National Aeronautics and Space Administration

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Multiscale Mesh Adaptation for Transonic Aeroelastic Flutter Problems

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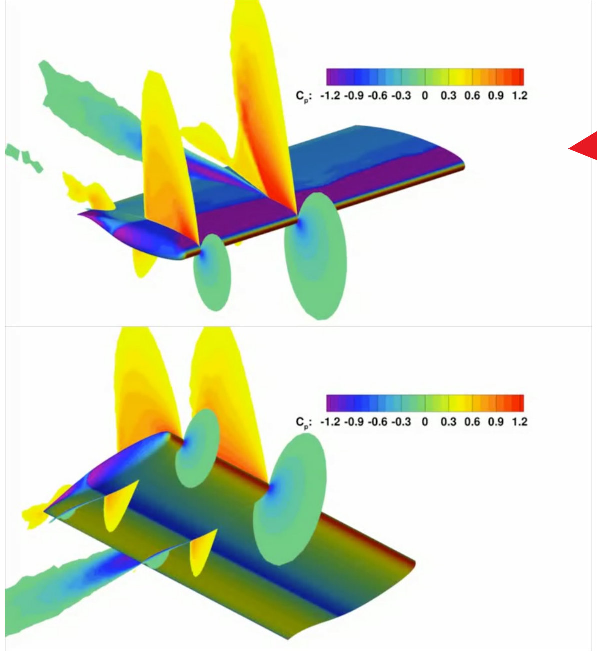
Background

- Transonic aeroelasticity is difficult to simulate due to complex nonlinear physics
- High cost ➜ rarely demonstrate spatial and temporal convergence
- These lead to the spread of results in the Aeroelastic Prediction Workshop (AePW)
- In this work, we are applying mesh adaptation to aeroelastic benchmark problems



Ranges of High-Fidelity Computational Results

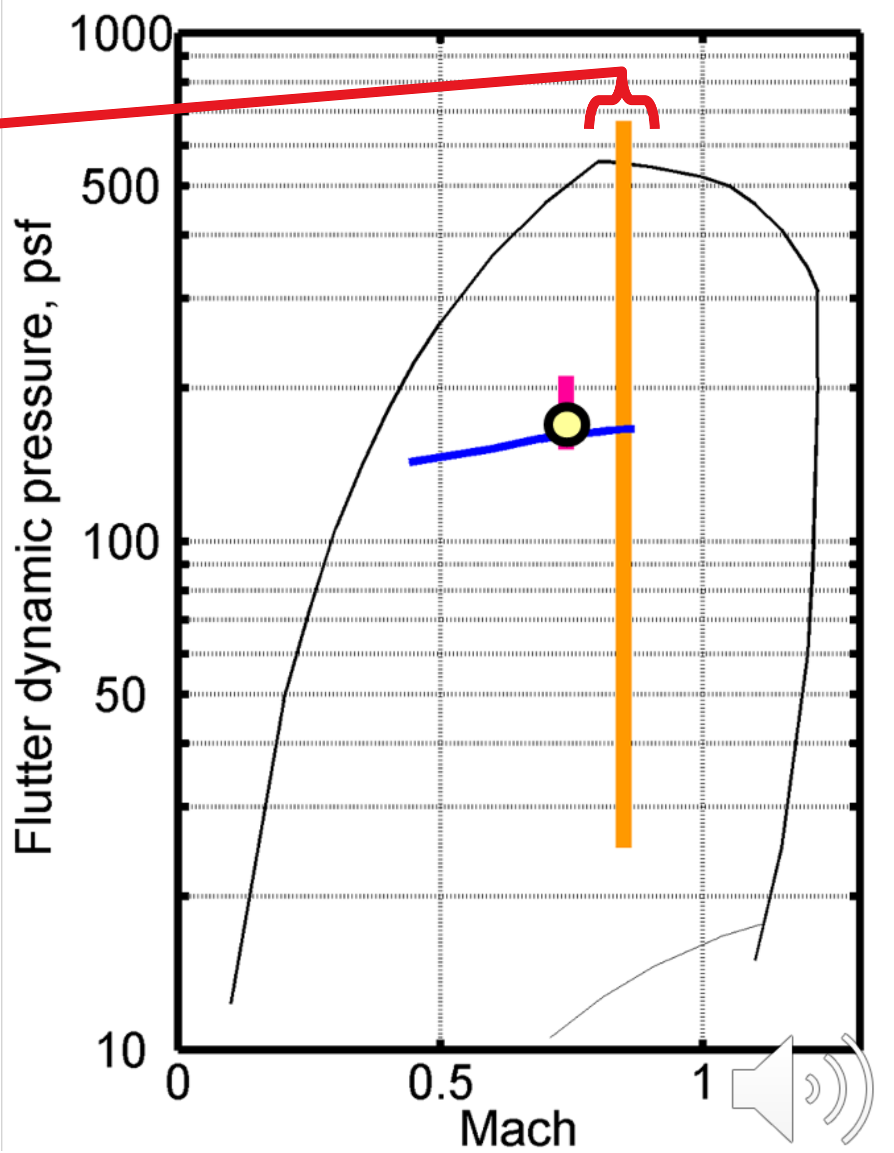
Mach 0.74, α = 0°

Mach 0.85, α = 5°

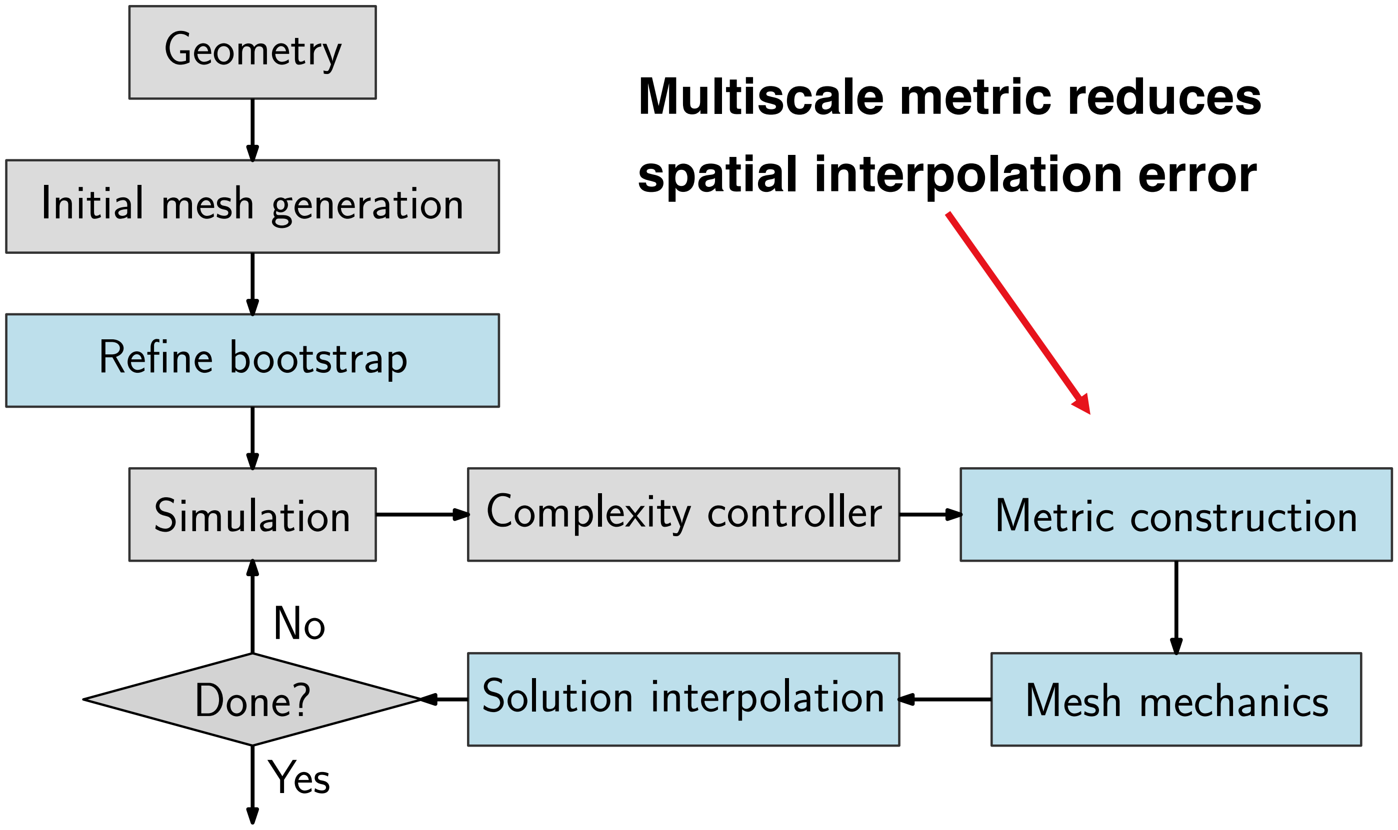
Experiment

Linear Analysis Results

TDT operating envelope

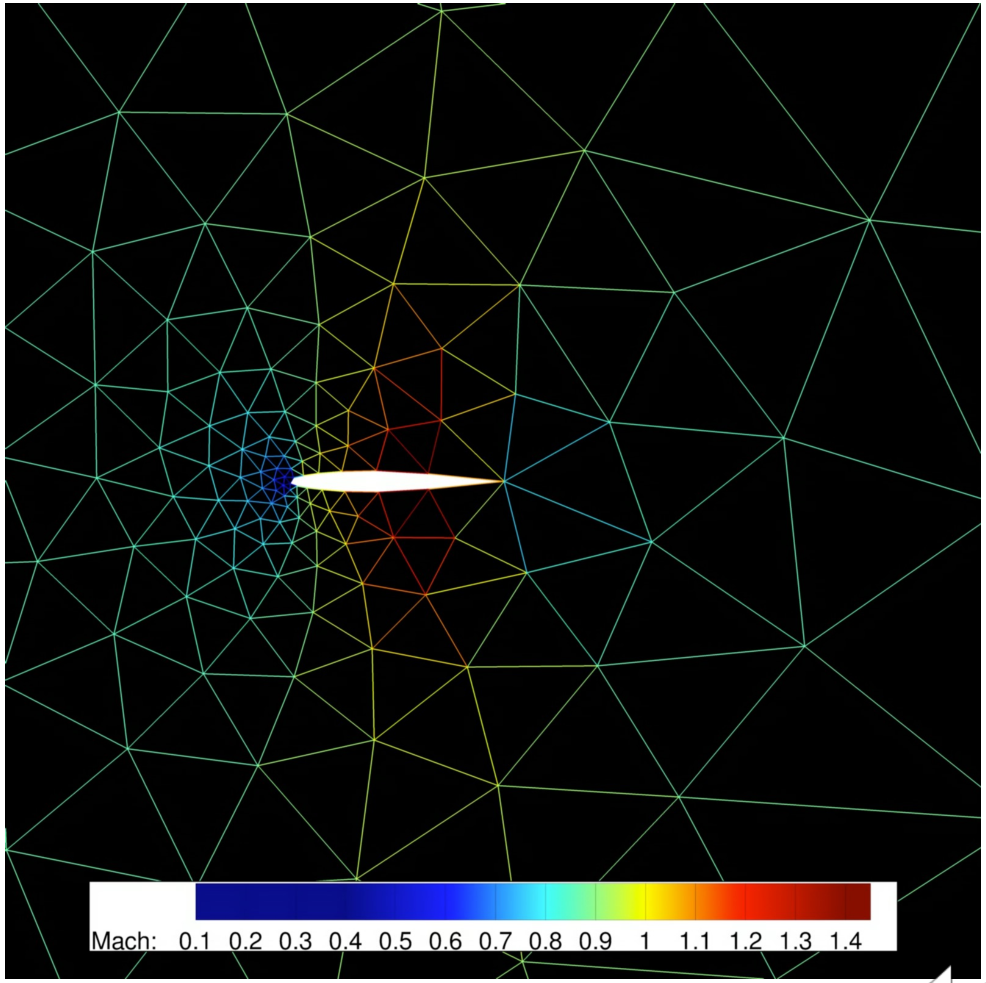


Mesh Adaptation with *refine*



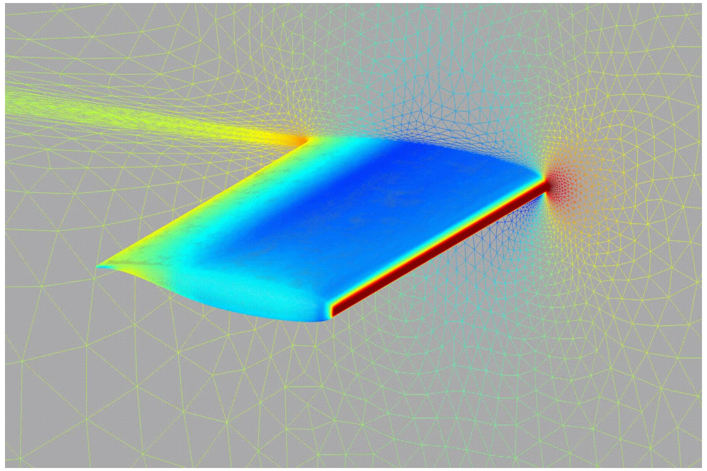
Multiscale metric reduces spatial interpolation error

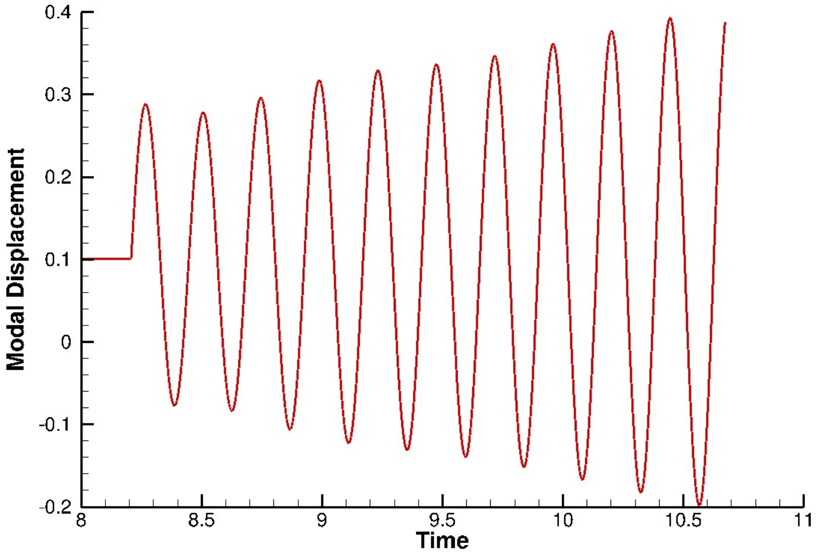
= Operation in *refine*



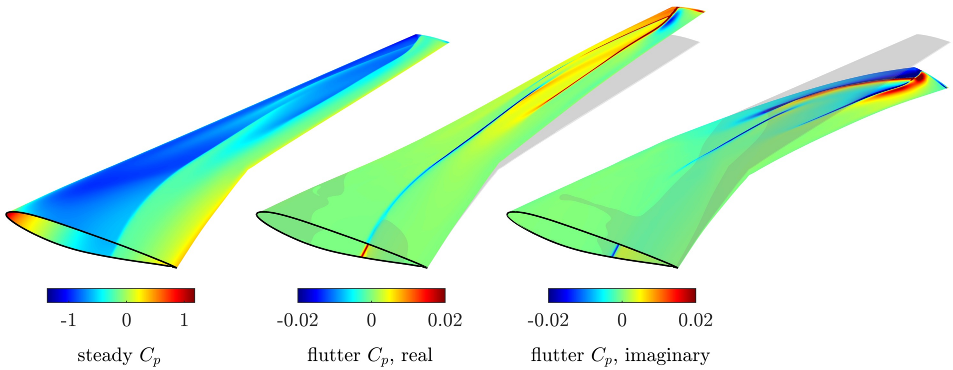
FUN3D Aeroelastic Simulations

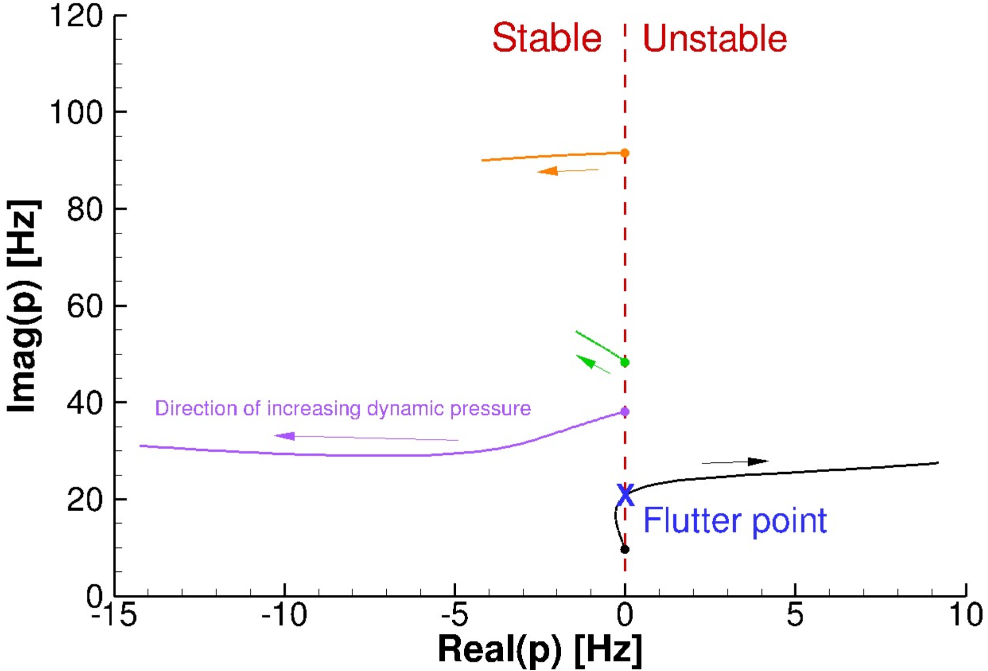
Time-domain analysis





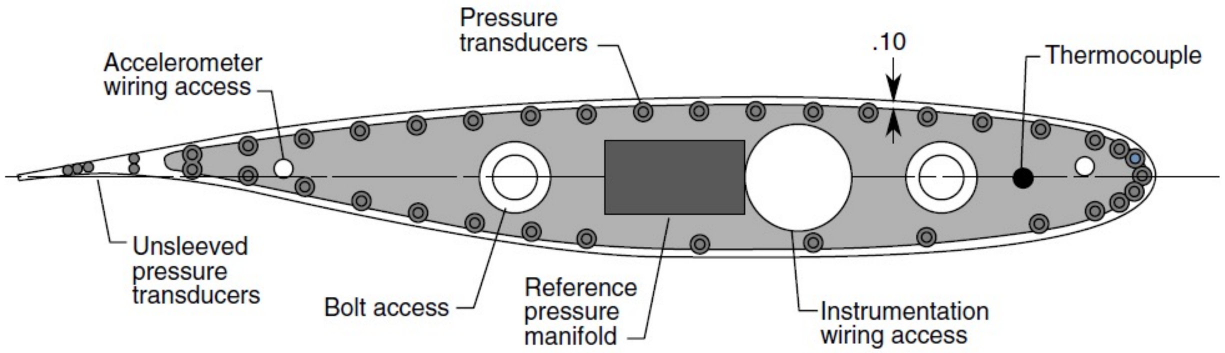
Linearized Frequency Domain (LFD) analysis



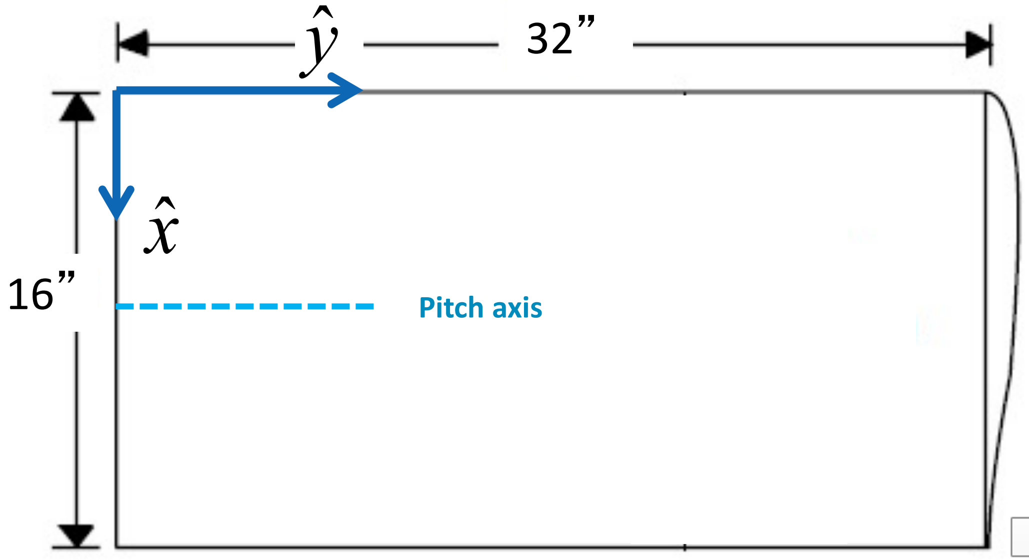


Benchmark Supercritical Wing (BSCW)

- **Simple geometry**
- **Simple structure**
- **Two cases studied:**
  - Mach 0.74, AOA = 0°
  - Mach 0.80, AOA = 5°
- **LFD adaptations:**
  - Vary dynamic pressure to find the flutter point
- **Time-domain adaptations:**
  - Fix dynamic pressure and compute the damping ratio

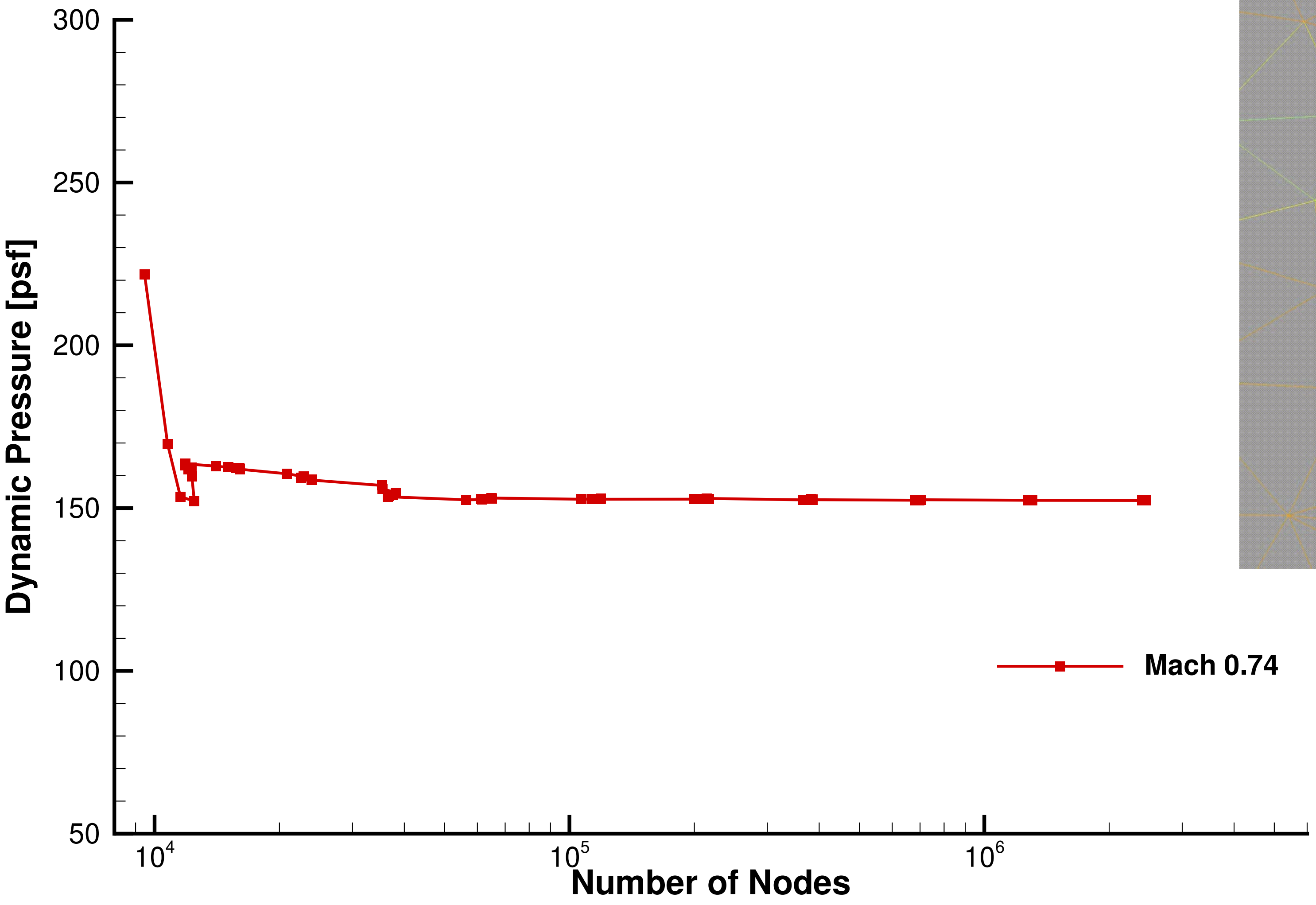


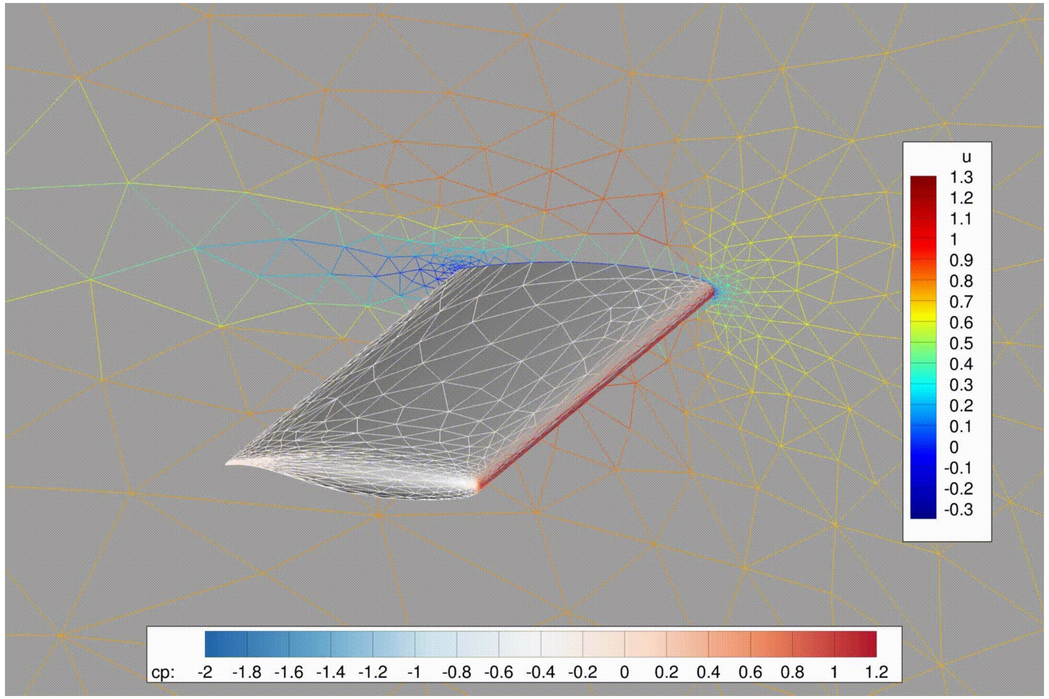
Airfoil section is SC(2)-0414



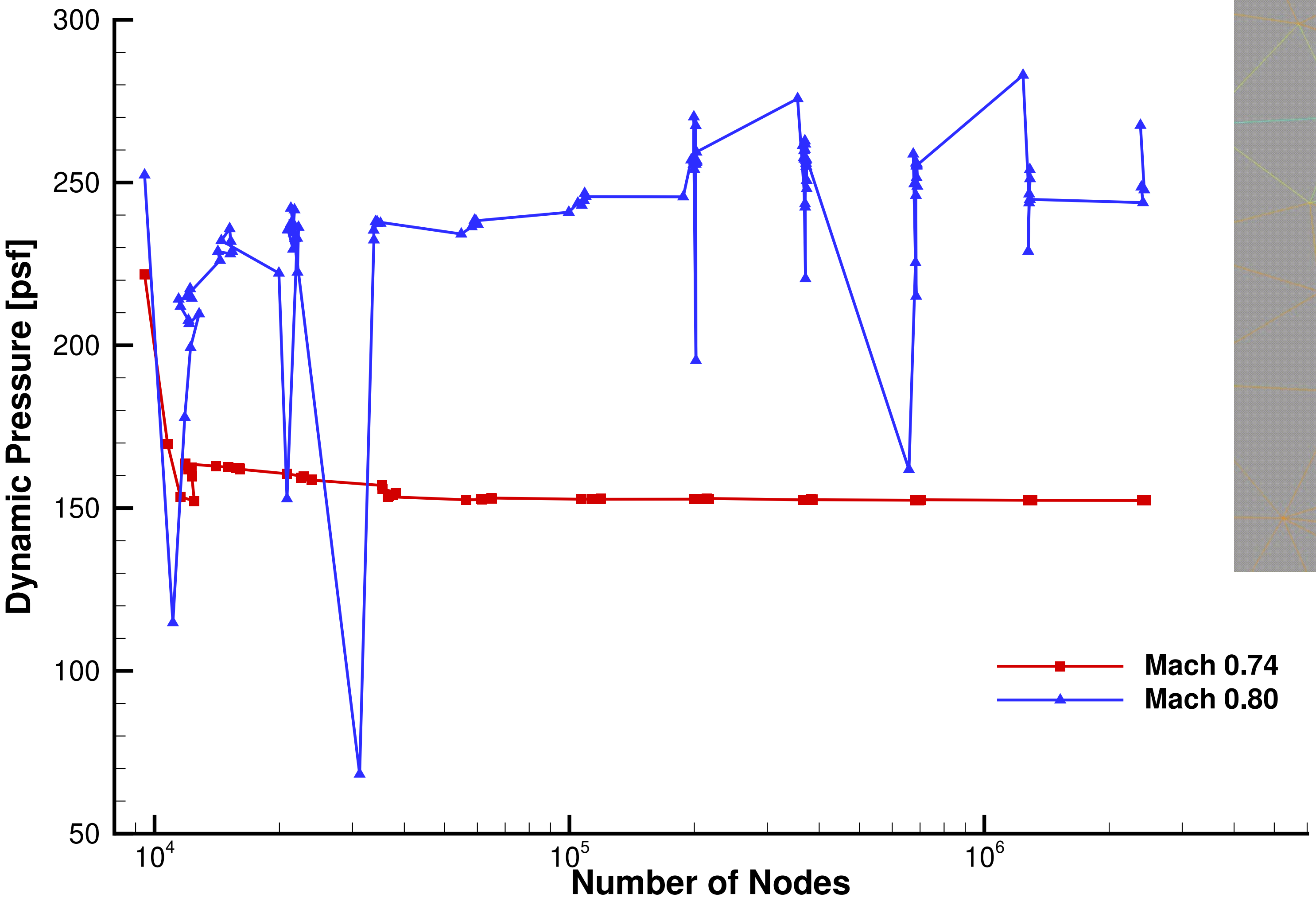
Model planform

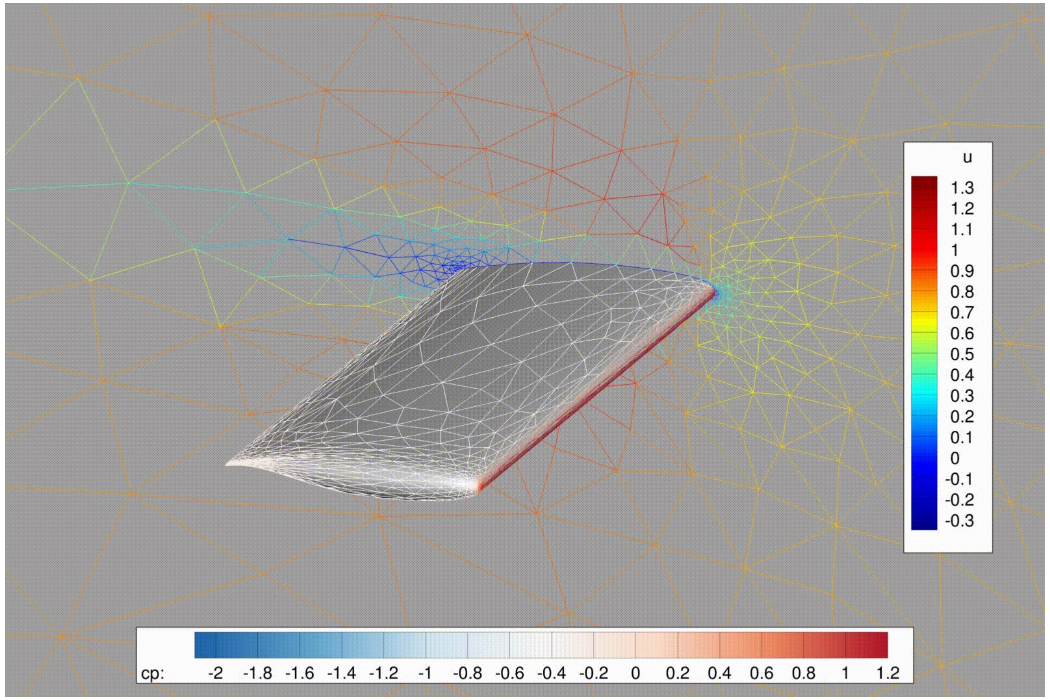
BSCW LFD Adaptations, Mach 0.74



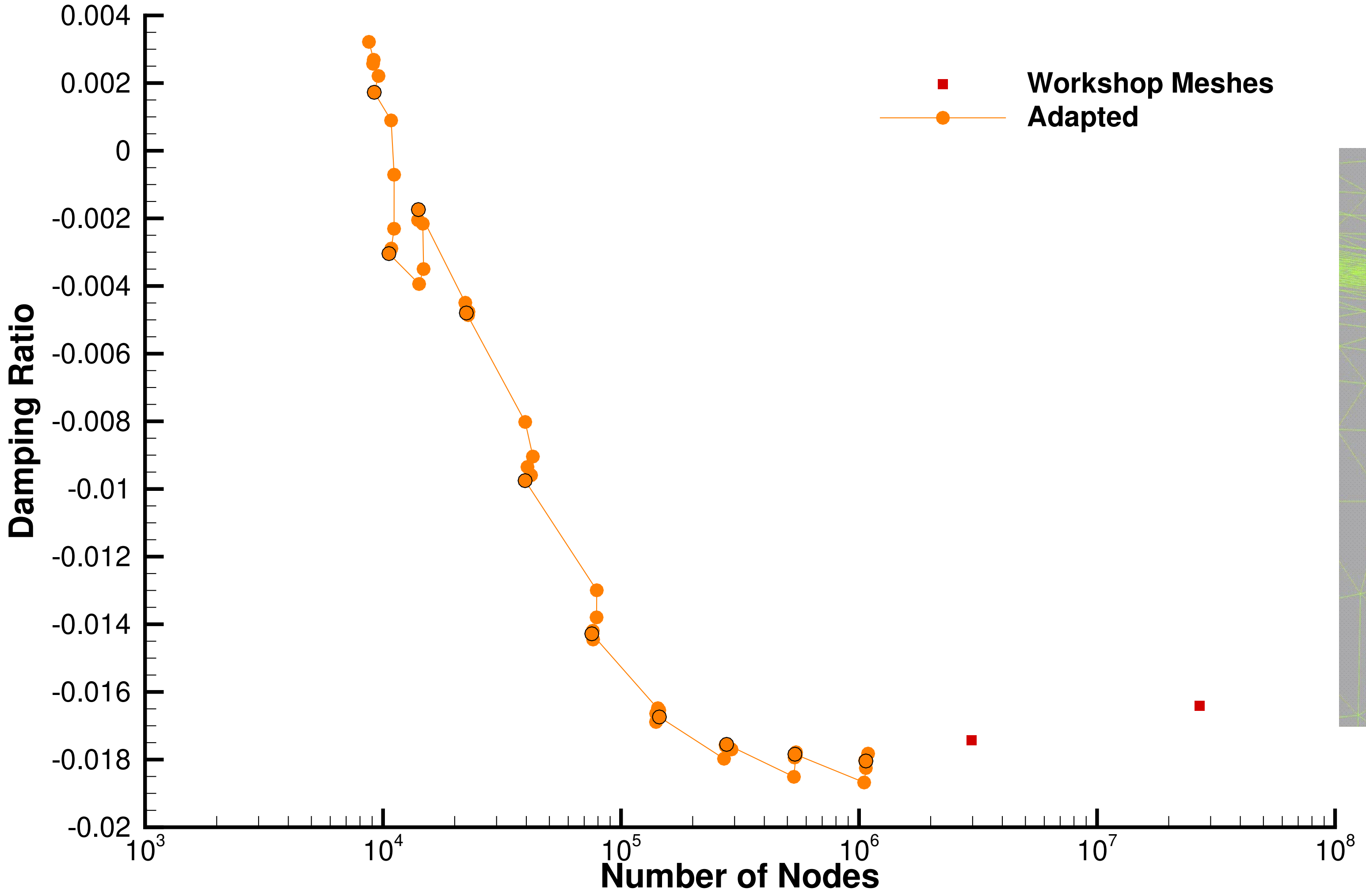


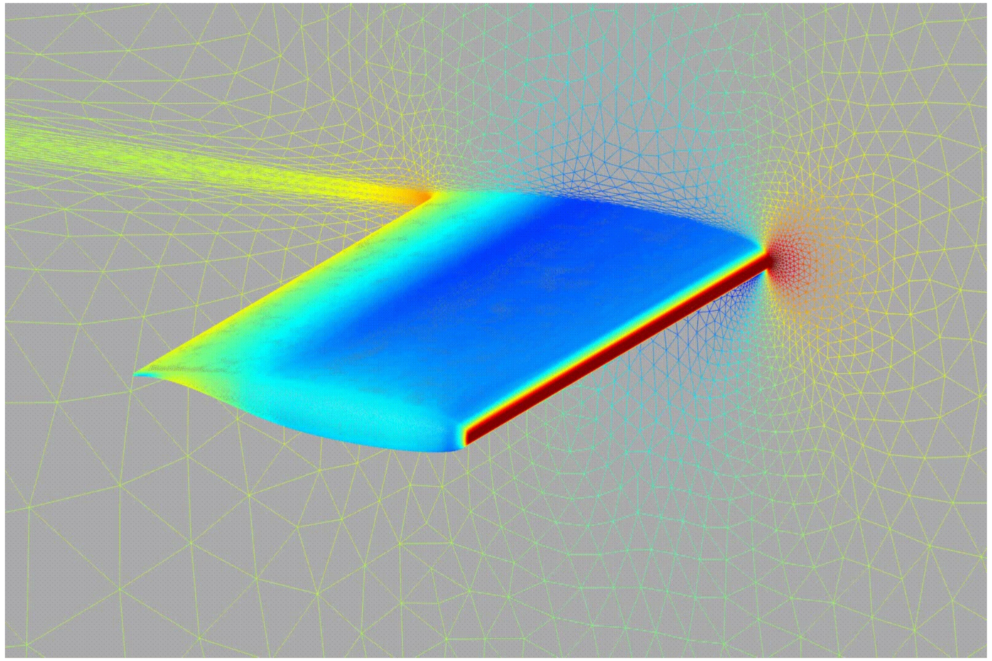
BSCW LFD Adaptations, Mach 0.8



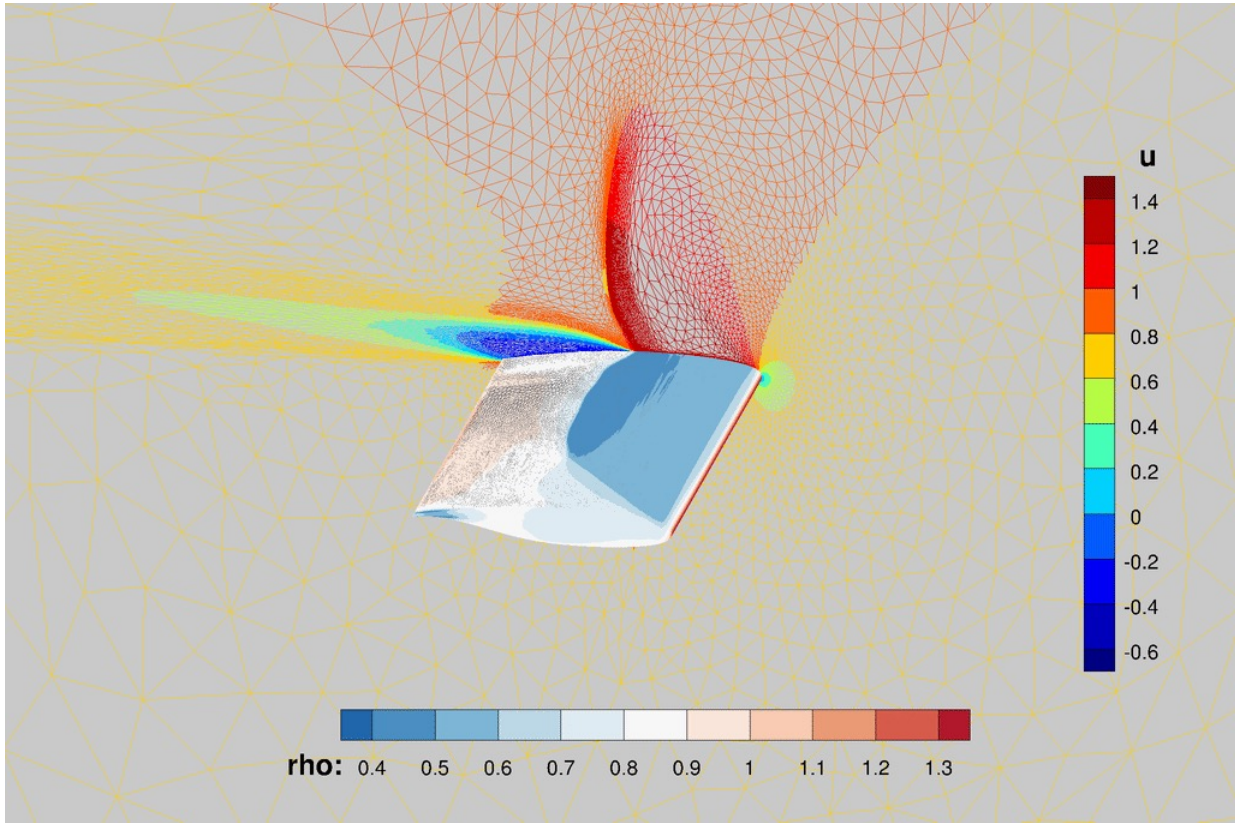


BSCW Time-domain Adaptations, Mach 0.74

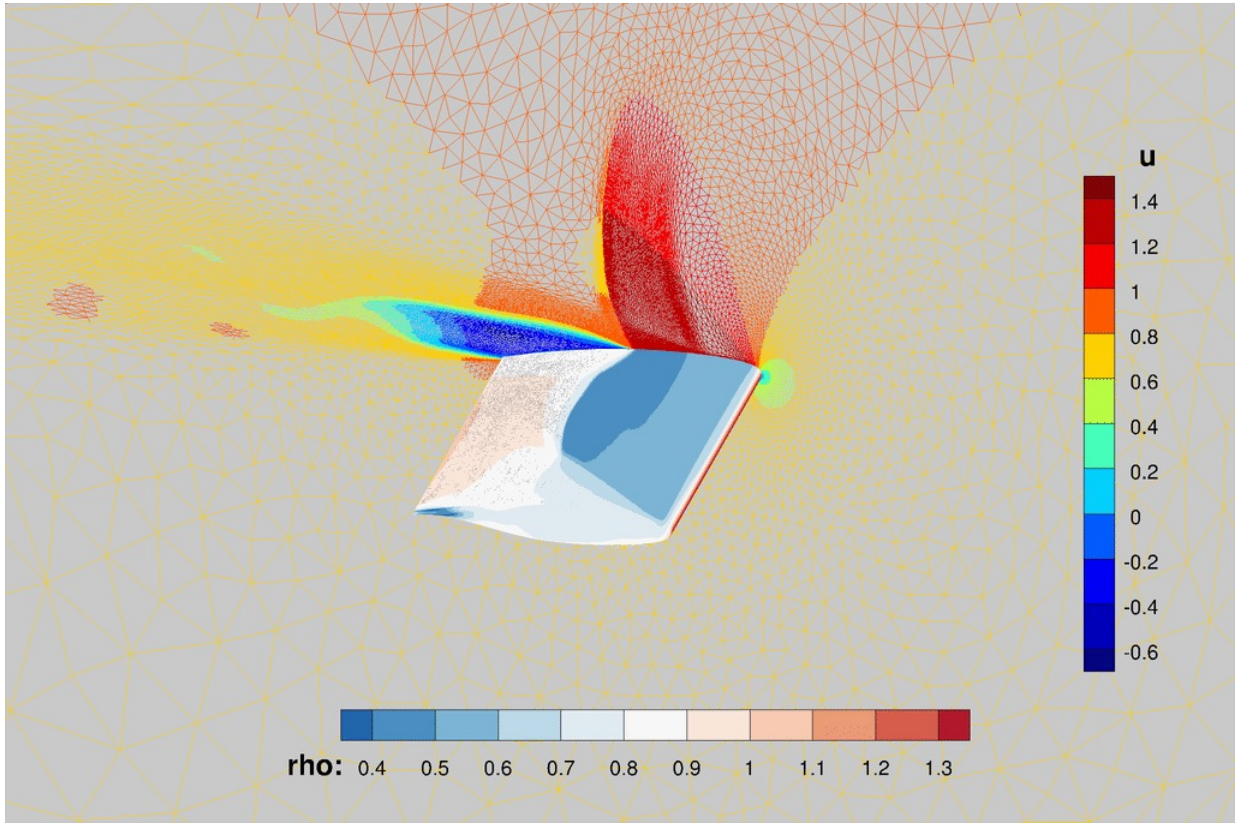




BSCW Time-domain Adaptations, Mach 0.8

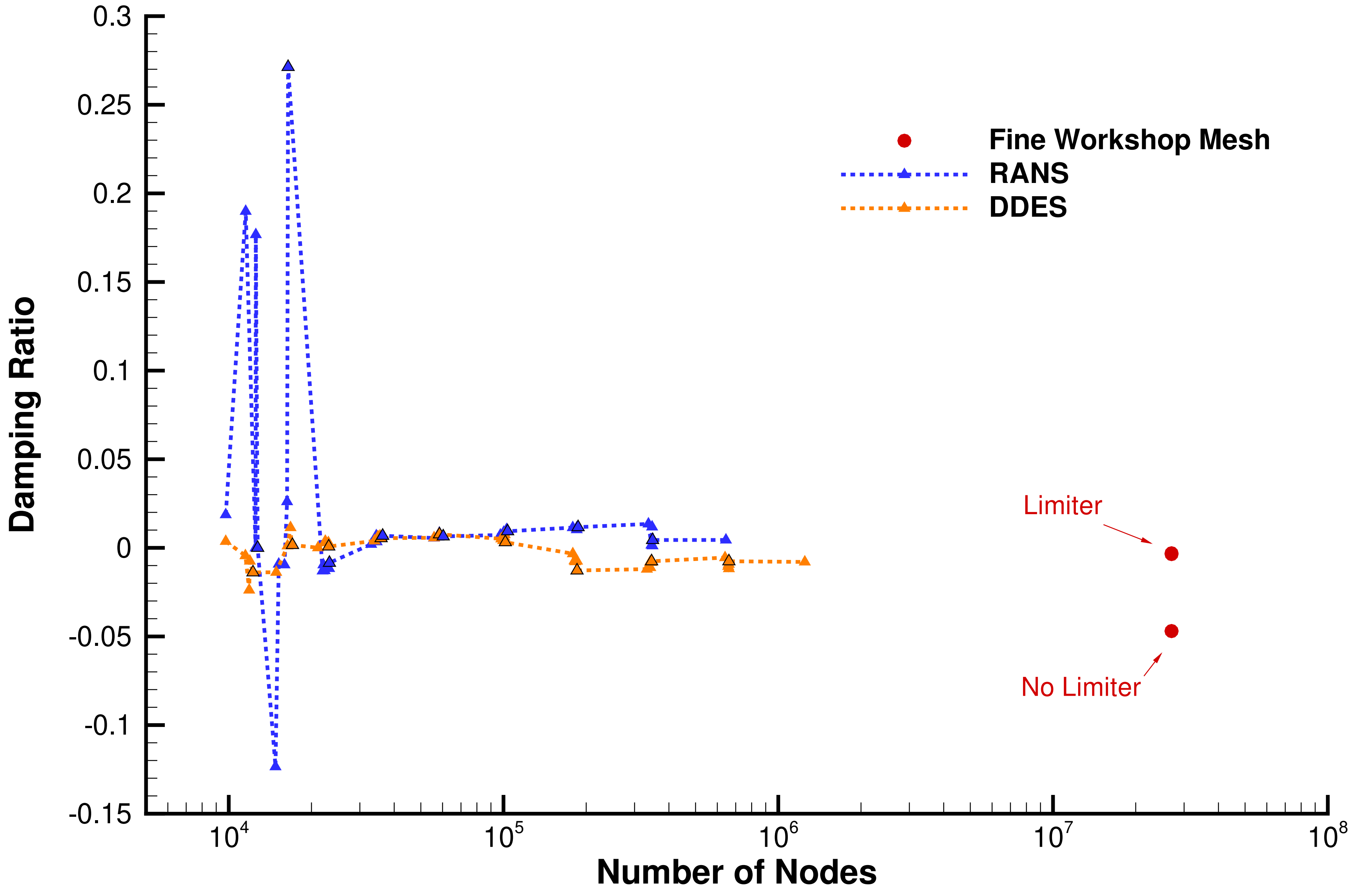


Reynolds-averaged Navier-Stokes (RANS) – Spalart-Allmaras



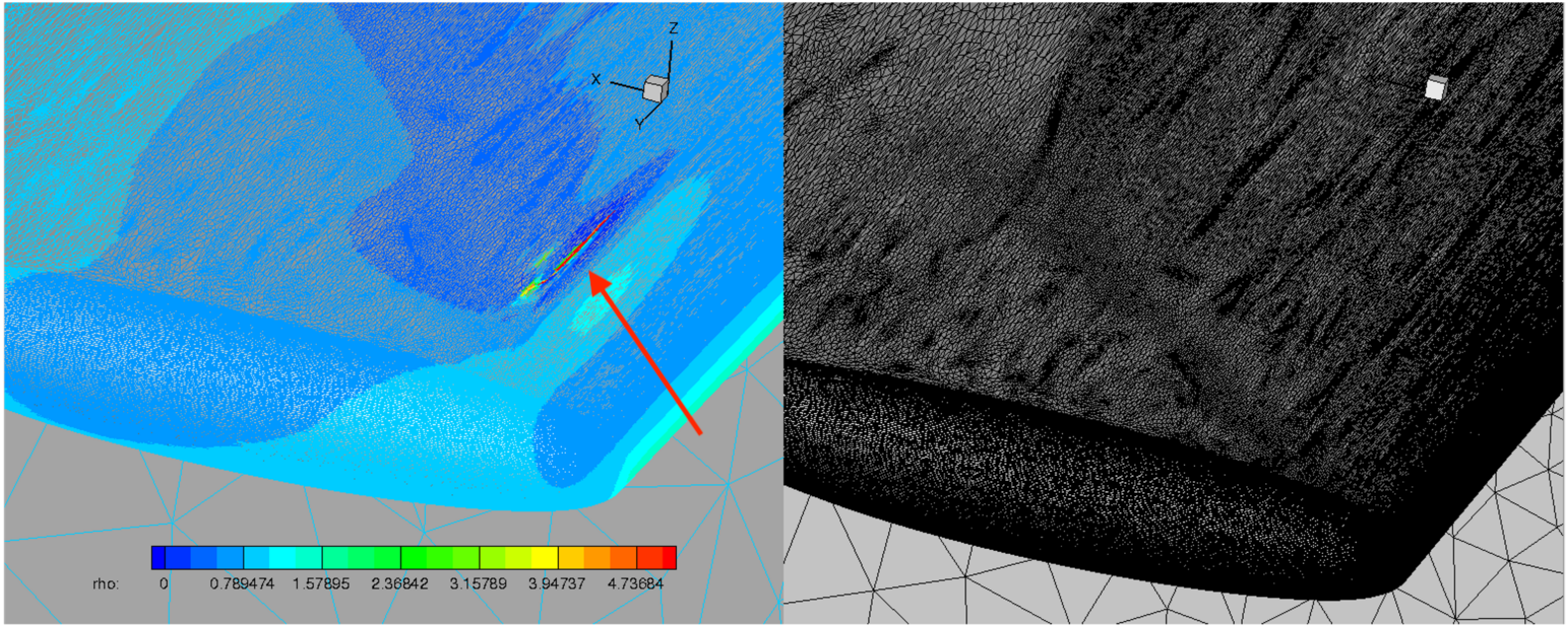
Delayed Detached Eddy Simulation (DDES)

BSCW Time-domain Adaptations, Mach 0.8



BSCW Time-domain Adaptations, Mach 0.8

- **Difficult to achieve convergence of the process:**
  - Mesh deformation struggled to maintain a valid grid with all positive cell volumes
  - Feedback mechanism between grid and solution



Conclusions

Performed multiscale mesh adaptation on aeroelastic benchmark problem: BSCW

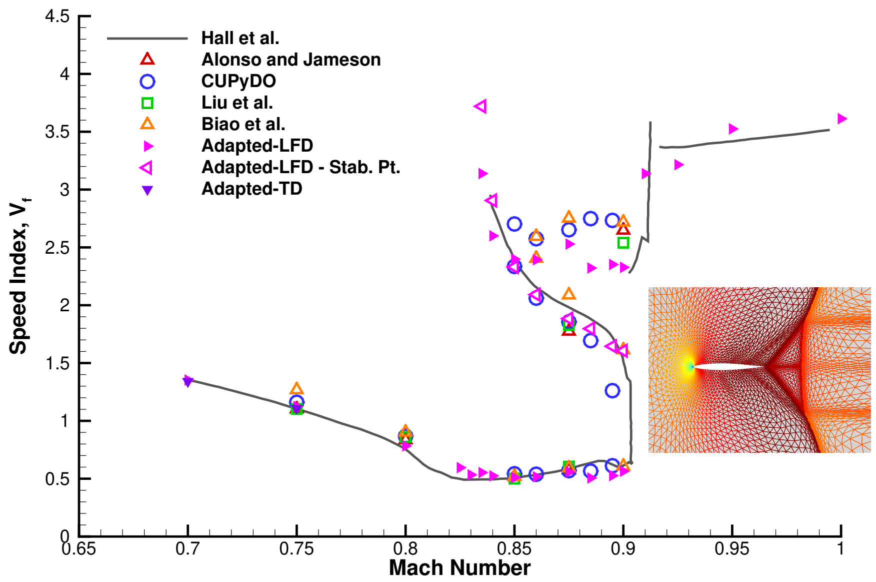
- Isogai airfoil and the NASA Common Research Model also in the paper

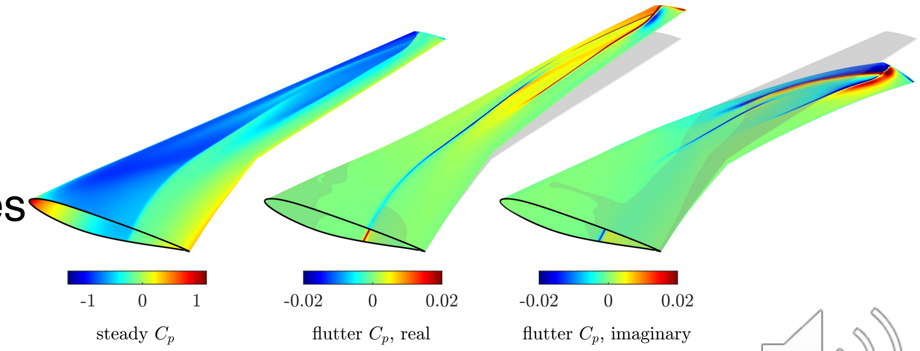
Mesh adaptation led to converged flutter predictions with smaller meshes compared to hand-crafted meshes

- At subsonic and transonic conditions
- With LFD and time-domain simulations

Encountered robustness issues on the moving adapted grids

- FUN3D’s linear elasticity mesh deformation is the biggest challenge





Acknowledgments

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