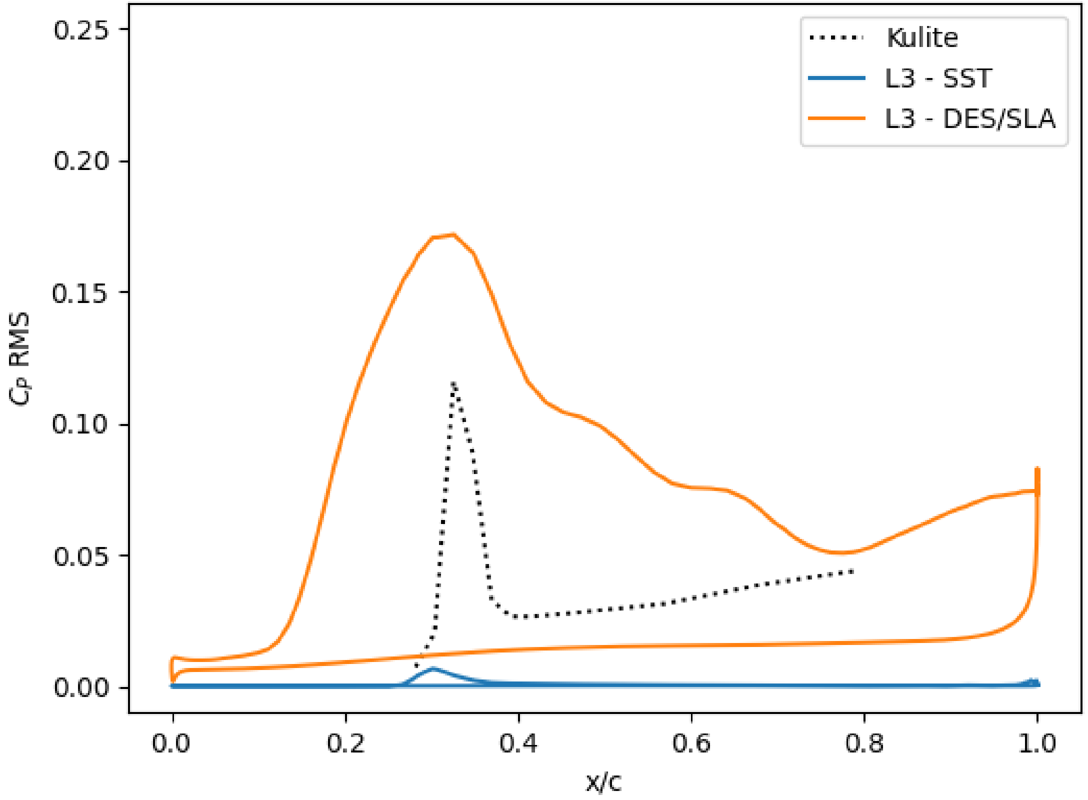
Case 2 Results – C_P and C_P RMS, α = 2.29°, η = 0.6



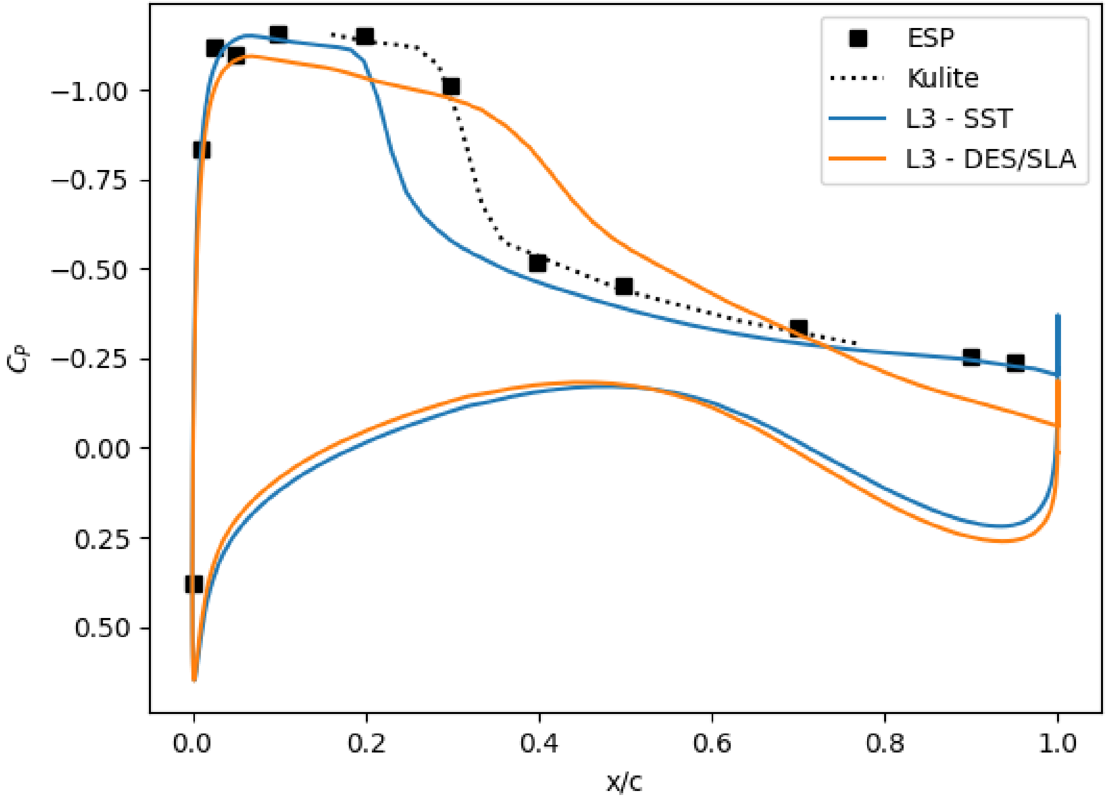


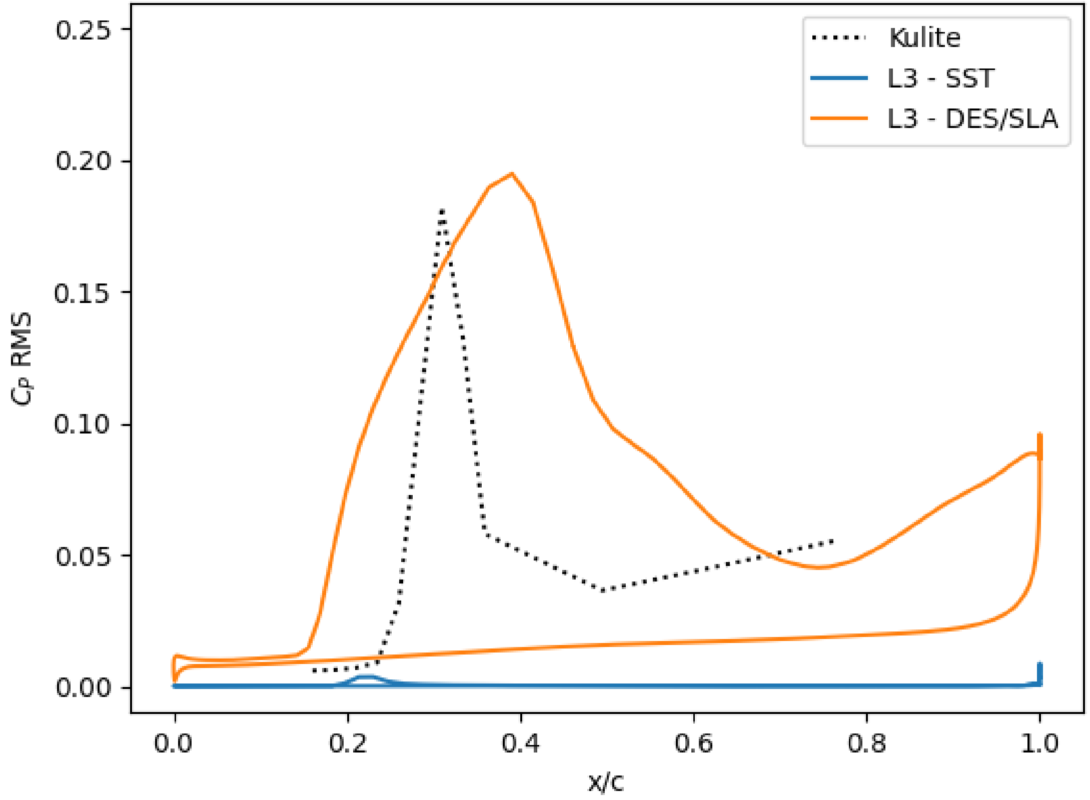
Case 2 Results – C_P and C_P RMS, α = 4.84°, η = 0.5



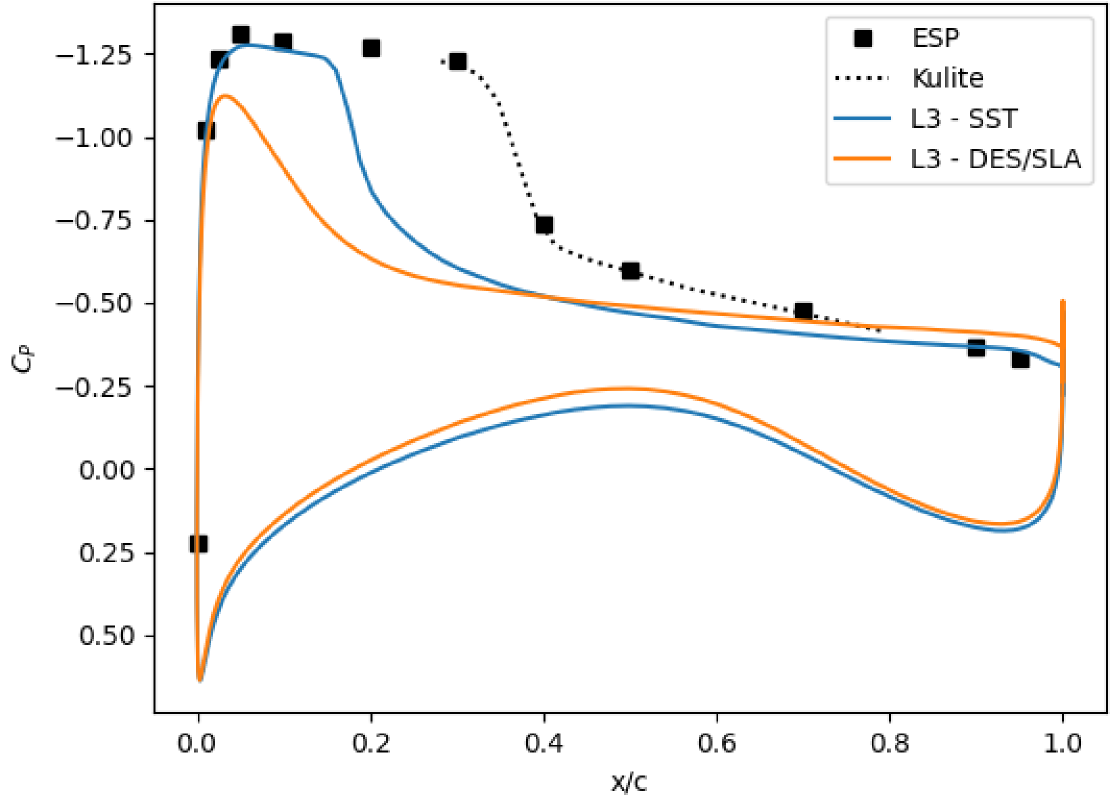


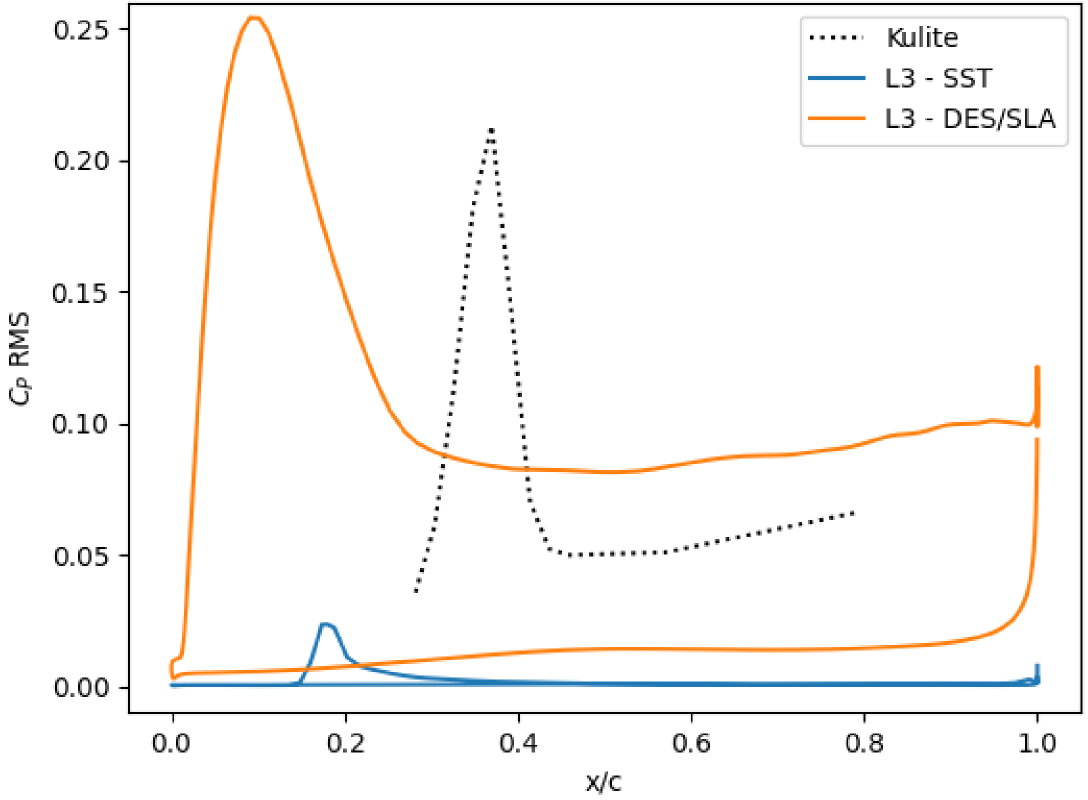
Case 2 Results – C_P and C_P RMS, $\alpha = 4.84°$, $\eta = 0.6$



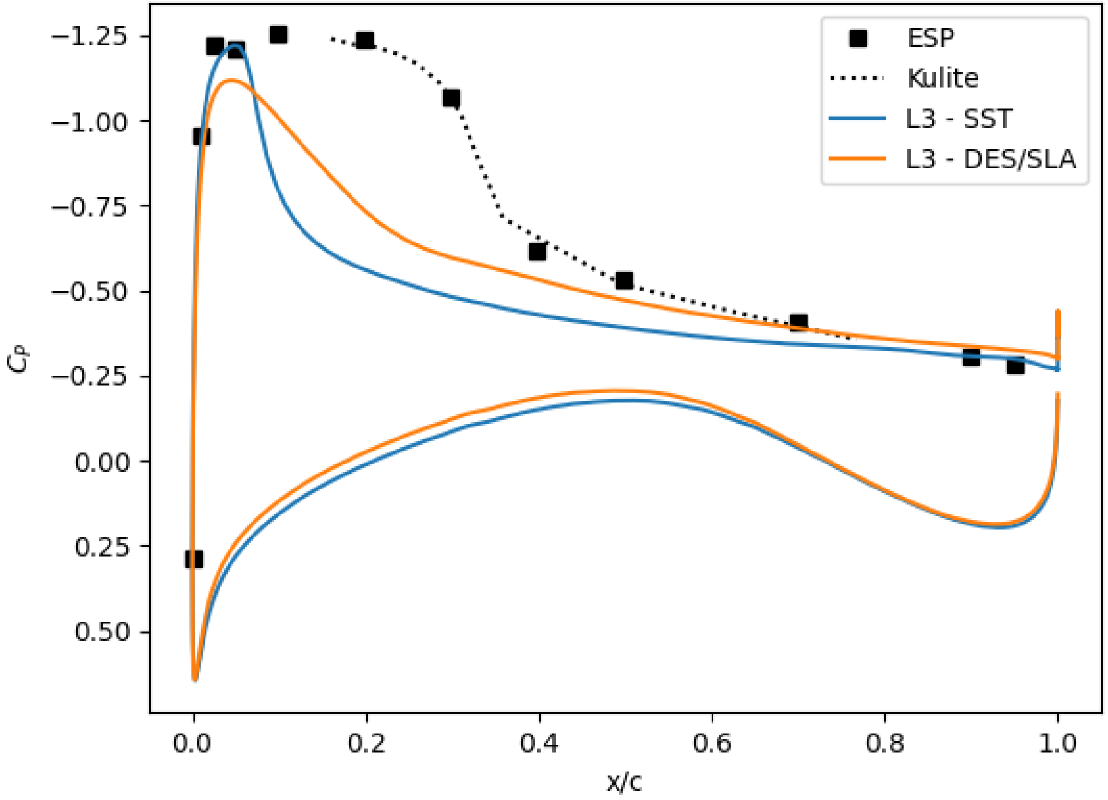


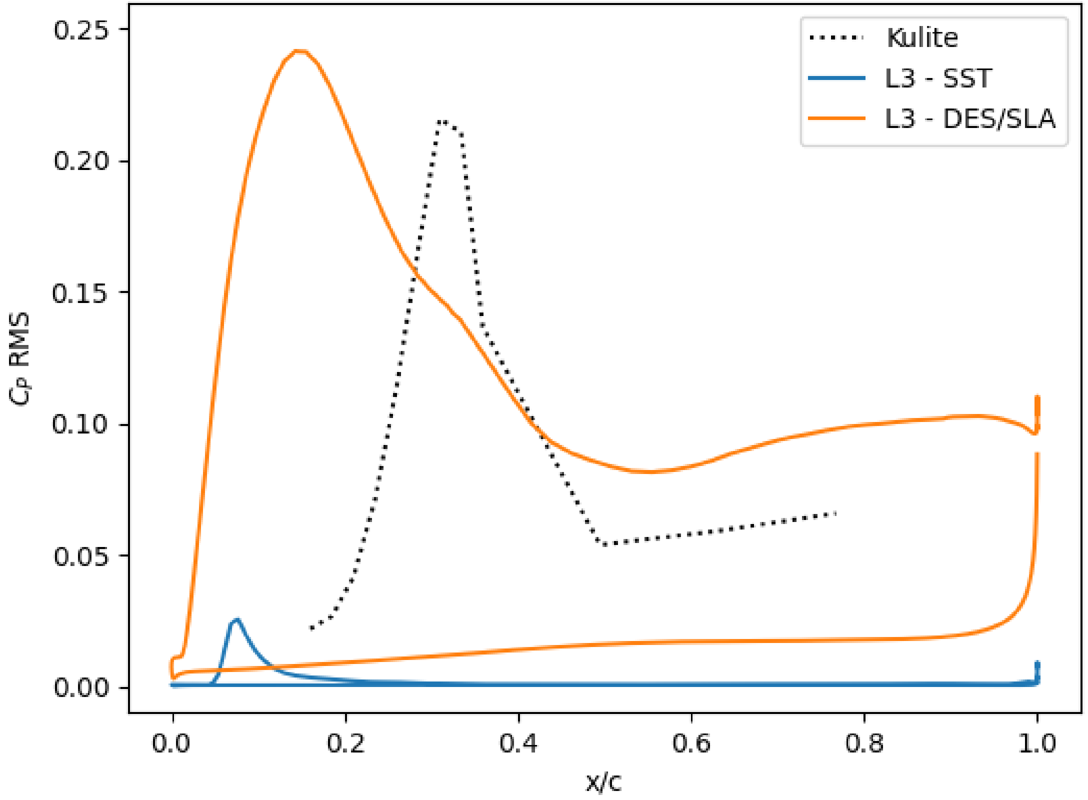
Case 2 Results – C_P and C_P RMS, α = 5.89°, η = 0.5





Case 2 Results – C_P and C_P RMS, α = 5.89°, η = 0.6





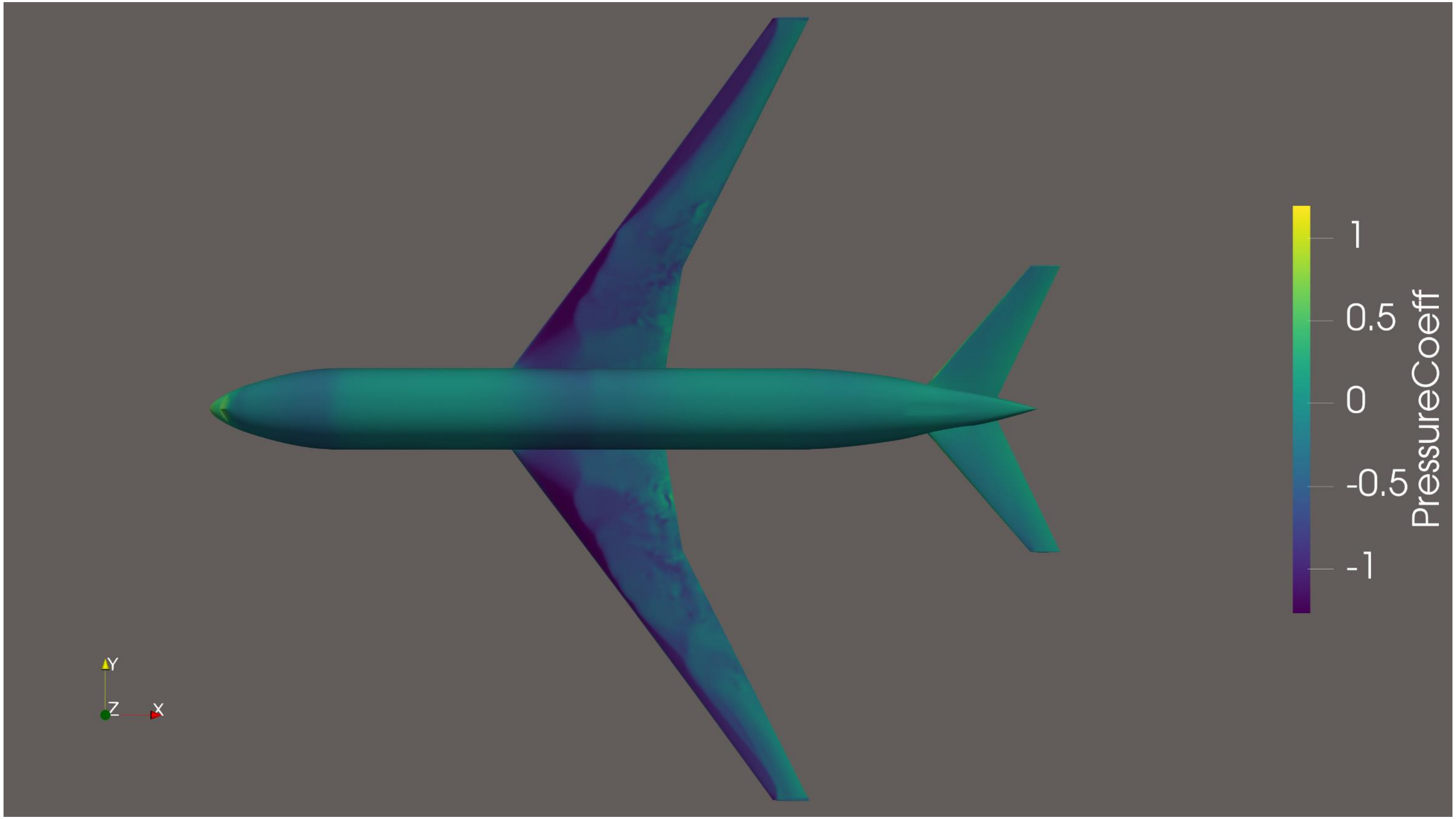
Case 2 Discussion

- **Investigating SA**
- **Hybrid RANS/LES needs improvement**
  - Still need to do time-step study with DES/SLA, and investigate IDDES
  - Curious if transition model would improve shock onset location predictions
  - Consider constructing a grid intended for DES (i.e., L4+ with isotropic-ish grid spacing)

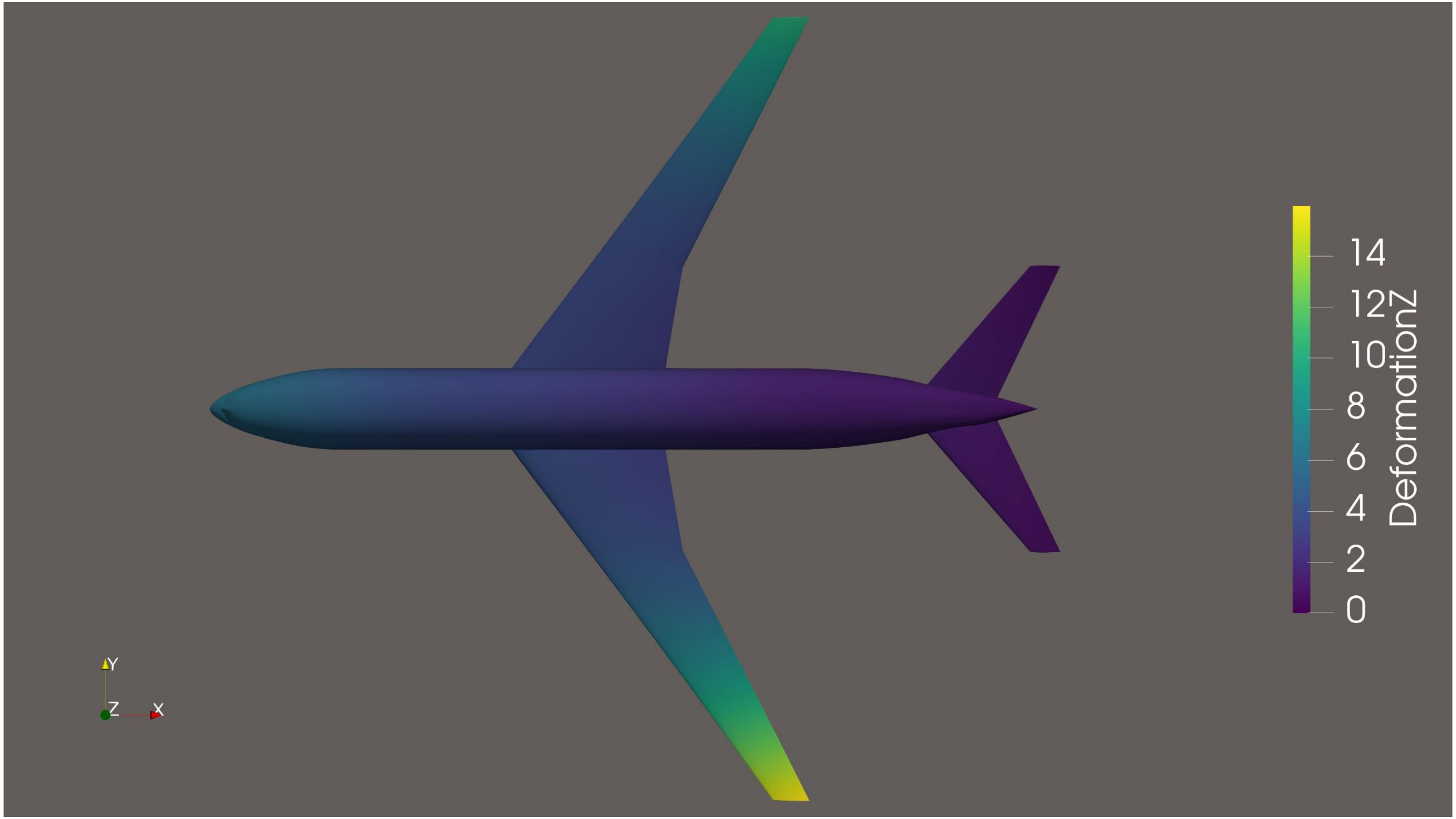
Case 3 Setup and Challenges

- **Kestrel Setup**
  - Use workshop-provided unstructured grids from Helden Aerospace
  - Look Hybrid RANS/LES
    - Menter SST with compressibility correction, rotational/curvature correction, and QCR 2020
    - “Shear Layer Aligned” formulation of DES
  - Using Kestrel’s “FN1+NN” expanded gradient stencil
  - 3rd Order MUSCL
  - Run first with high structural damping, then turn off additional damping
- **Challenges**
  - Surface Influence scheme has lots of knobs.
    - Got it working for L1 mesh but could not get it working with the L3 mesh.
  - Radial Basis Function scheme easier to use when it works.
    - In Kestrel, bug prevents it from working with symmetry planes -> **had to mirror the mesh**

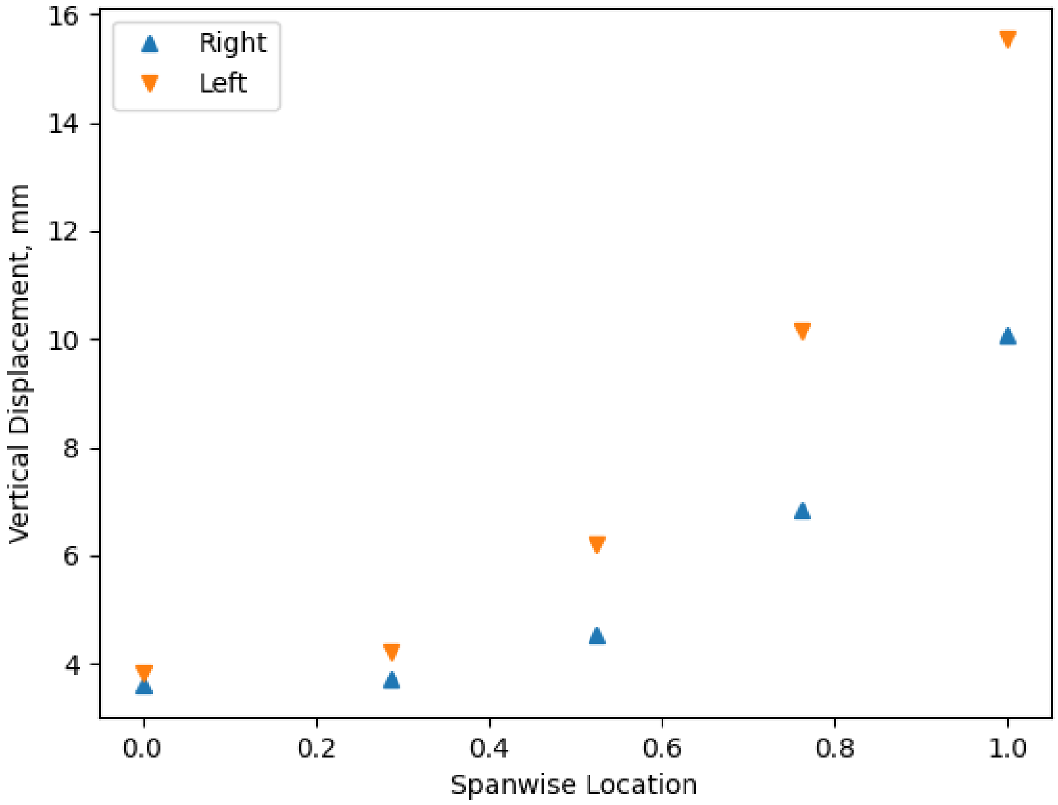
Case 3 Results – Instantaneous C_P, $\alpha = 4.70°$

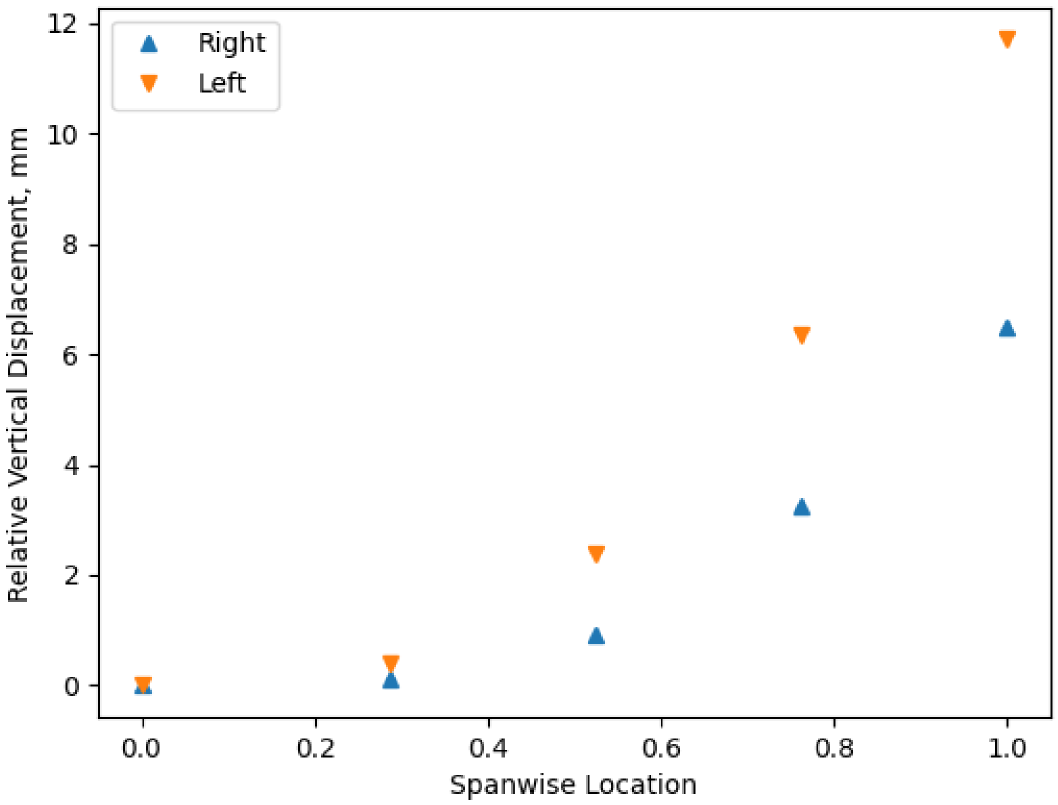


Case 3 Results – Instantaneous Deformation, α = 4.70°



Case 3 Results – Wing Bending, α = 4.70°





- **Expect wing tip vertical deflection approximately 10-12 mm at α = 4.70°**

Case 3 Discussion

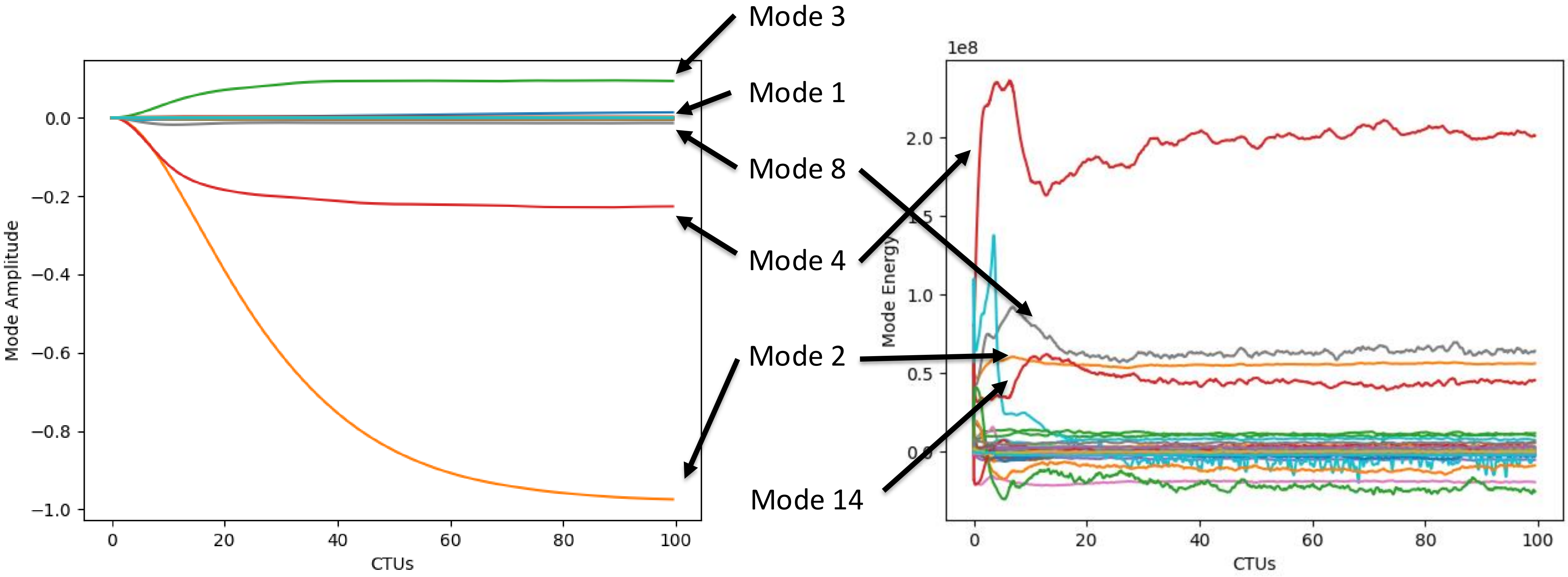
- **Had to mirror grid and use full structural model.**
- **Need to improve setup:**
  - Remove additional structural damping then run cases out further so we can look at C_P and C_PRMS.
  - Look into removing rigid-body “roll” mode.
- **Need to look at other α.**

Acknowledgements

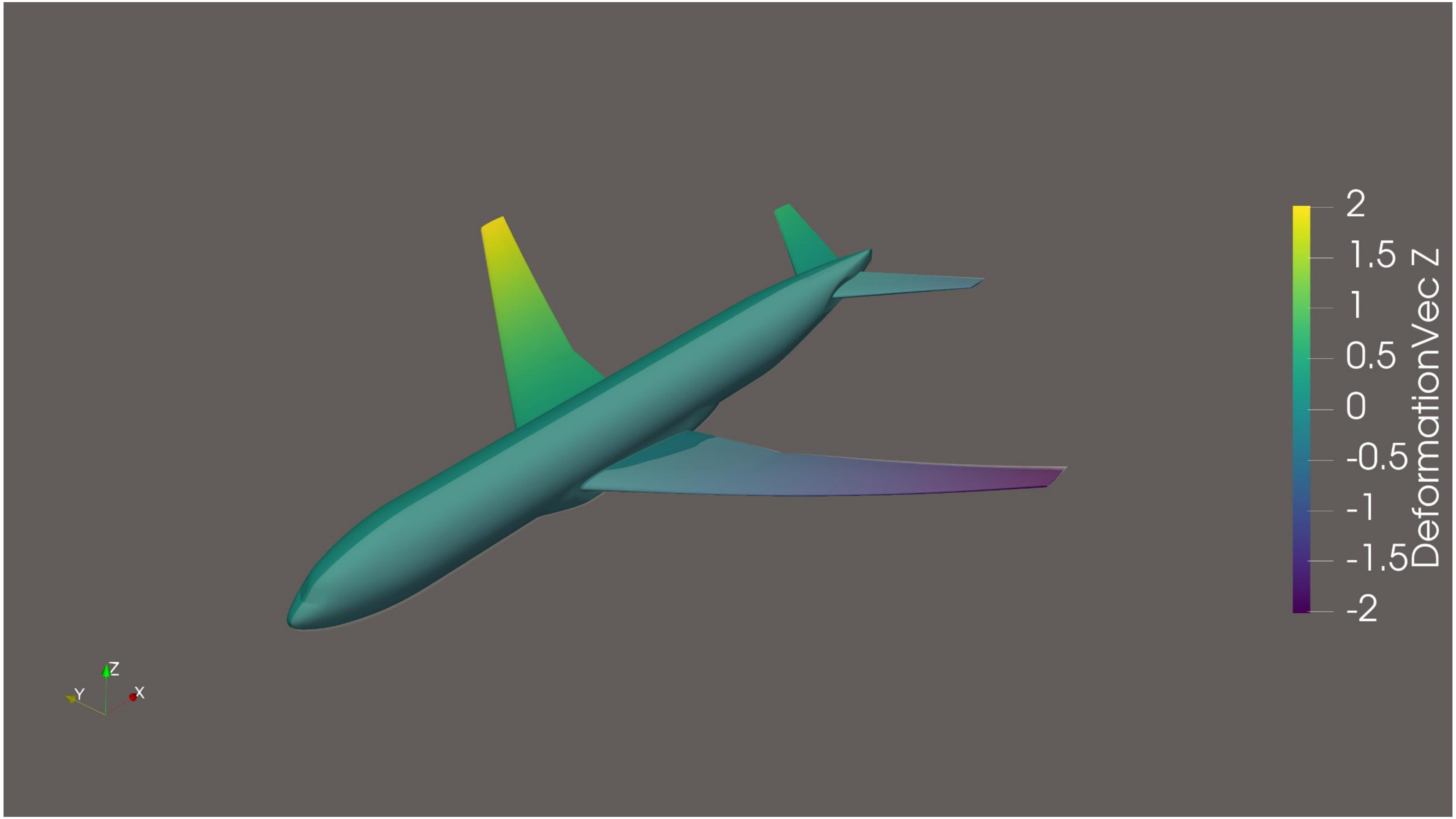
- Material presented here is a product of the Computational Research and Engineering for Acquisition Tools and Environments (CREATE) Program sponsored by the U.S. Department of Defense HPC Modernization Program Office.
- Computations done in support of this effort were done on supercomputing resources provided by the HPCMP at the Navy DoD Supercomputing Resource Center (DSRC) and by the High-End Computing Capability (HECC) at the NASA Advanced Supercomputing (NAS) Facility.

BACKUP

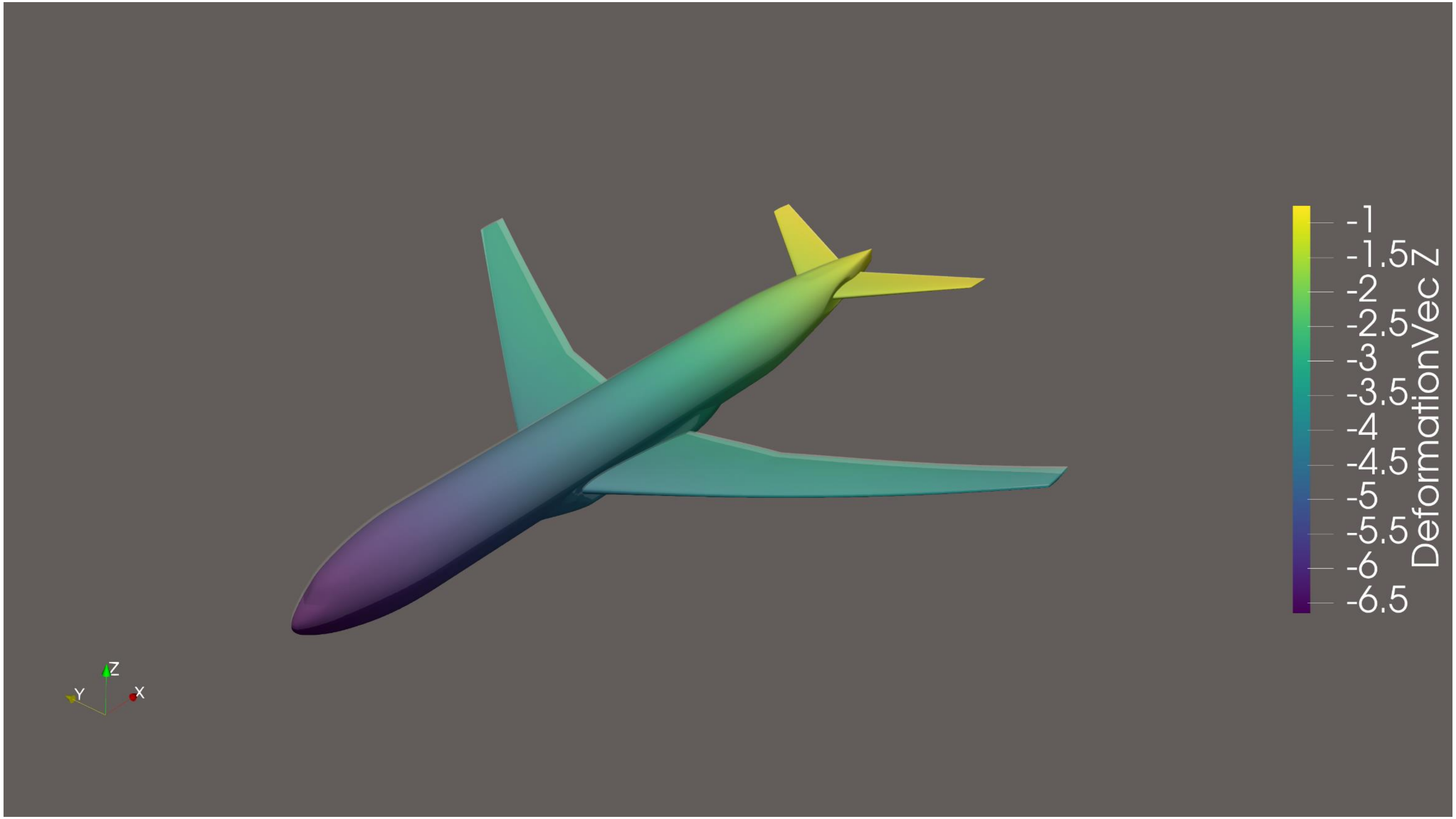
Case 3 Results – Mode Amplitudes, α = 4.70°



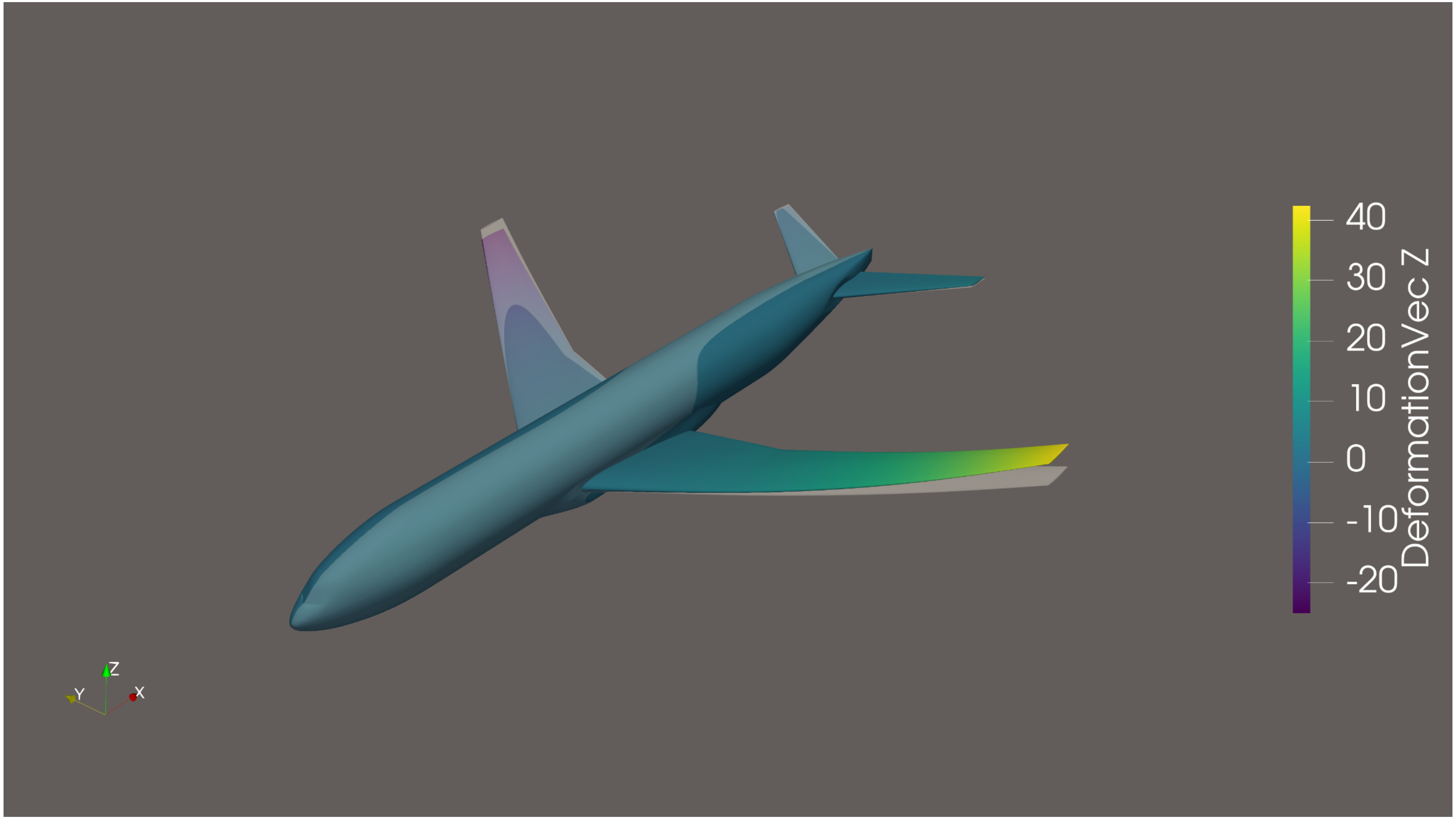
Case 3 – Mode 1



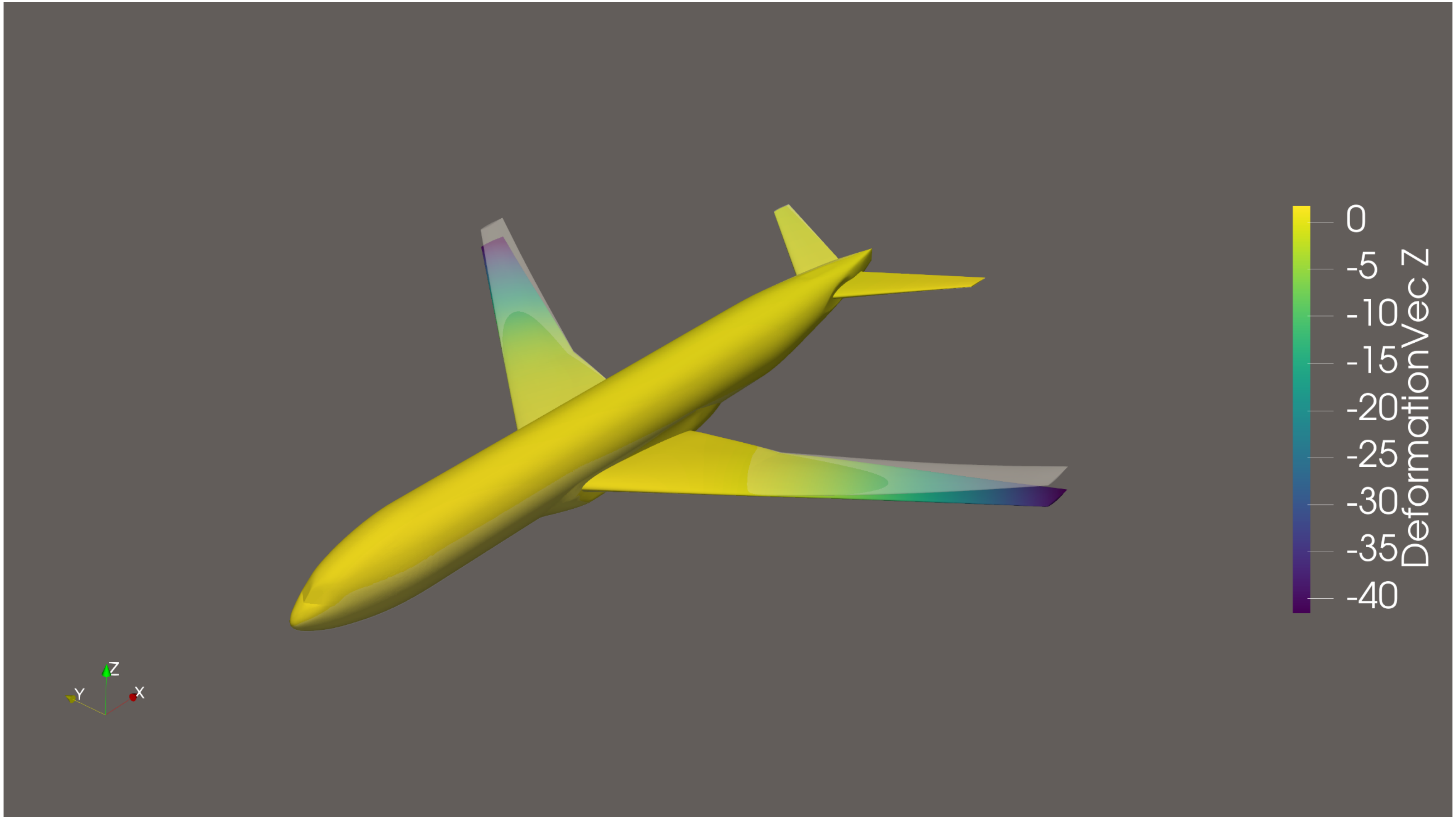
Case 3 – Mode 2



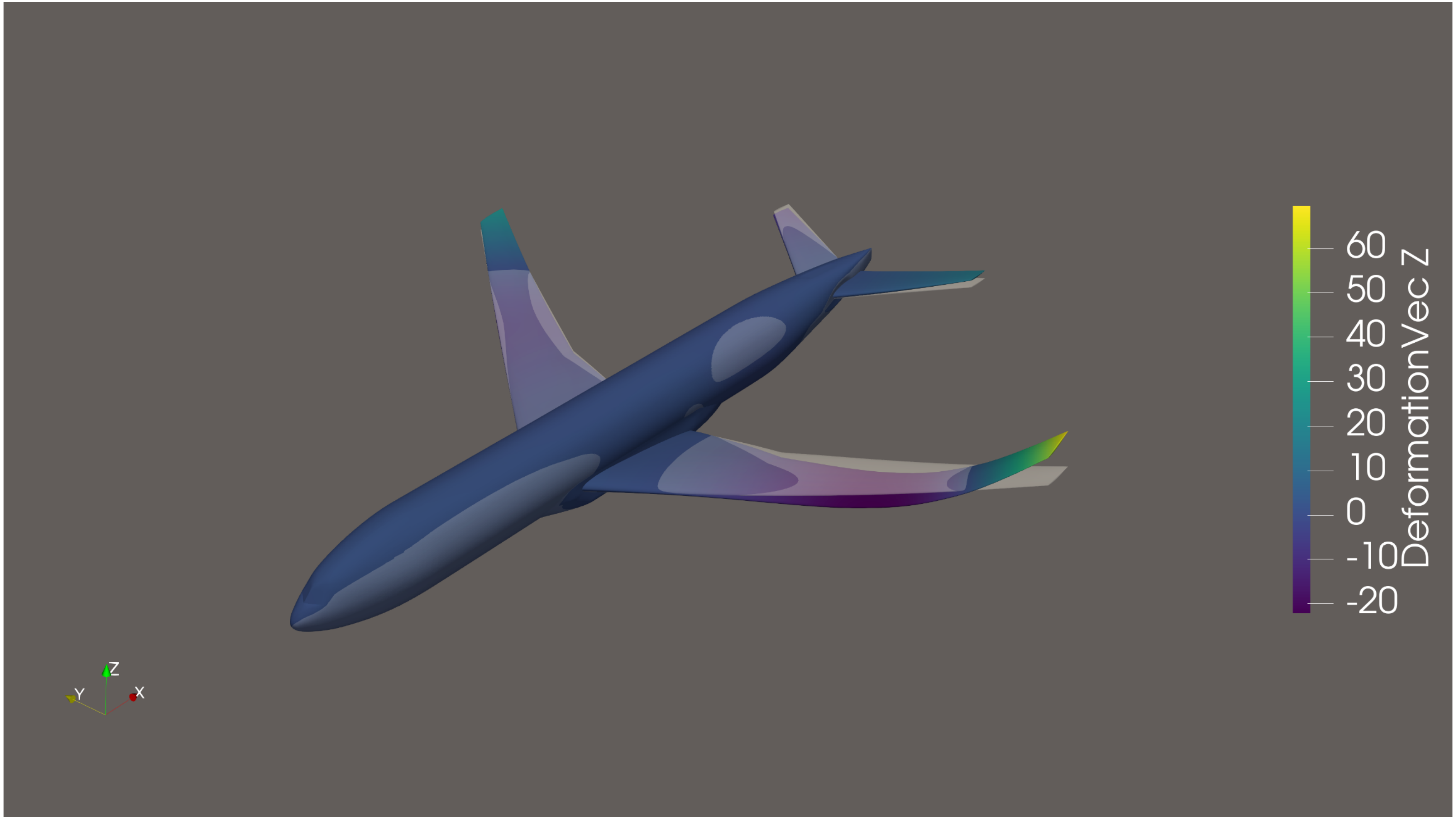
Case 3 – Mode 3



Case 3 – Mode 4



Case 3 – Mode 8



Case 3 – Mode 14