Sensitivity of Aerodynamic Loads to Attachment Hardware for the CRM using LAVA RANS Based Analysis

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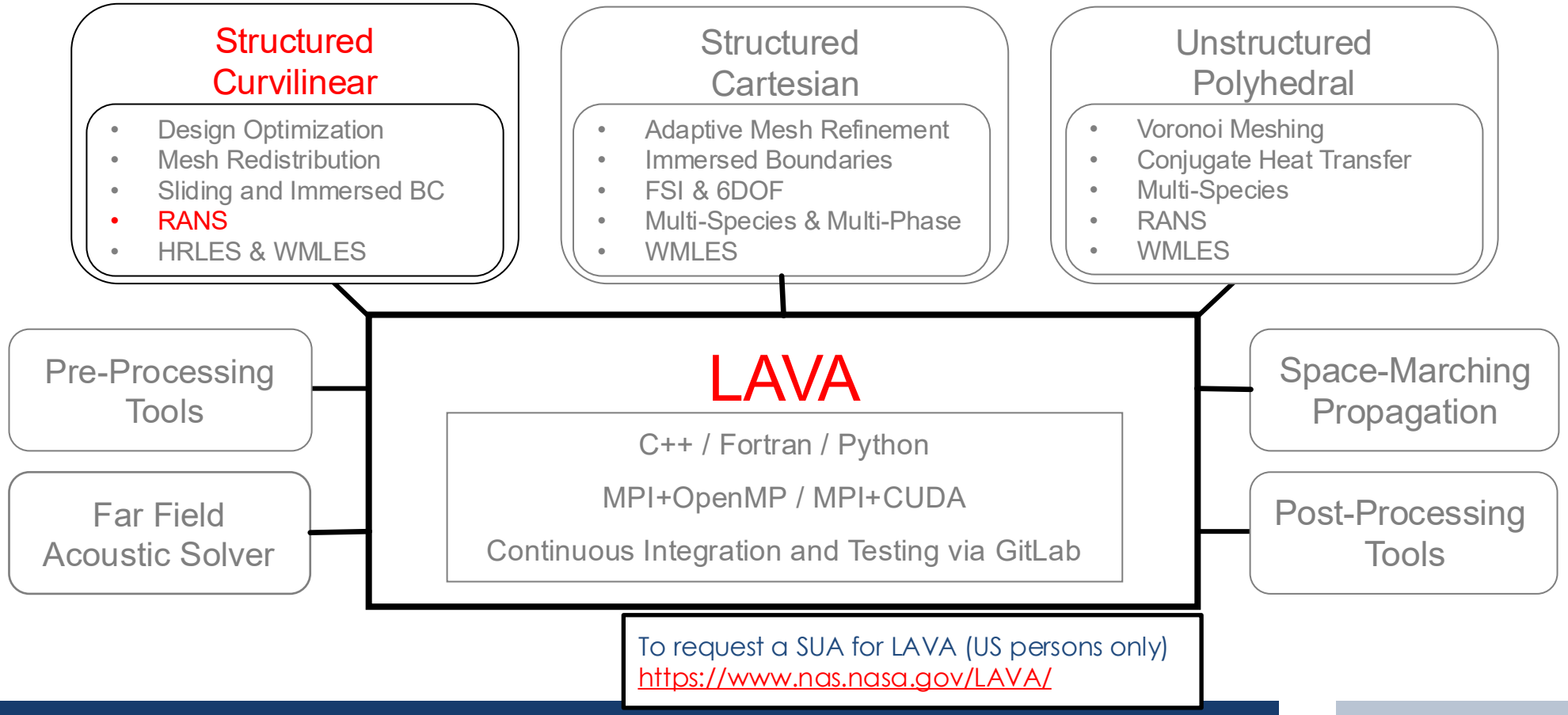
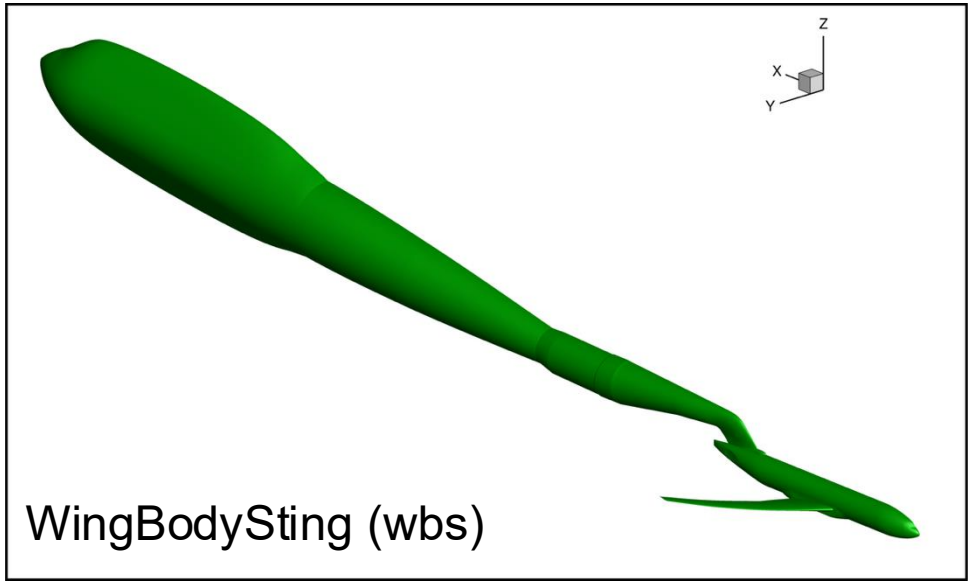
LAVA Framework

- Structured Overset / Multiblock
- Finite-difference formulation
- RANS equations + SAneg-QCR2000
- 2nd order modified Roe scheme
- 3rd order left/right state reconstruction with a Koren slope limiter

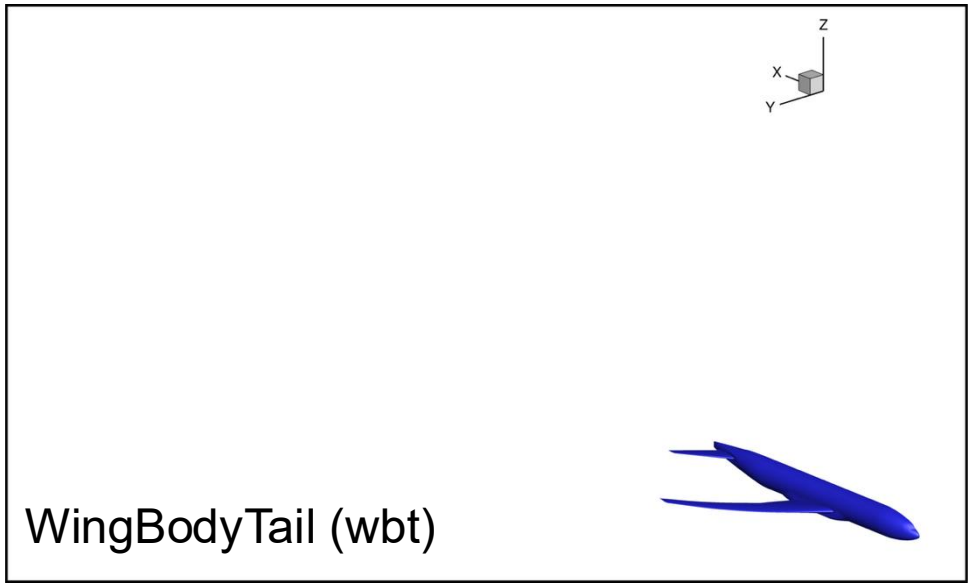


Configuration Outline

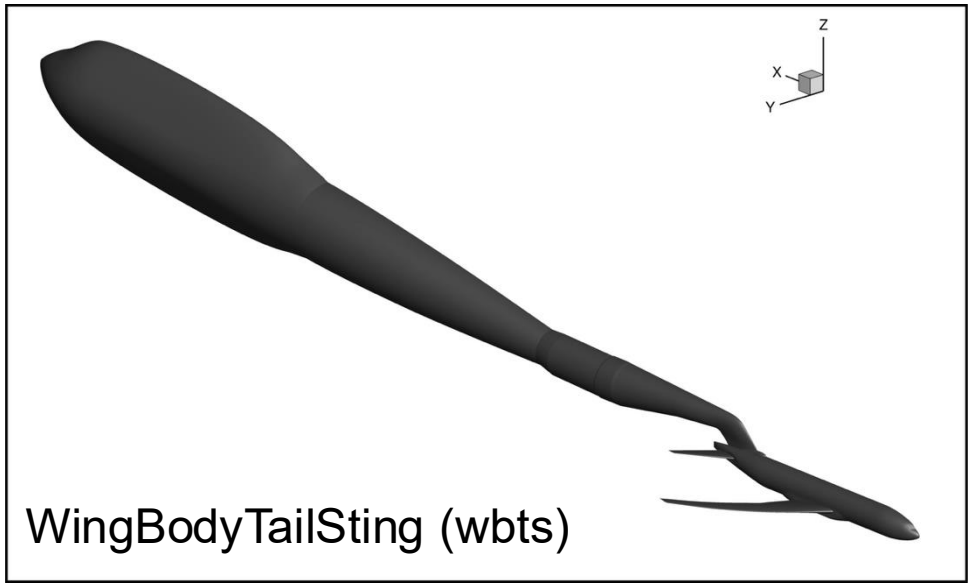
WingBody (wb)



WingBodySting (wbs)

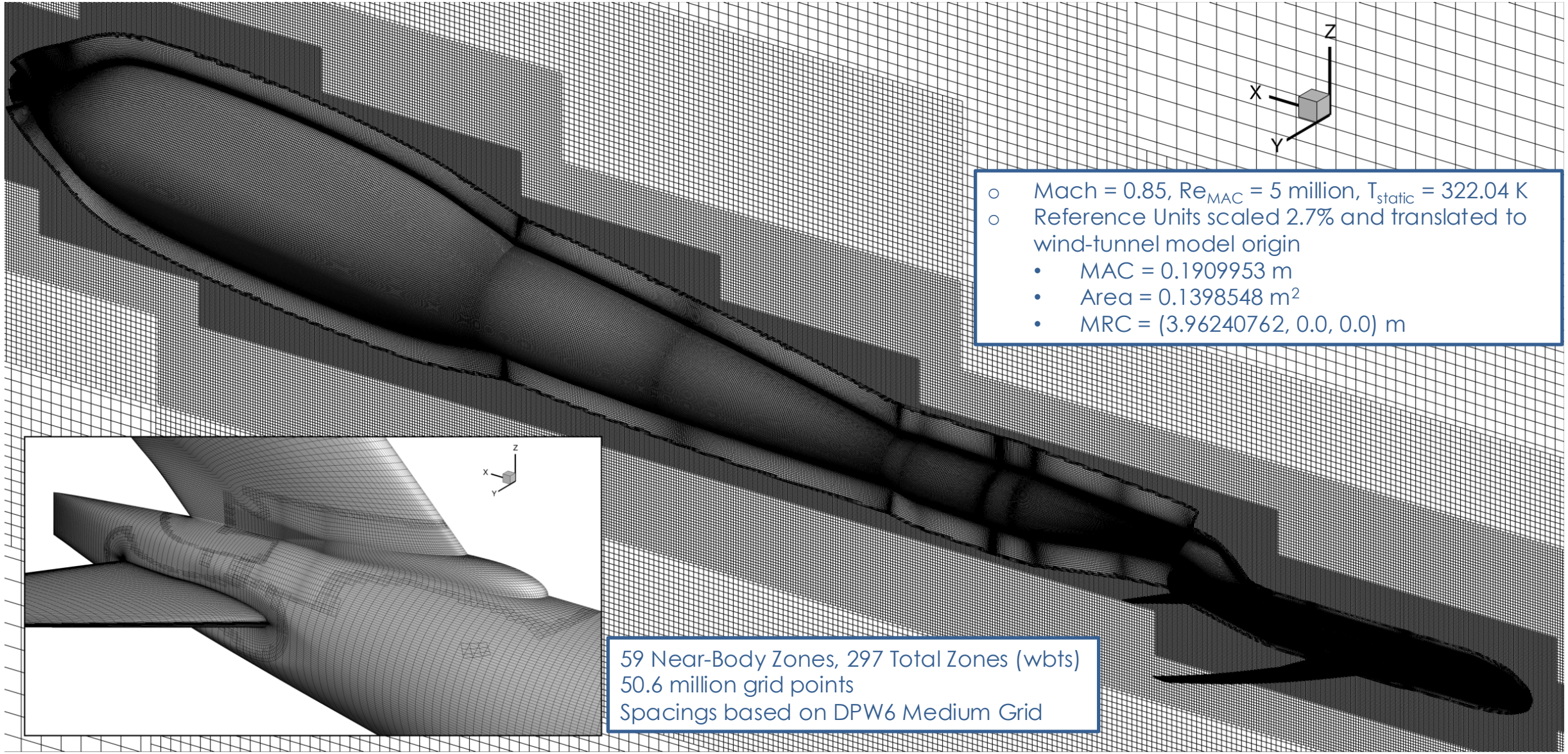


WingBodyTail (wbt)



WingBodyTailSting (wbts)

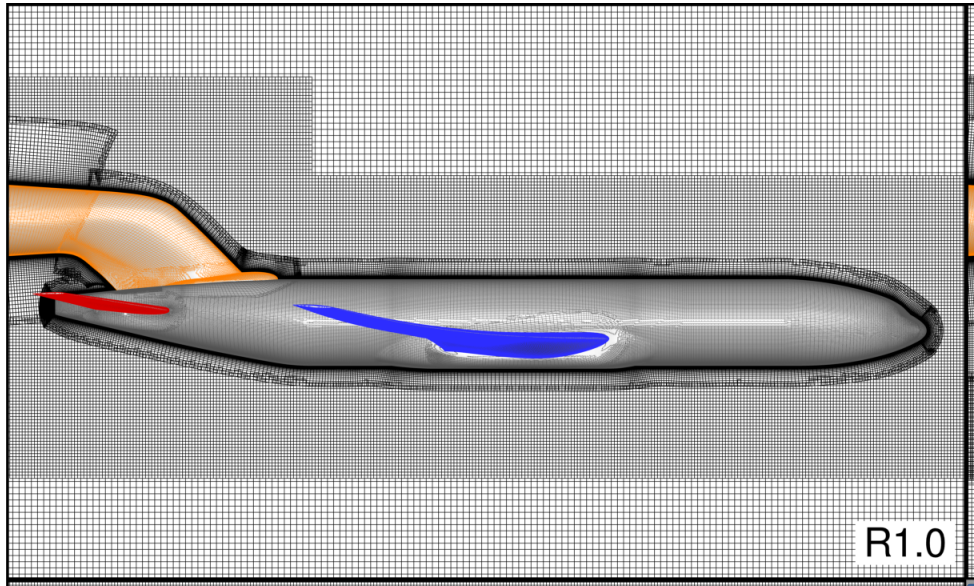
Baseline Grid (Jig-Shape) and Flow Conditions

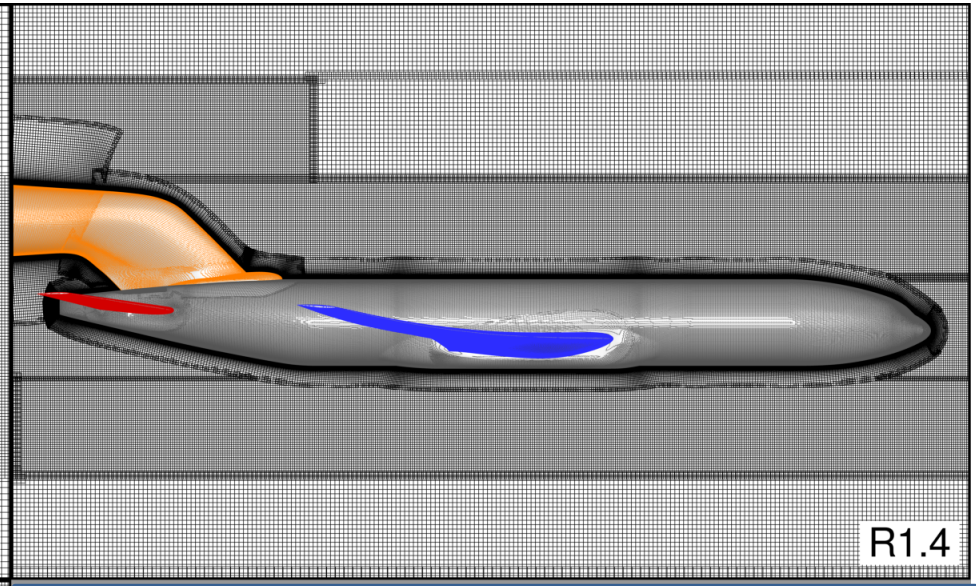


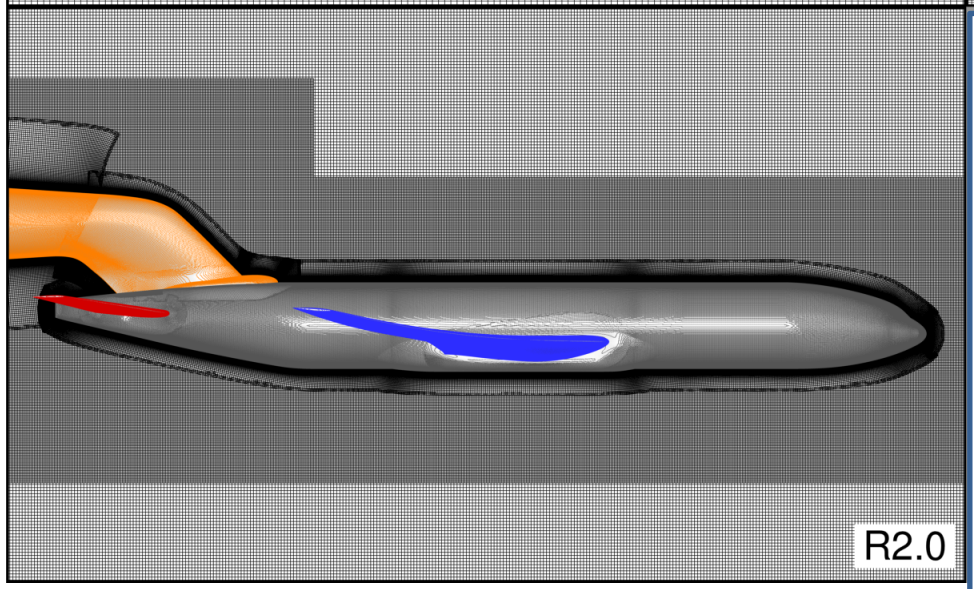
- Mach = 0.85, Re_{MAC} = 5 million, T_{static} = 322.04 K
- Reference Units scaled 2.7% and translated to wind-tunnel model origin
  - MAC = 0.1909953 m
  - Area = 0.1398548 m^2
  - MRC = (3.96240762, 0.0, 0.0) m

59 Near-Body Zones, 297 Total Zones (wbts)
50.6 million grid points
Spacings based on DPW6 Medium Grid

Structured Overset/Multiblock Mesh Family

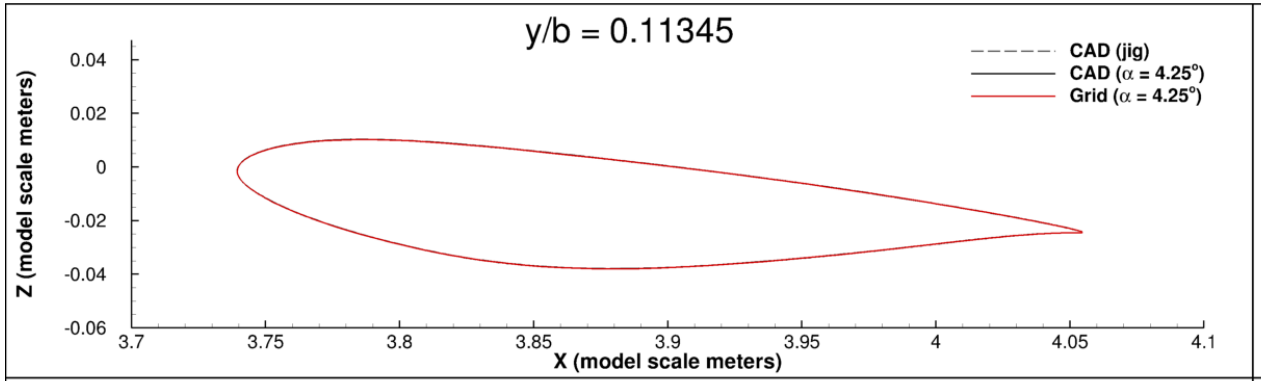


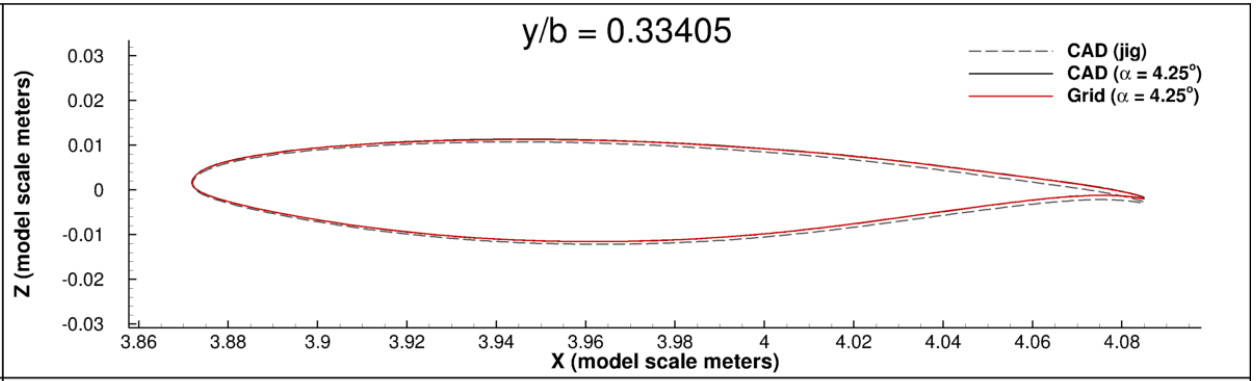


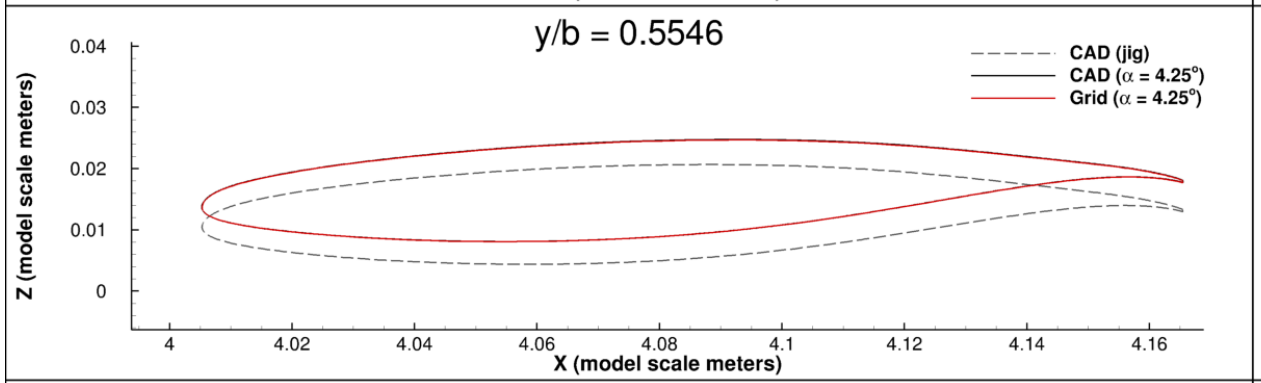


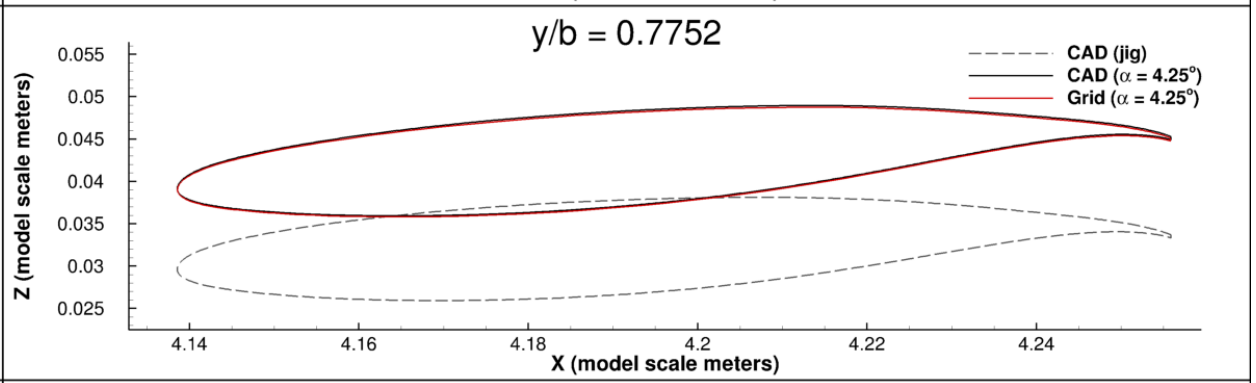
- R1.0: 50.6 million grid points
- R1.4: 140.5 million grid points
- R2.0: 393.5 million grid points
- Mesh family constructed with spline and refine procedure with R1.4 generated using sqrt(2) refinement in all 3 directions from R1.0 and R2.0 using 2.
- Grids are available for download at https://dpw.larc.nasa.gov/DPW8/Test_Environment/Test_Case_{2,3}/LAVA.REV00/

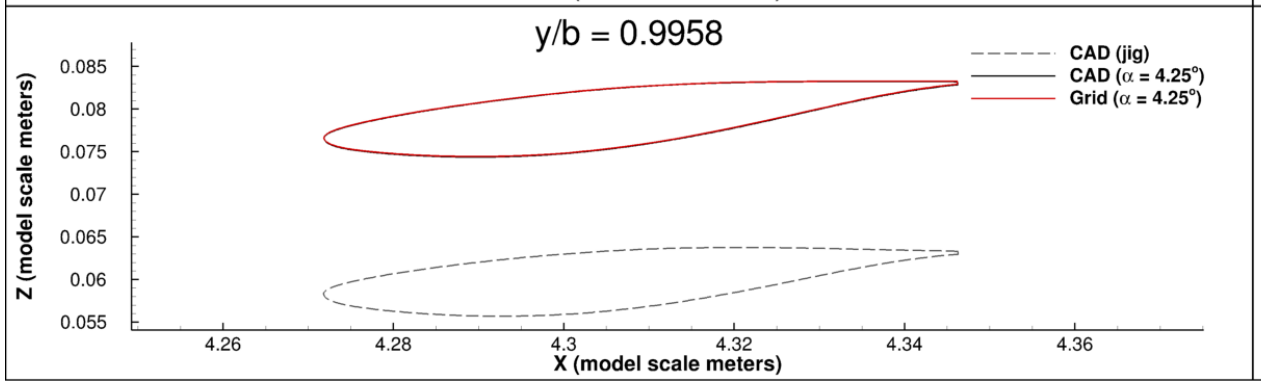
Wing Deflection Mesh Morphing

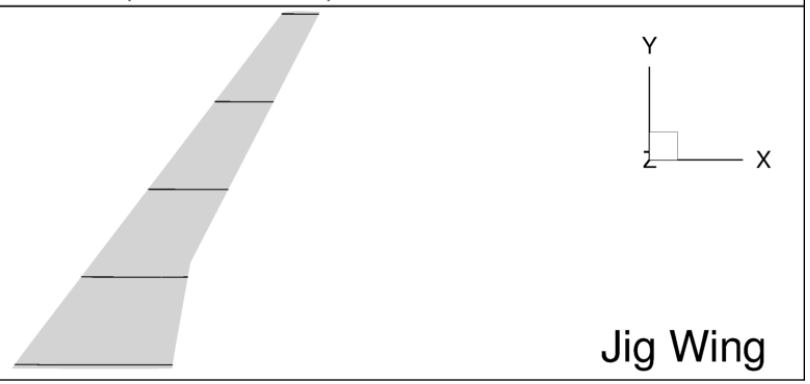








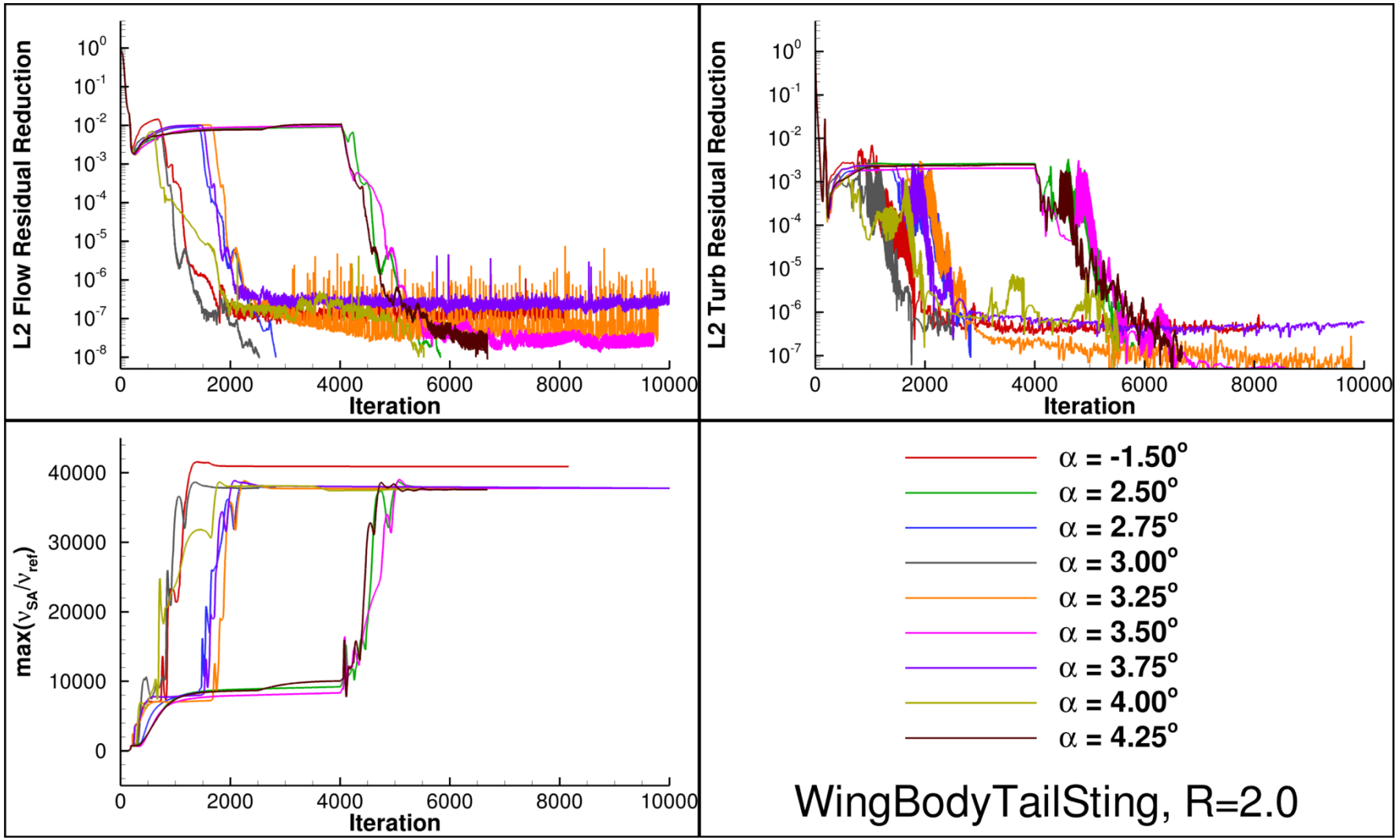




Alpha = 4.25-degrees

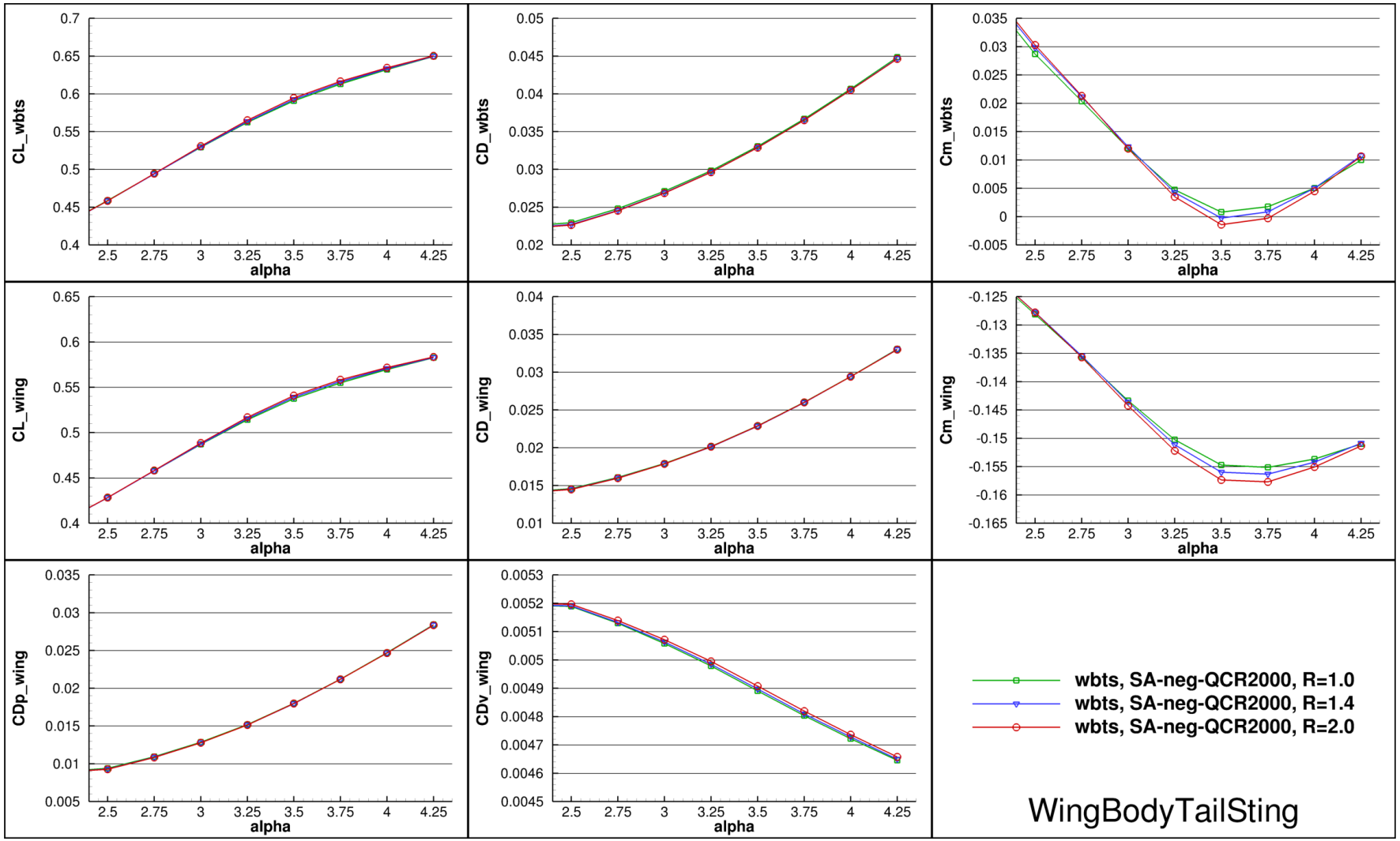
Results

Residual Convergence



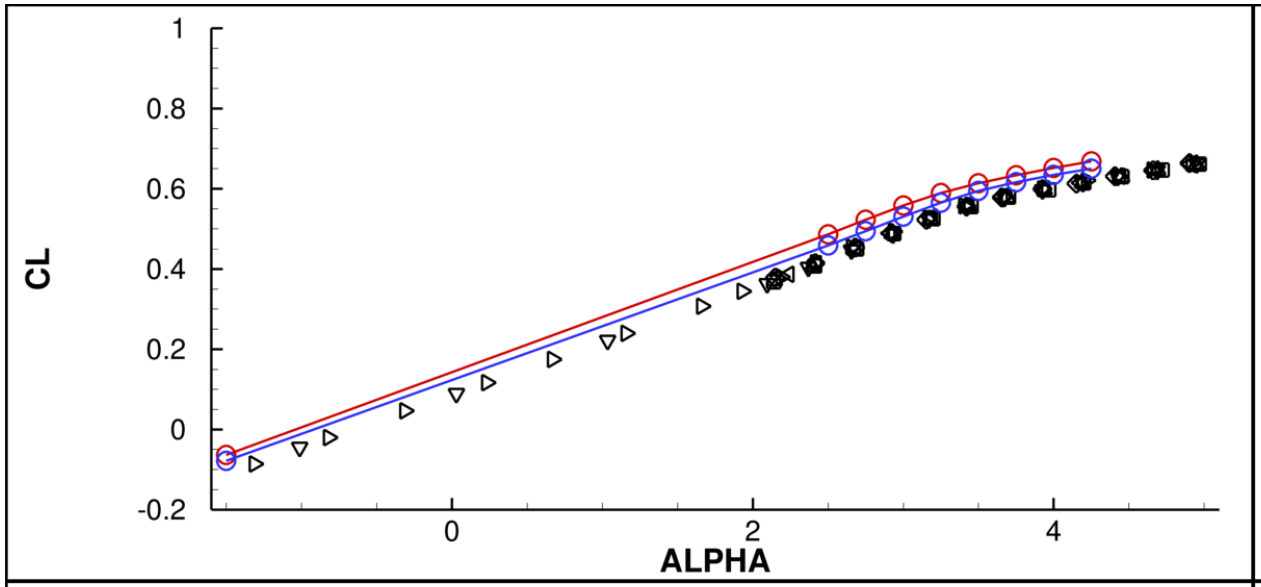
- Residual convergence of 7 to 8 orders of magnitude reduction is achieved for both flow and turbulence model

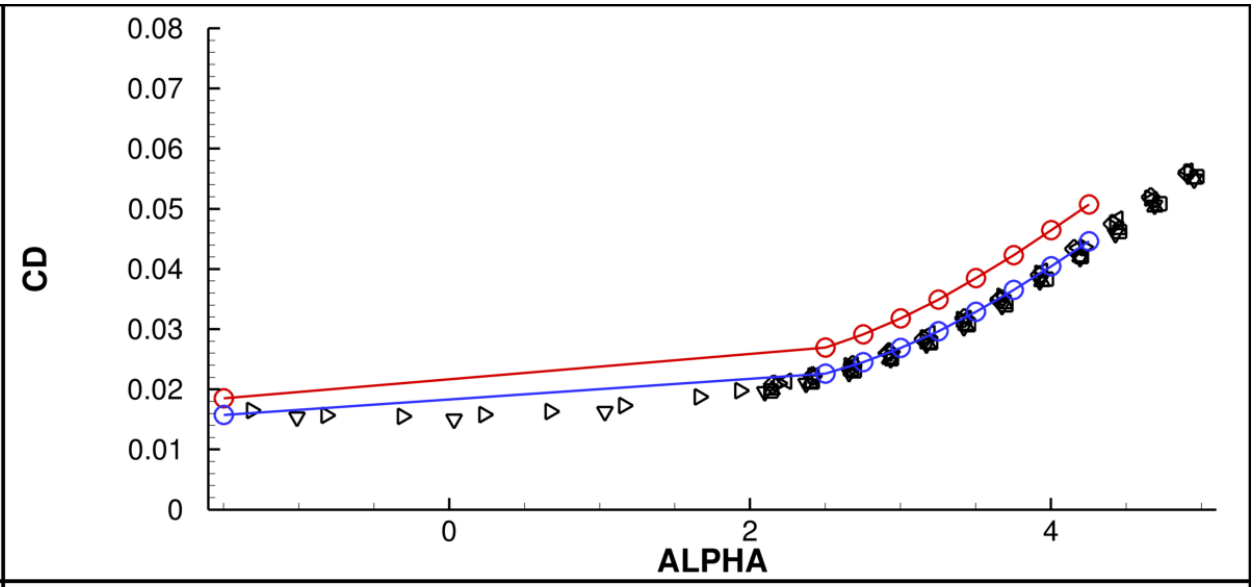
Mesh Sensitivity

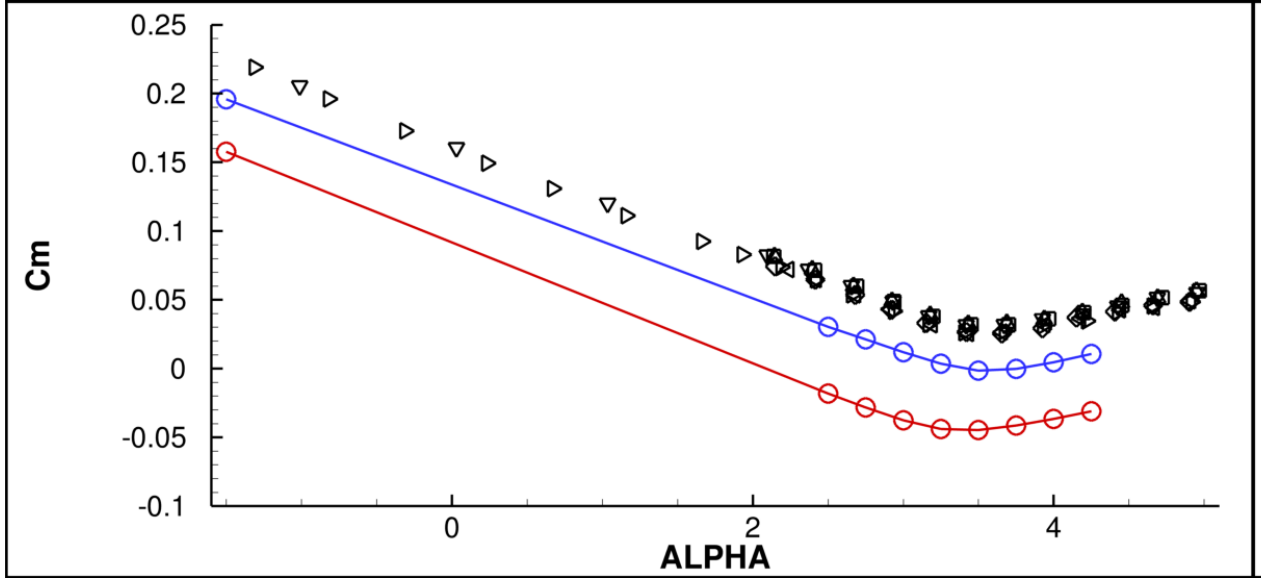


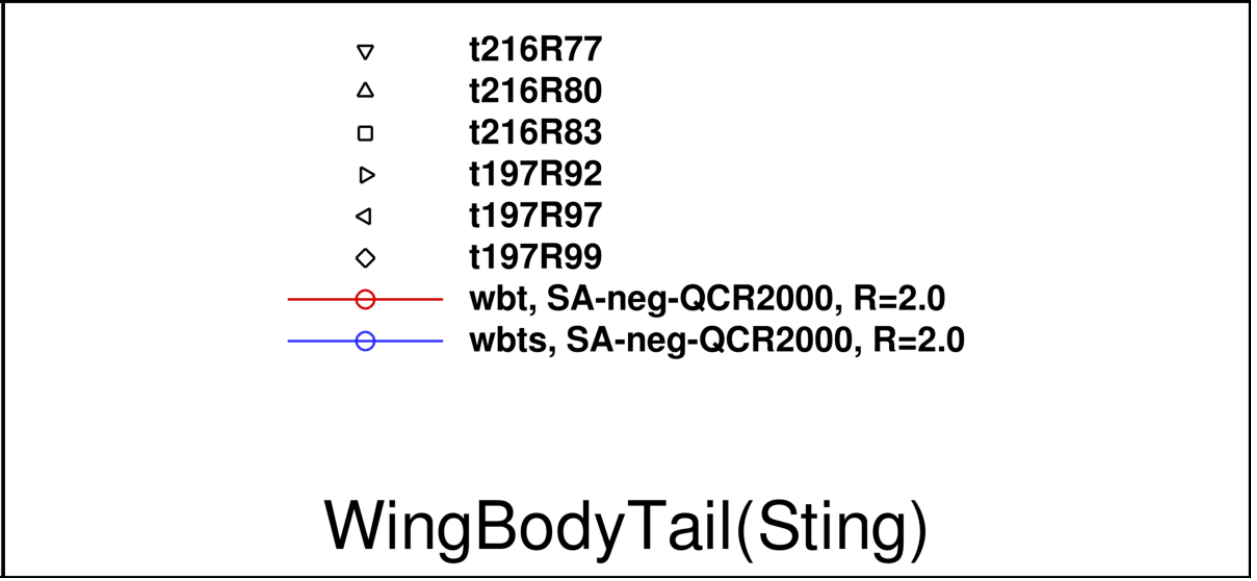
- Largest mesh sensitivity observed in pitching moment between 3.25° to 3.75°

Sensitivity to Sting

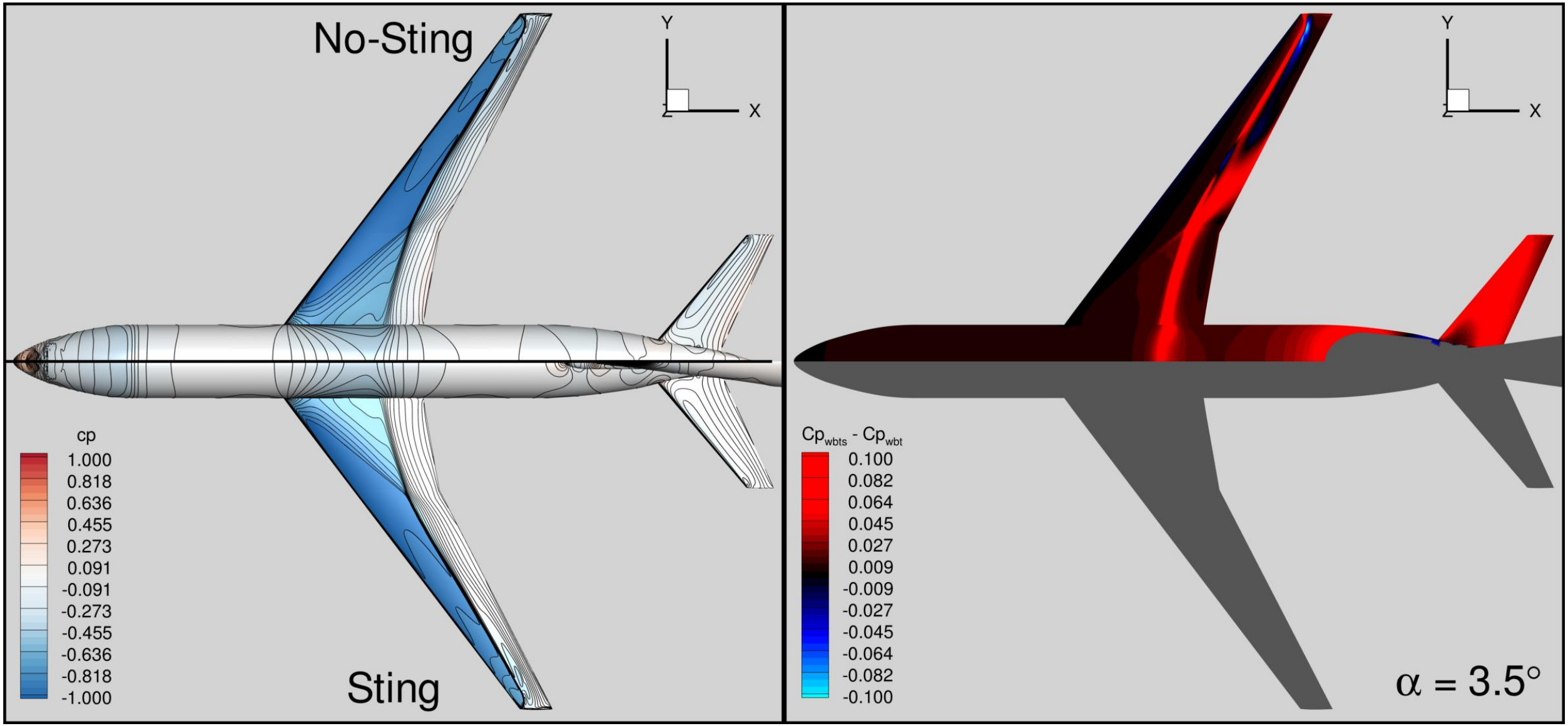




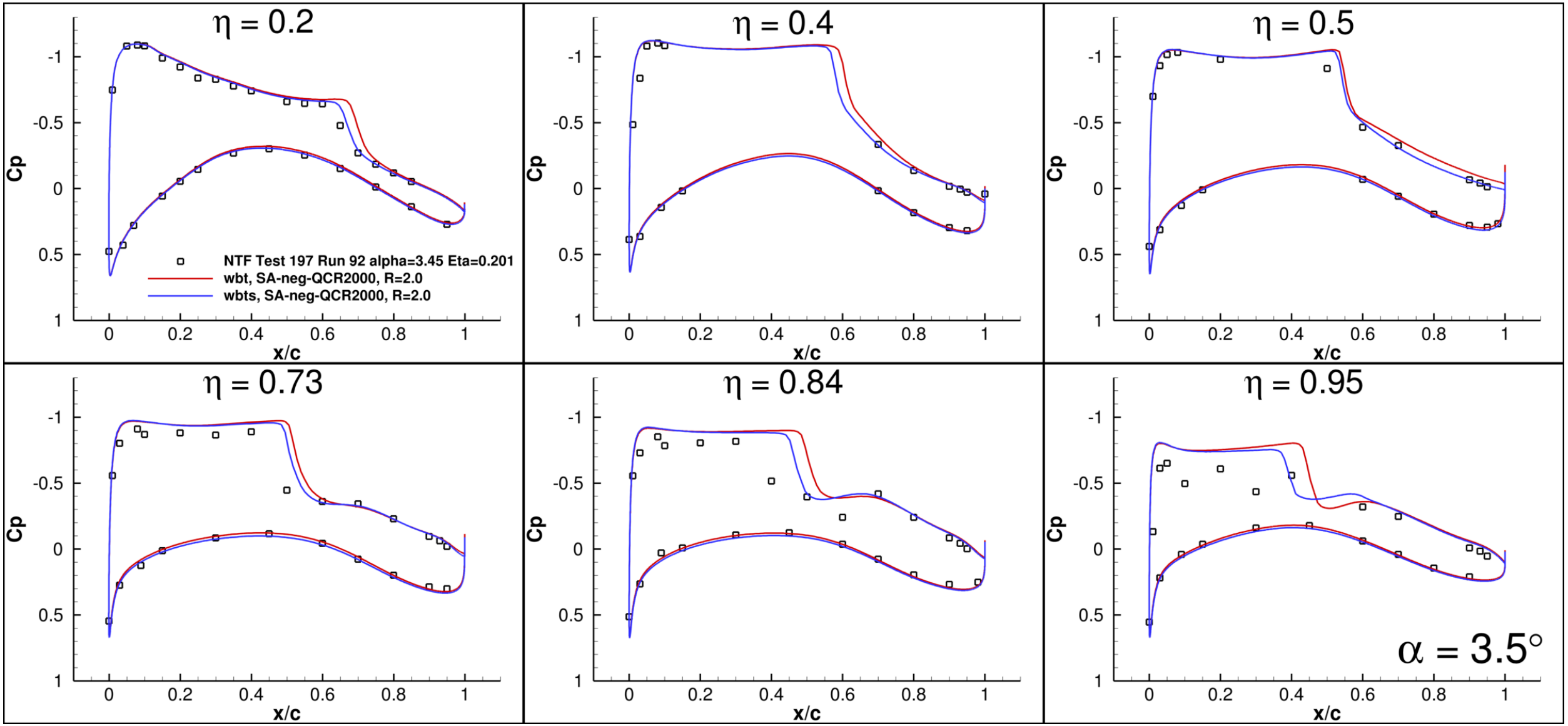




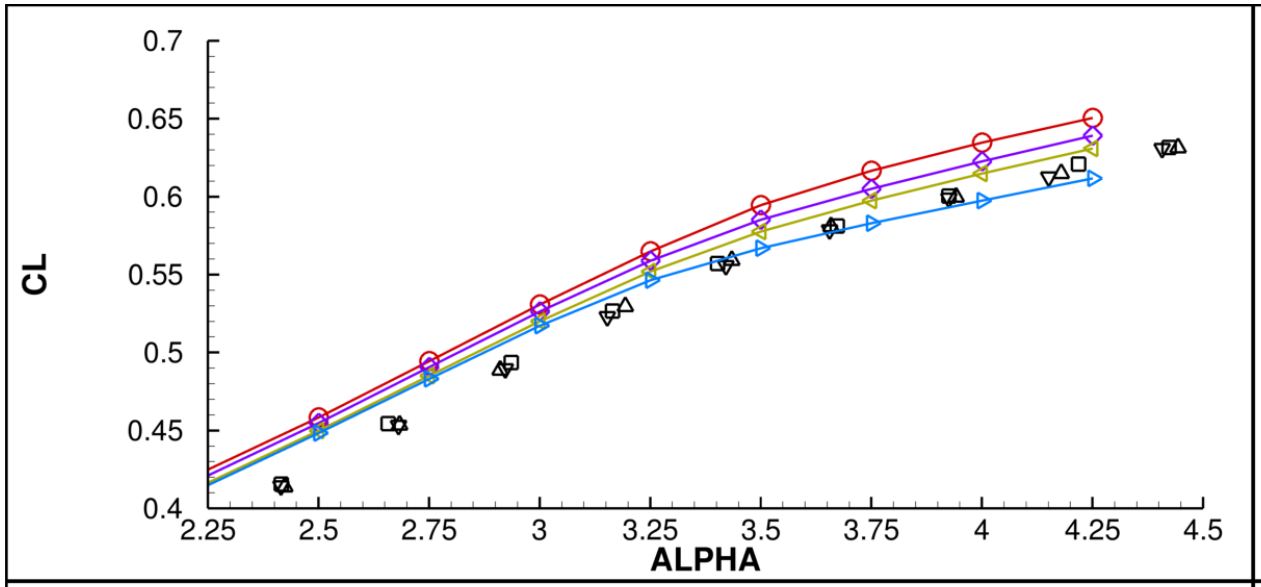
Sensitivity to Sting

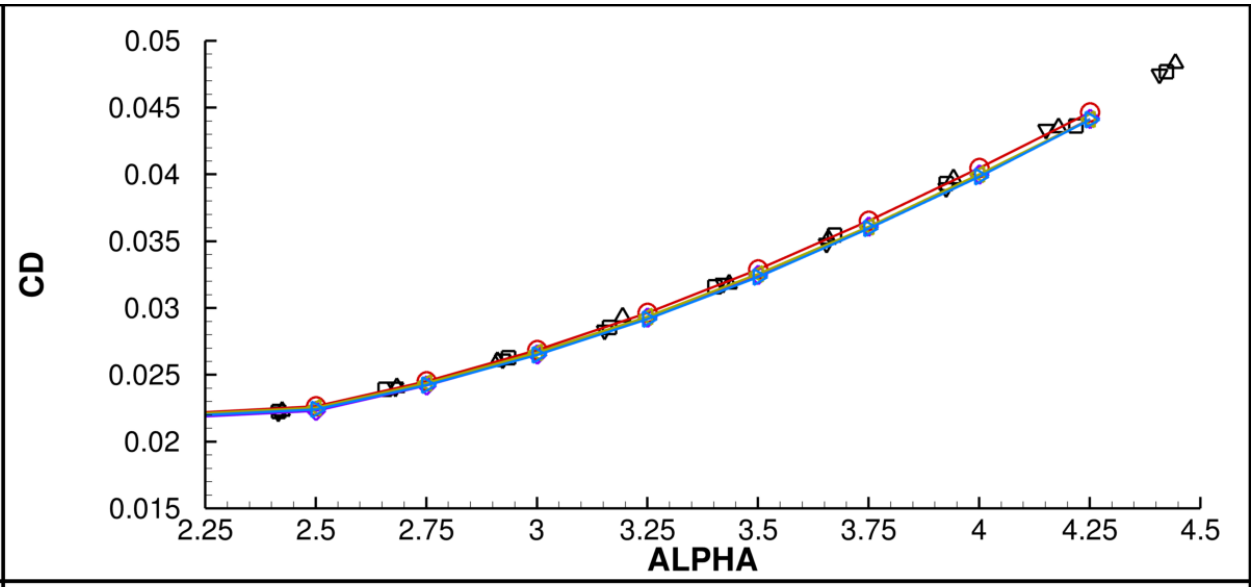


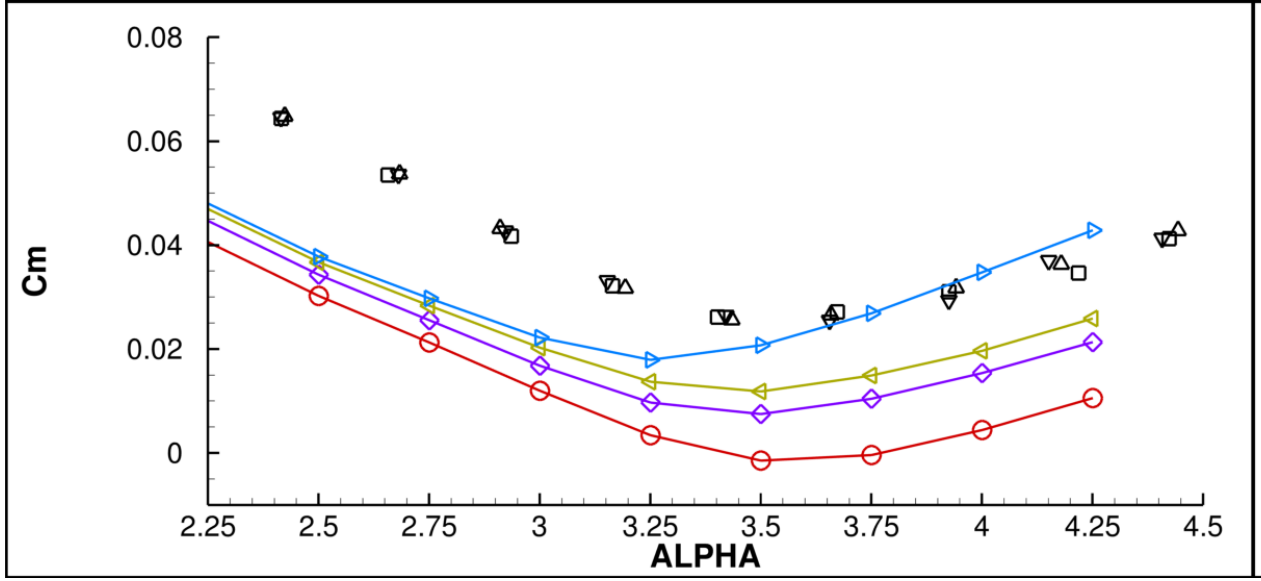
Sensitivity to Sting



Sensitivity to Turbulence Model Corrections



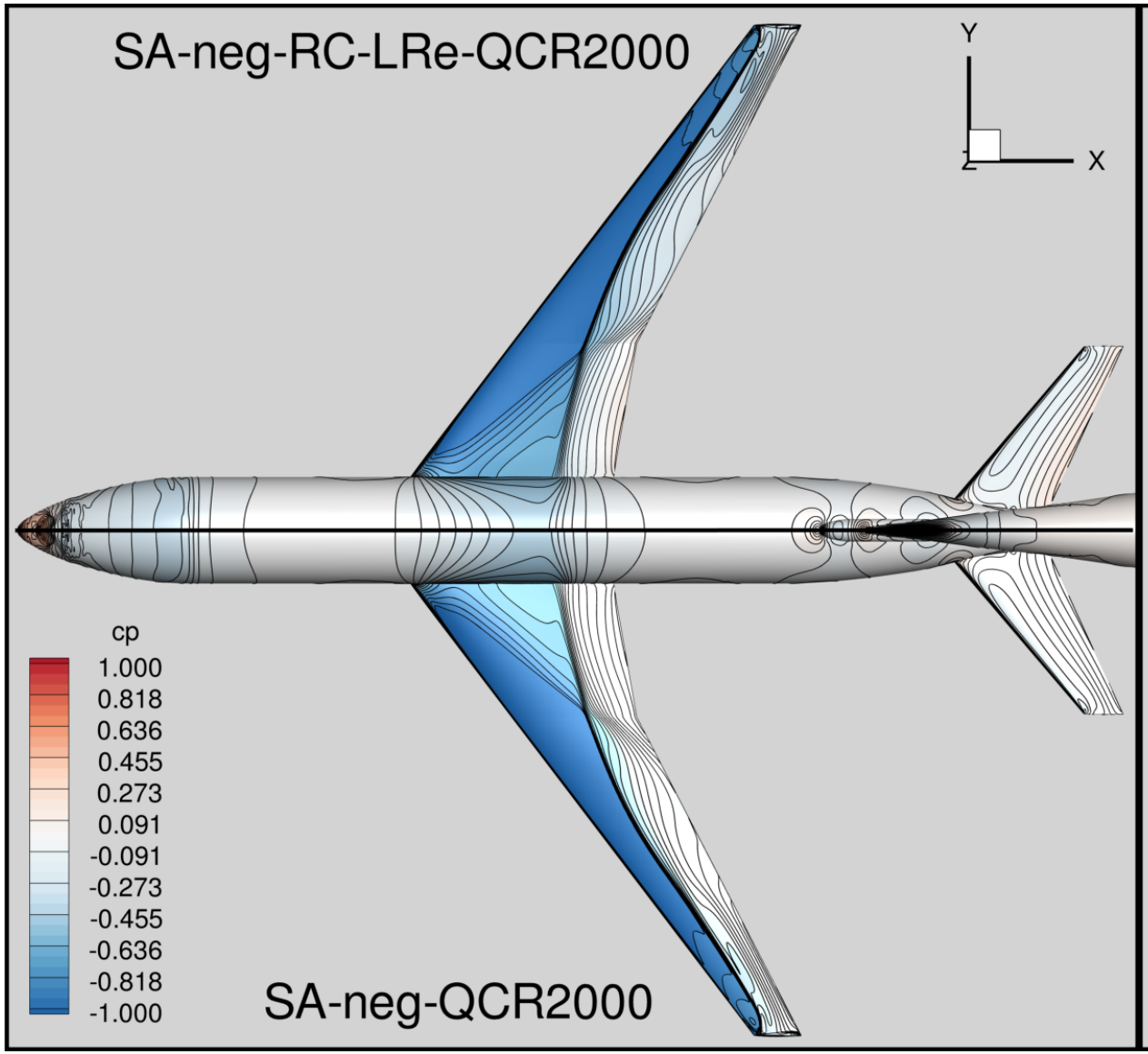


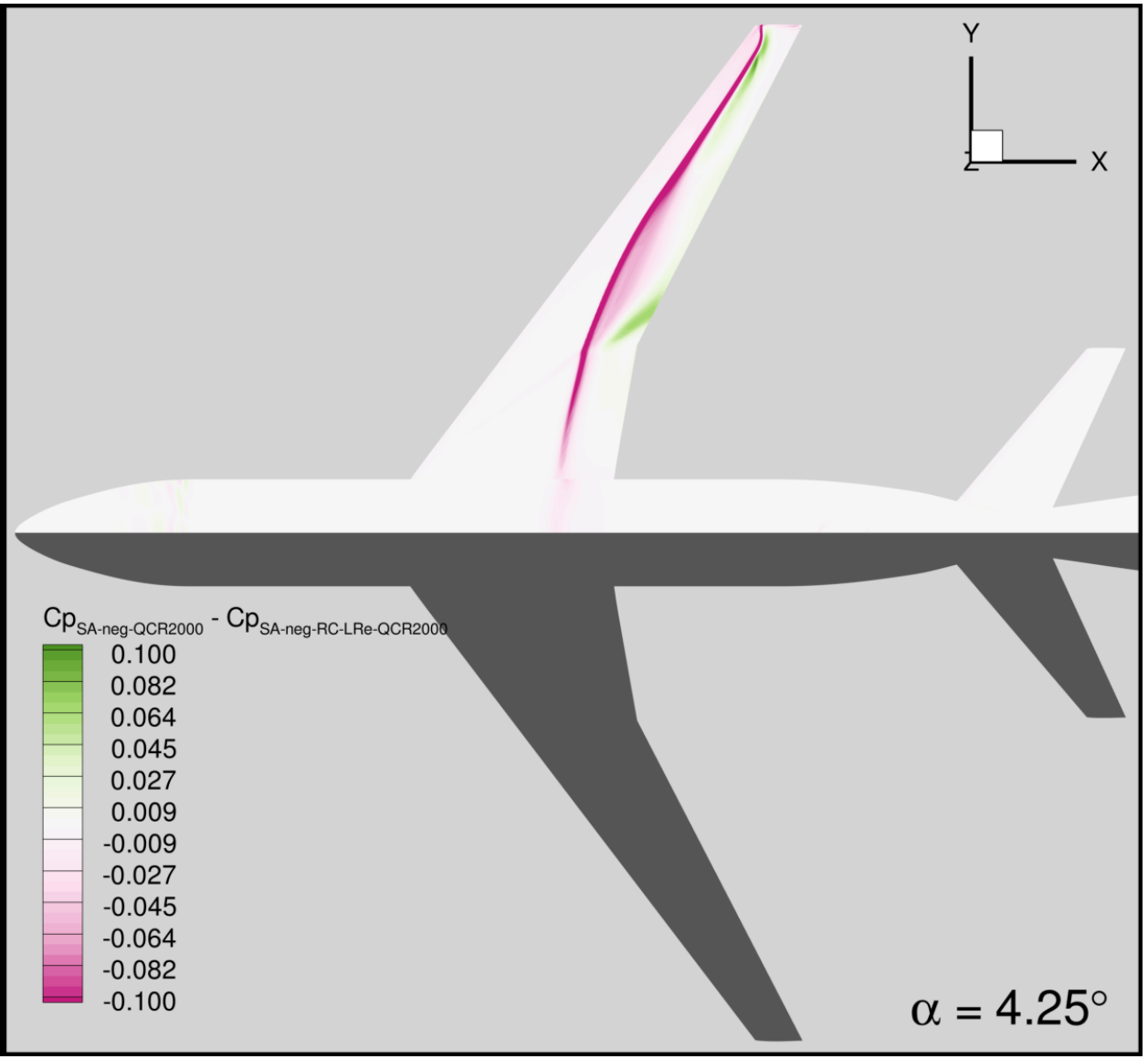


t197R92
t197R97
t197R99
wbts, SA-neg-QCR2000, R=2.0
wbts, SA-neg-RC-QCR2000, R=2.0
wbts, SA-neg-RC-LRe-QCR2000, R=2.0
wbts, SA-neg-RC-LRe-comp-QCR2000, R=2.0

WingBodyTailSting

Sensitivity to Turbulence Model Corrections





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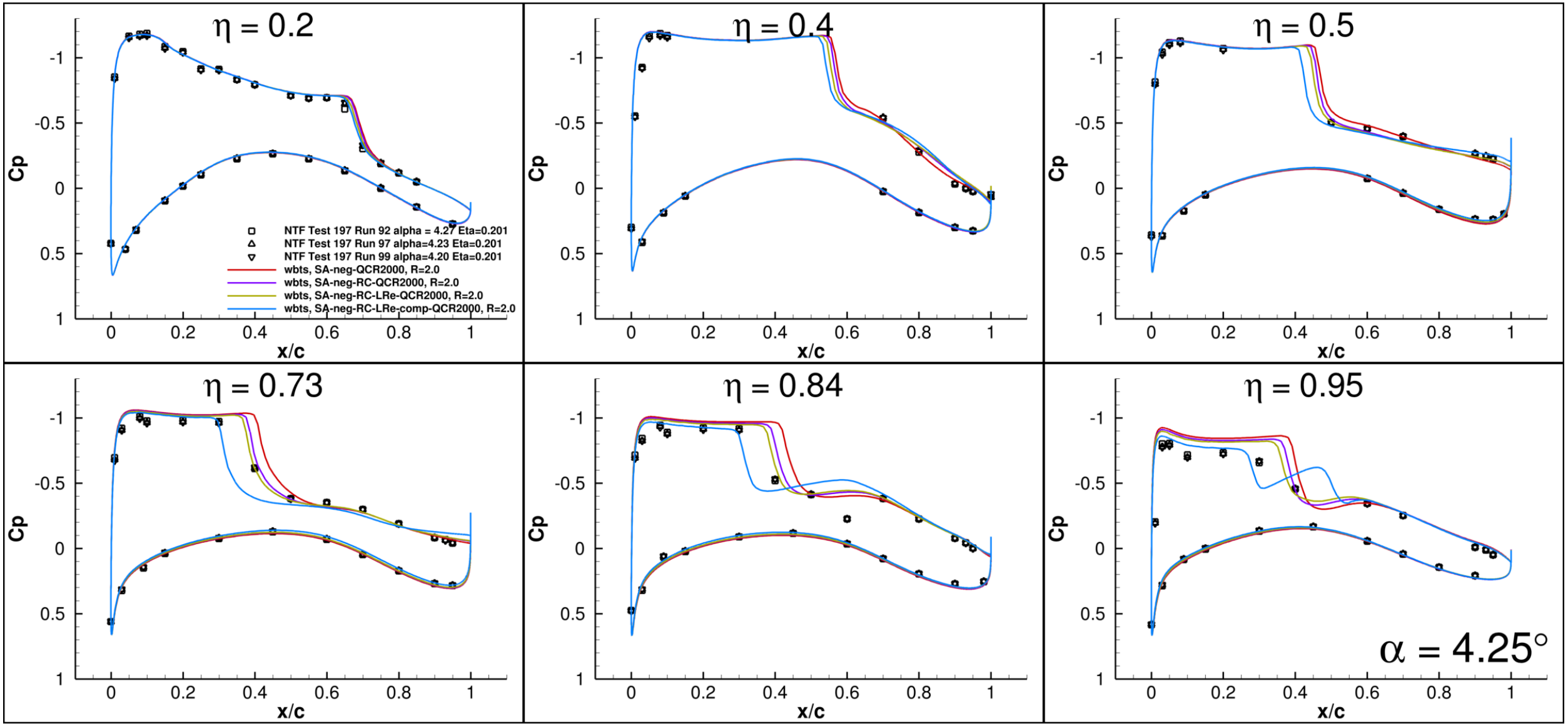

Summary

- Steady-state RANS based analysis was applied to CRM with and without sting for both the tail on and tail off configurations
- A total of 108 meshes were generated and delivered to the workshop
- Significant improvement in aerodynamic loads compared to experiment is achieved by including the sting
- Additional improvement is observed utilizing the rotation curvature (RC) correction and low Reynolds number (LRe) correction along with QCR2000
- A nearly constant offset remains between CFD and WT measurements even with including the sting and using SA-neg-RC-LRe-QCR2000

Acknowledgements

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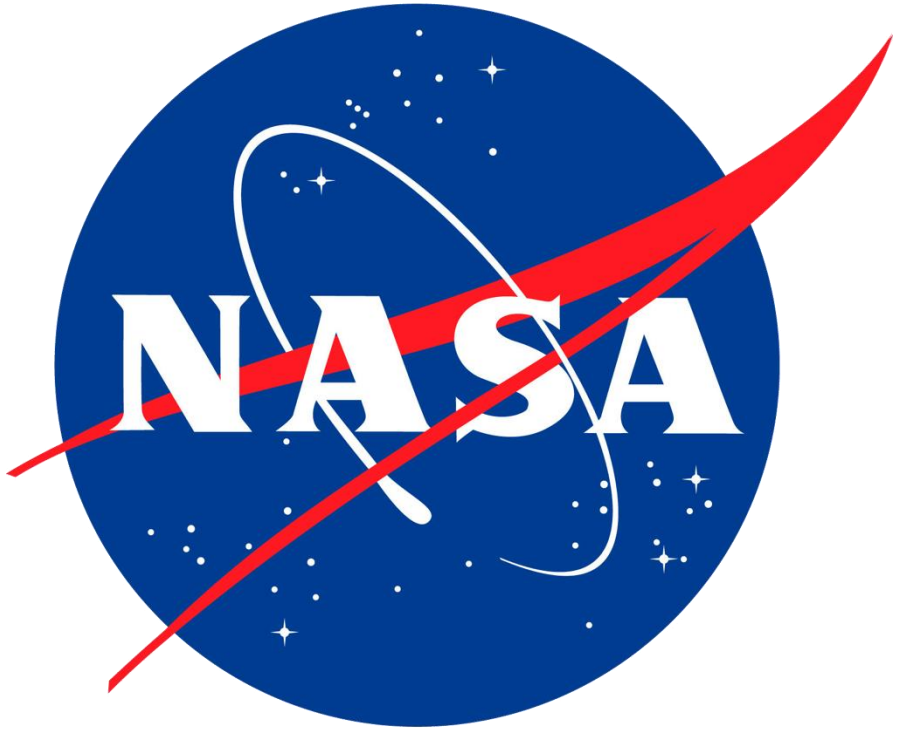
- Drag Prediction Workshop committee members especially Ben Rider, Ed Tinoco, and Seyedeh Hosseini

- LAVA teams members especially Timothy Chau, Joshua Anibal, and Luis dos Santos Fernandes for valuable discussions



Thank You