Lattice-Boltzmann Simulations for DPW-8/AePW-4 using PowerFLOW

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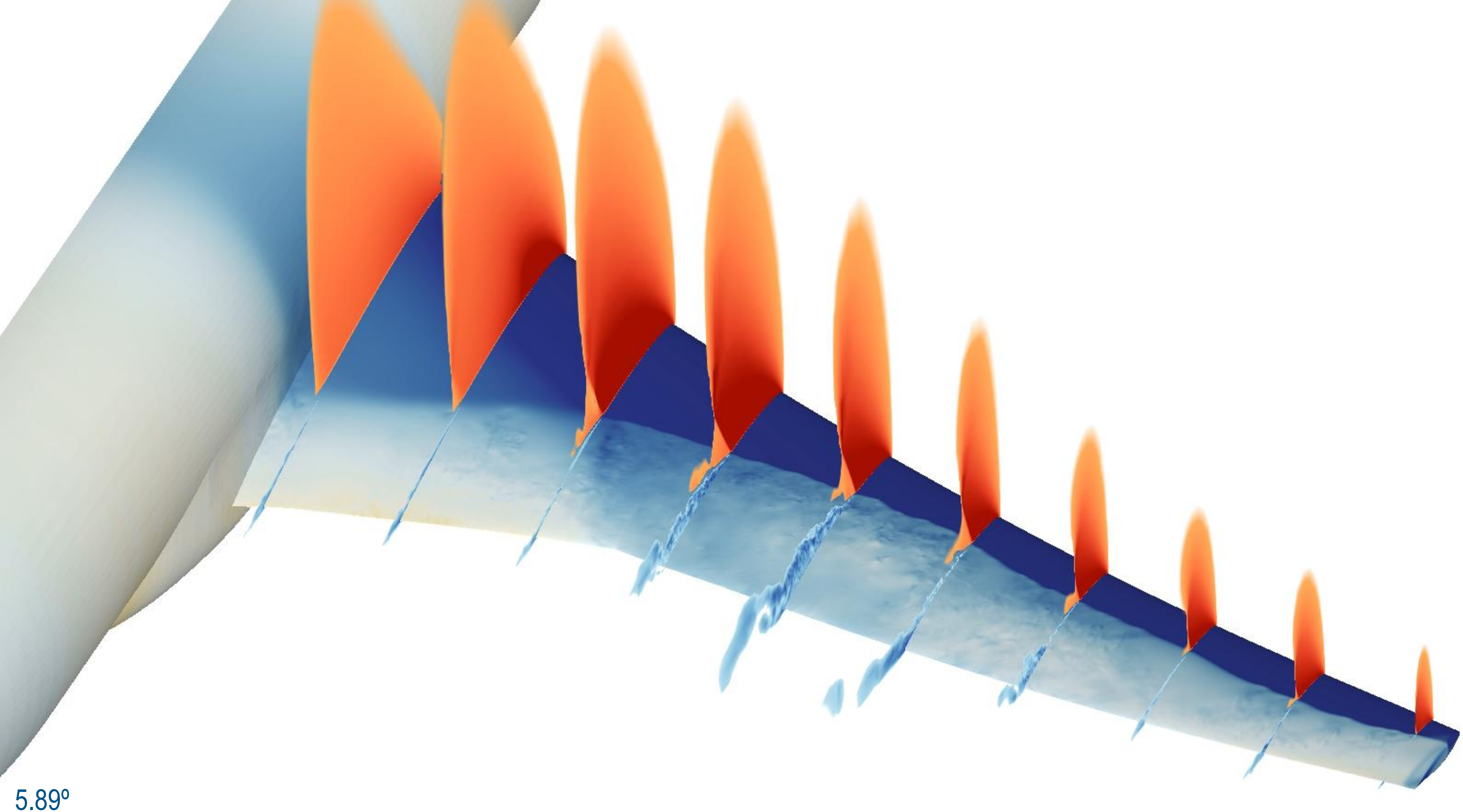
San Diego - June 7th, 2026



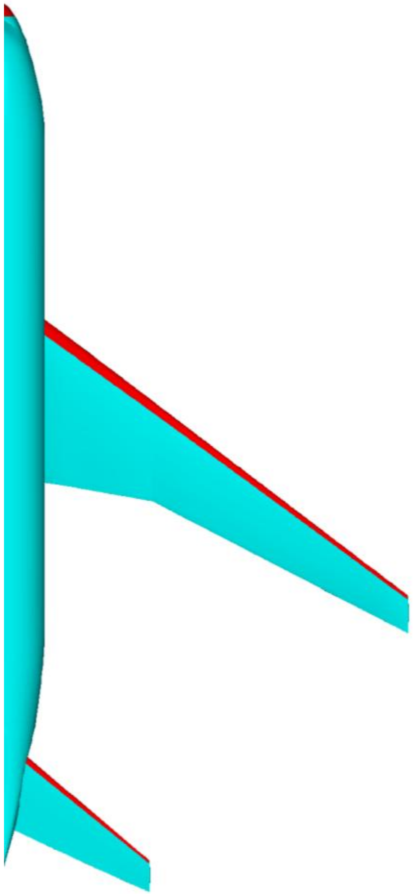
5.89º

AGENDA

POWERFLOW®

- Solver: Lattice-Boltzmann Method (**LBM**).
    - Time-accurate, unsteady solver.
- Flow regimes: subsonic, **transonic**, and supersonic flows.
- Lattice models: D3Q19 and **D3Q33**
- Spatial discretization: **second-order** accurate.
- Time integration: Explicit.
- Grid topology: **Cartesian**.
- Wall modeling:
    - Extended turbulent wall model that dynamically incorporates pressure gradient effects.
    - Wall functions scaled by the local pressure gradient.
    - Boundary layer types:
        - Fully turbulent.
        - Laminar.
        - Automatic transition.
- Turbulence modeling: state-of-the-art renormalization group (RNG) form of the k-epsilon equations.

SETUP

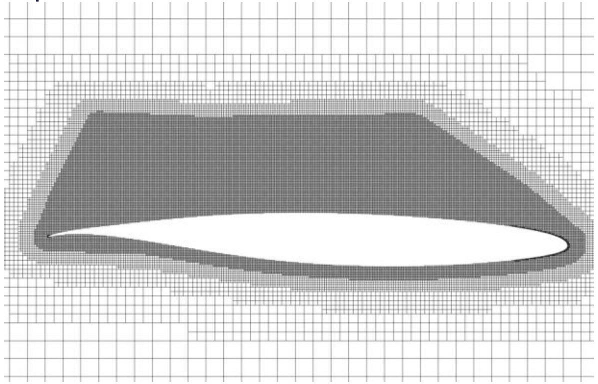


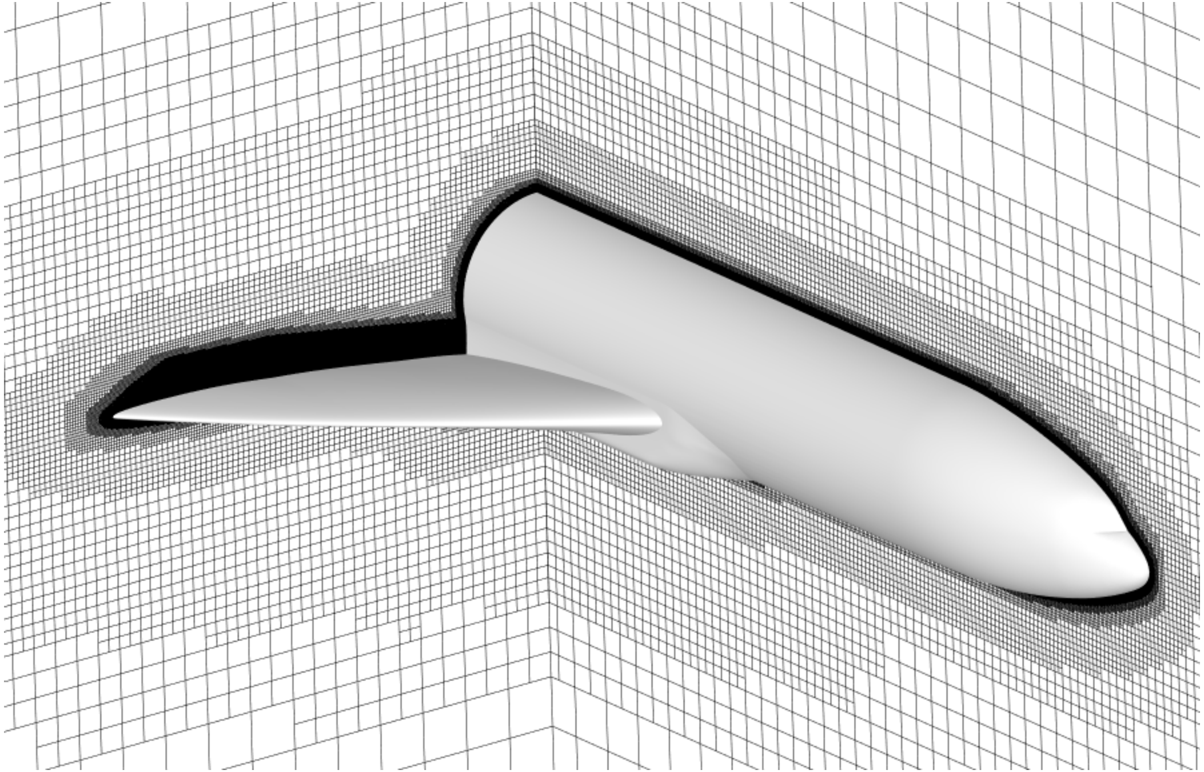
- PowerFLOW 6-2025-R2
- Cases:
  - Model: JAXA CRM, using the different deflected wings
- Boundary conditions:
  - Free-air.
  - Symmetry.
  - Laminar patches on leading edges (up to 10% chord) and fuselage nose.
- Flow conditions:
  - Re: 1.51 million
  - M: 0.84
  - AoAs: 1.22º, 2.29º, 4.84º, 5.89º
- Initialization method: cold start.
- Simulated physical time: 100 to 500 CTUs.

SETUP

- Grid: custom cartesian.
- Typical grid size: ~280 million voxels
- Typical y+ on upper wing surface: ~45

η = 50%

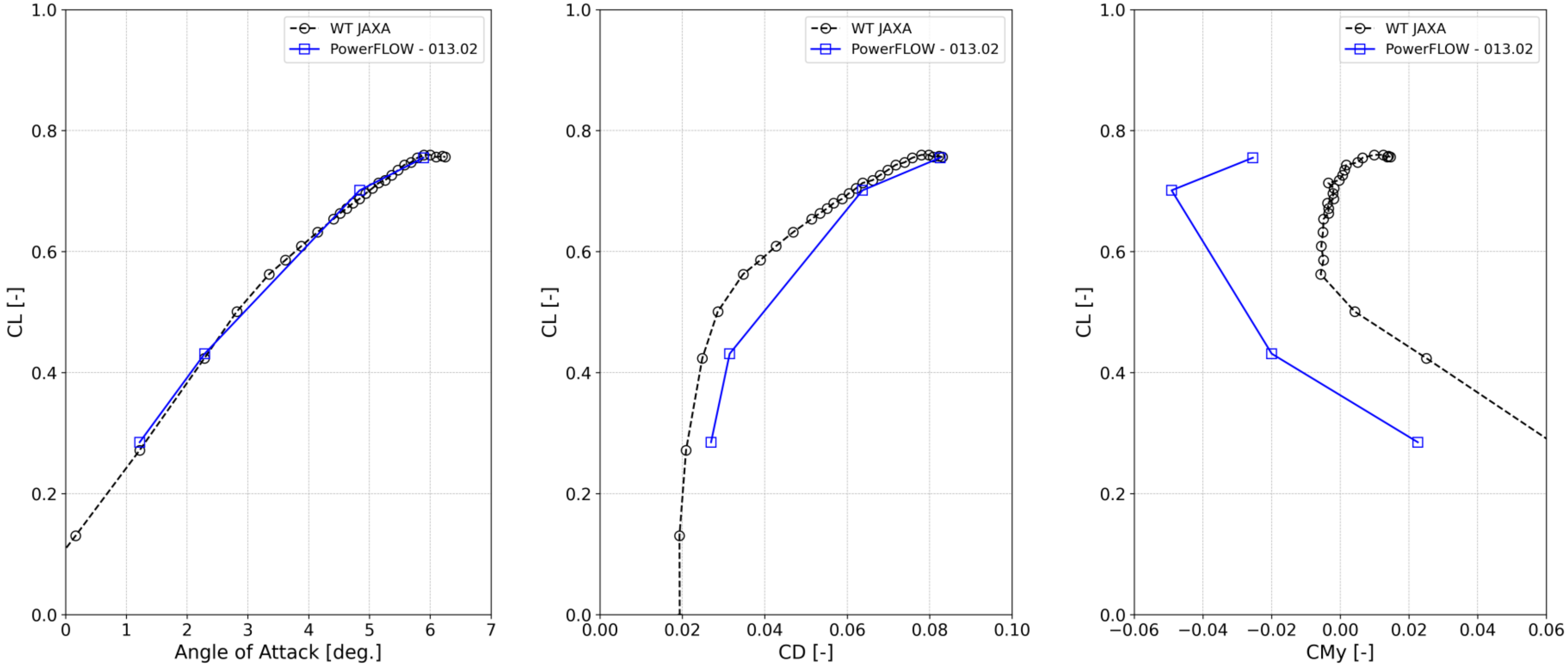




ANGLE OF ATTACK SWEEP

Grid L4

Re	1.51 million
M	0.85
α	1.22°, 2.29°, 4.84°, 5.89°



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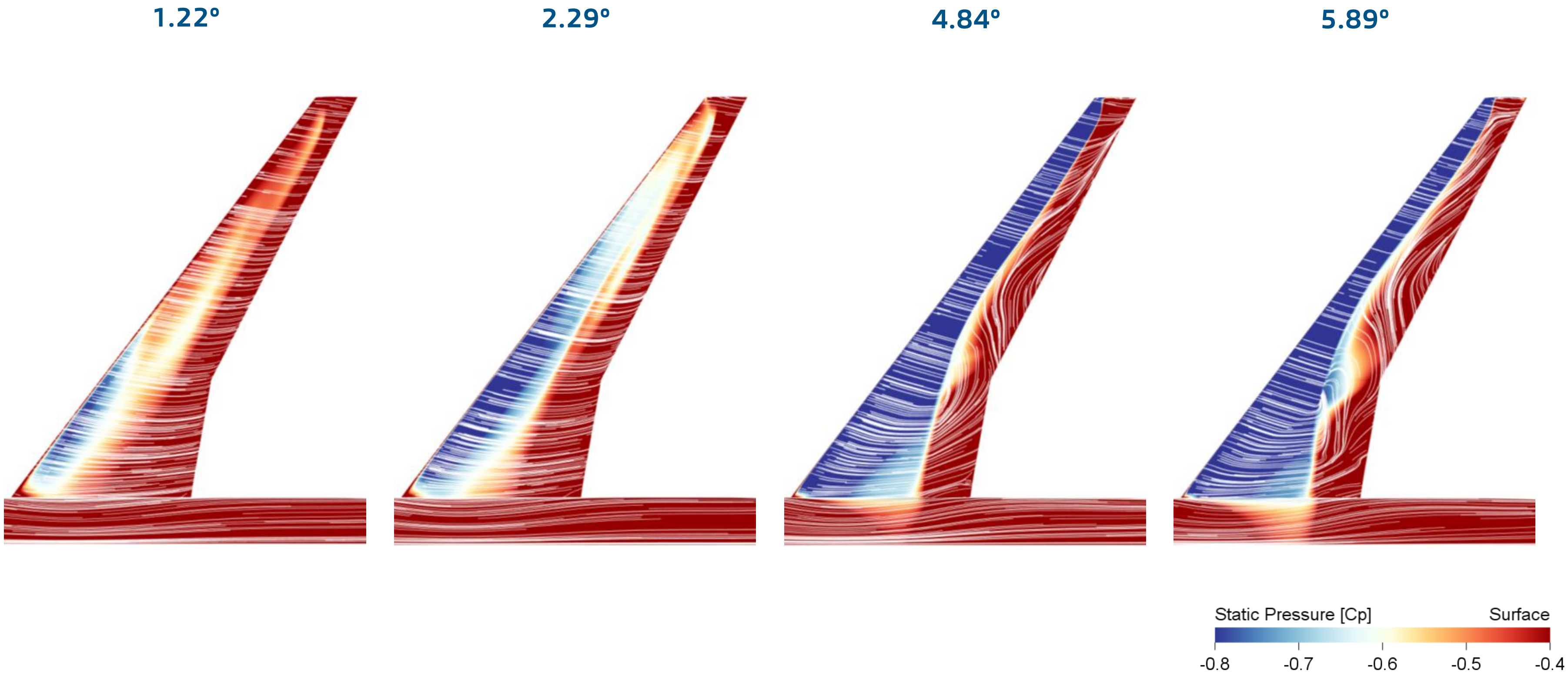
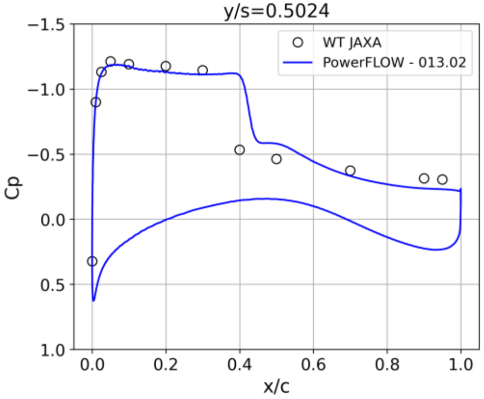
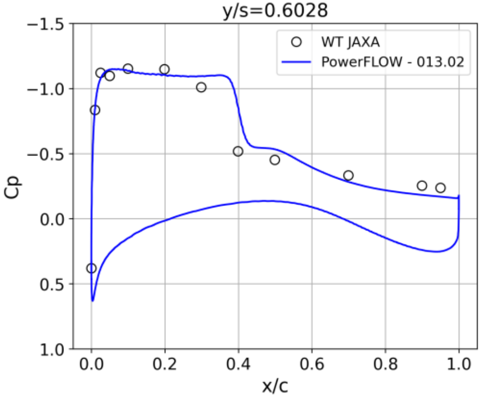
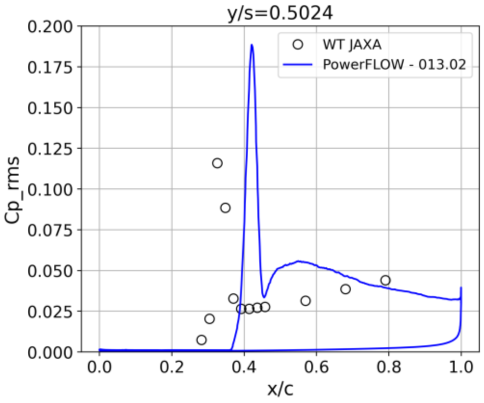


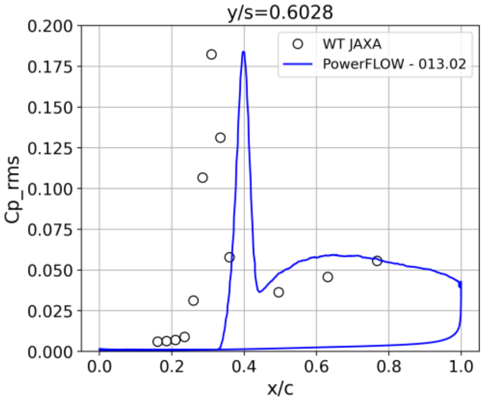
ANGLE OF ATTACK SWEEP

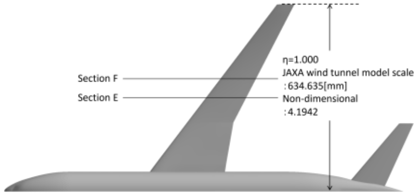
Grid L4











Re	1.51 million
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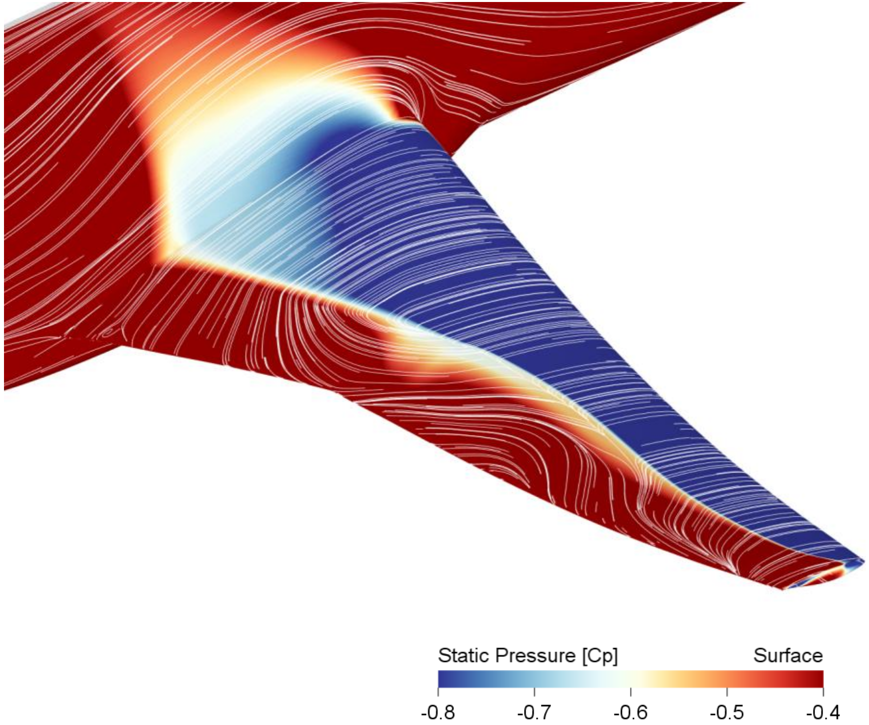
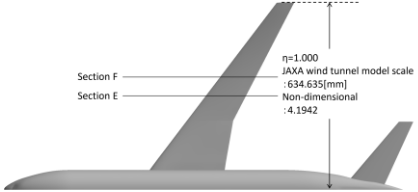
α	4.84°



ANGLE OF ATTACK SWEEP

Grid L4



Re	1.51 million
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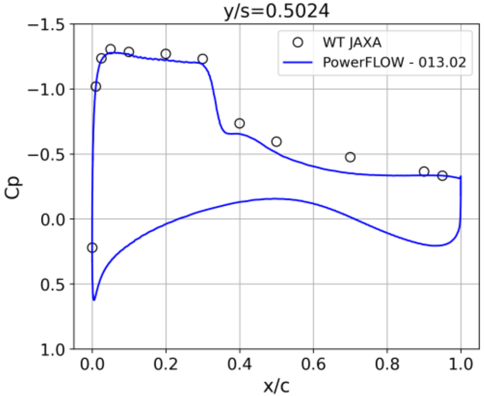
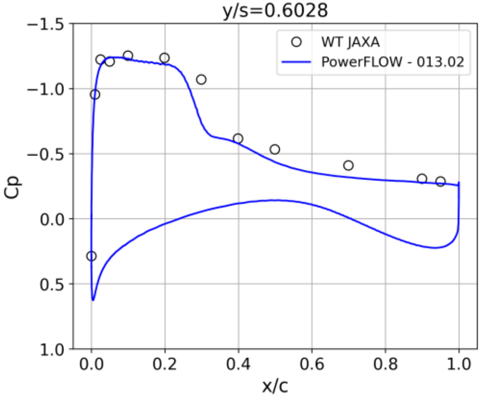
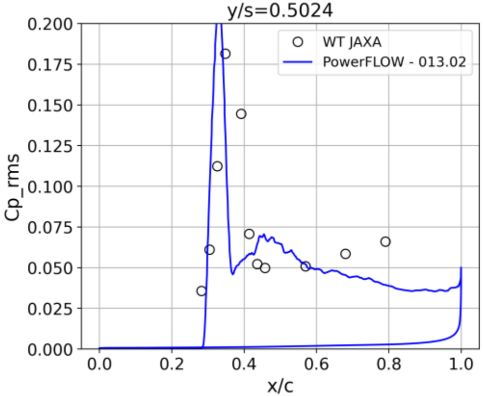
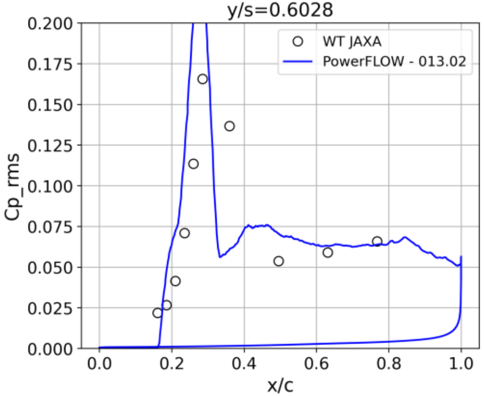
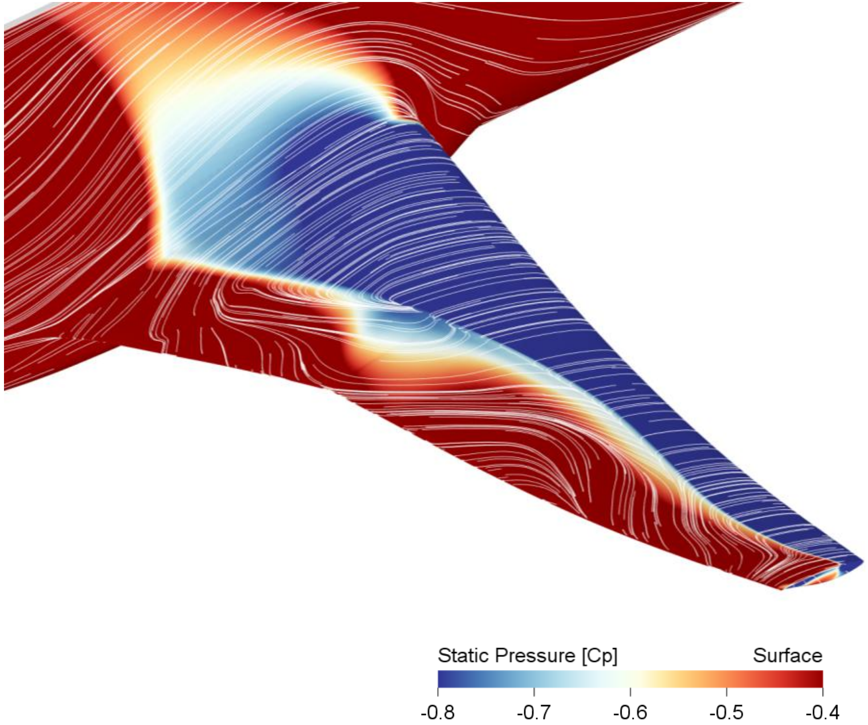
α	5.89º









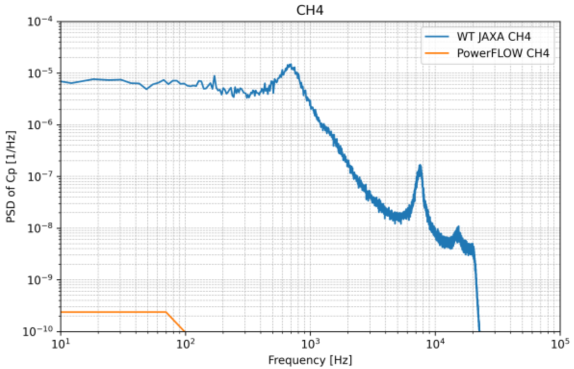


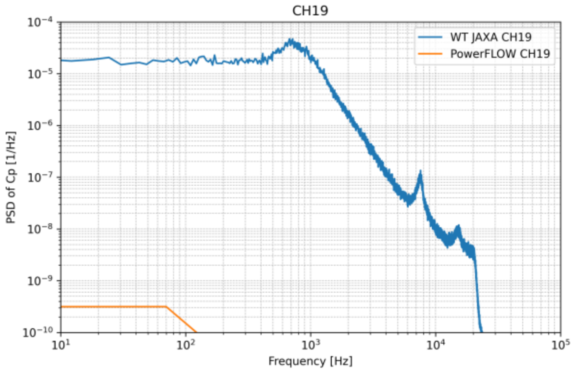
ANGLE OF ATTACK SWEEP

Grid L4

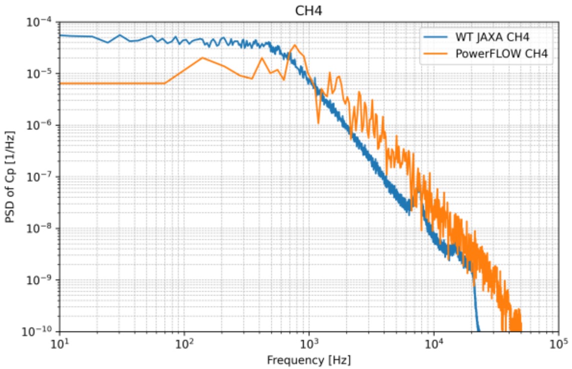
Re	1.51 million
M	0.85
α	4.84º, 5.89º

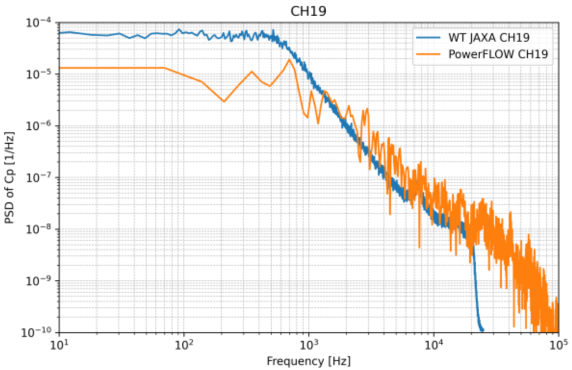
4.84º





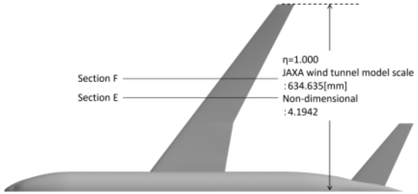
5.89º





ANGLE OF ATTACK SWEEP

Grid L4

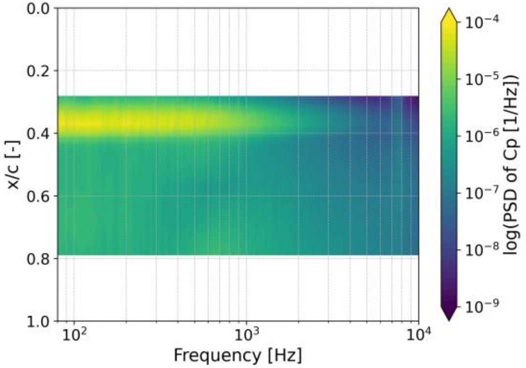


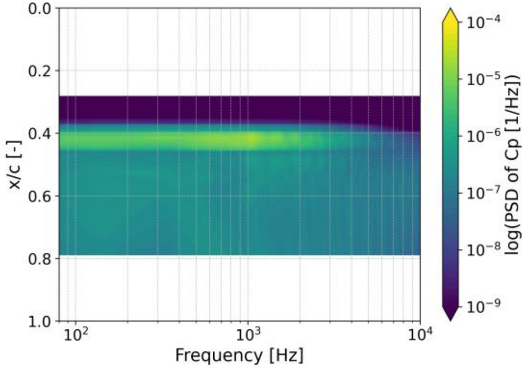
Re	1.51 million
M	0.85
α	4.84°

WT JAXA

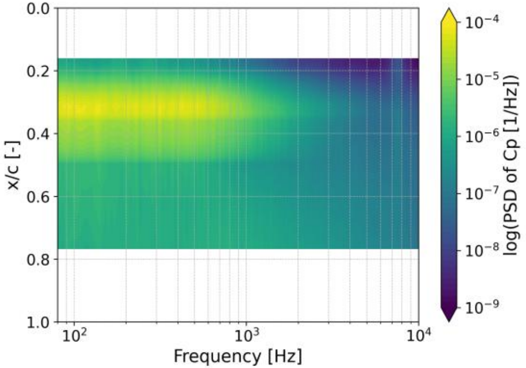
PowerFLOW

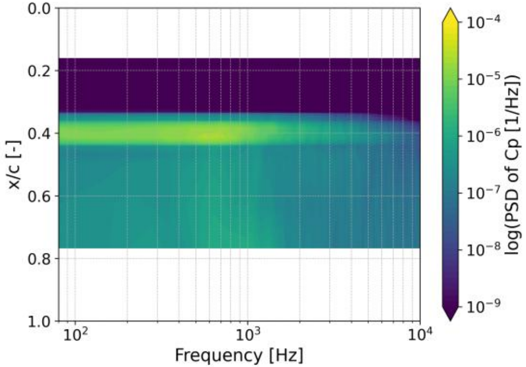
50%





60%



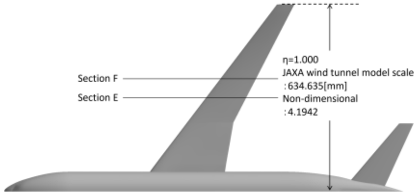


GRID RESOLUTION STUDY

Grids L1, L2, L3 L4

- Grids: scaled using a **factor of 1.5^n**

Level	Nr. Voxels (million)	Min. Voxel Size (mm)
1	14	0.371
2	34	0.248
3	93	0.165
4	281	0.110



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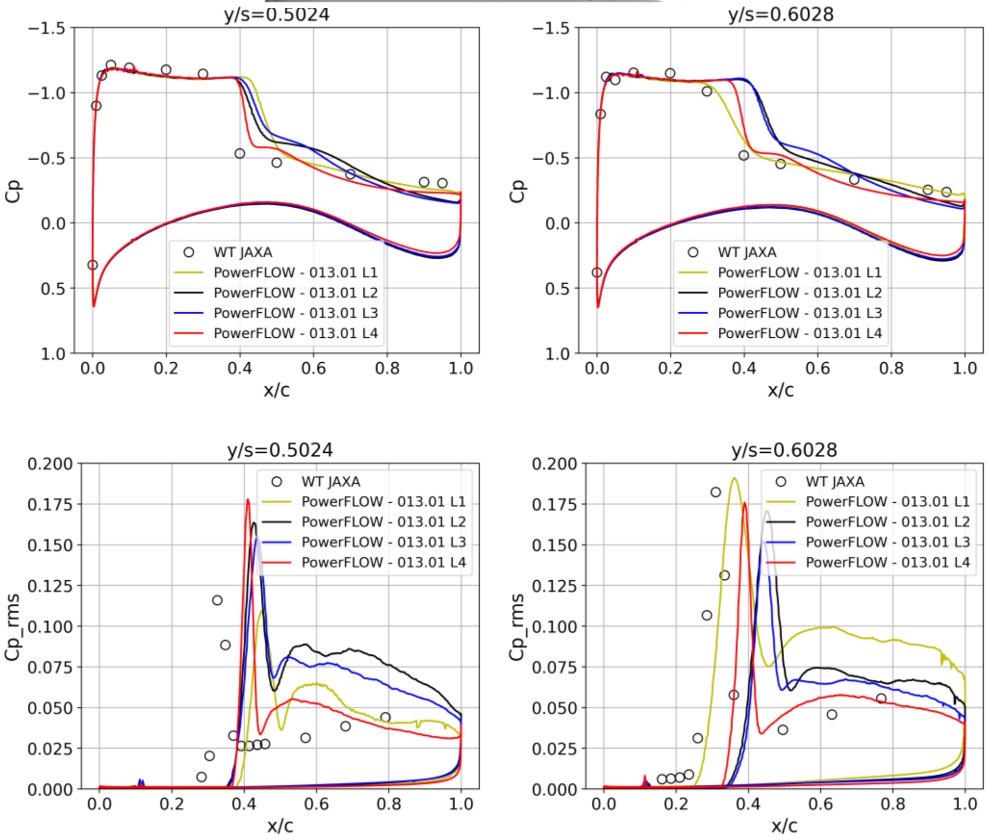

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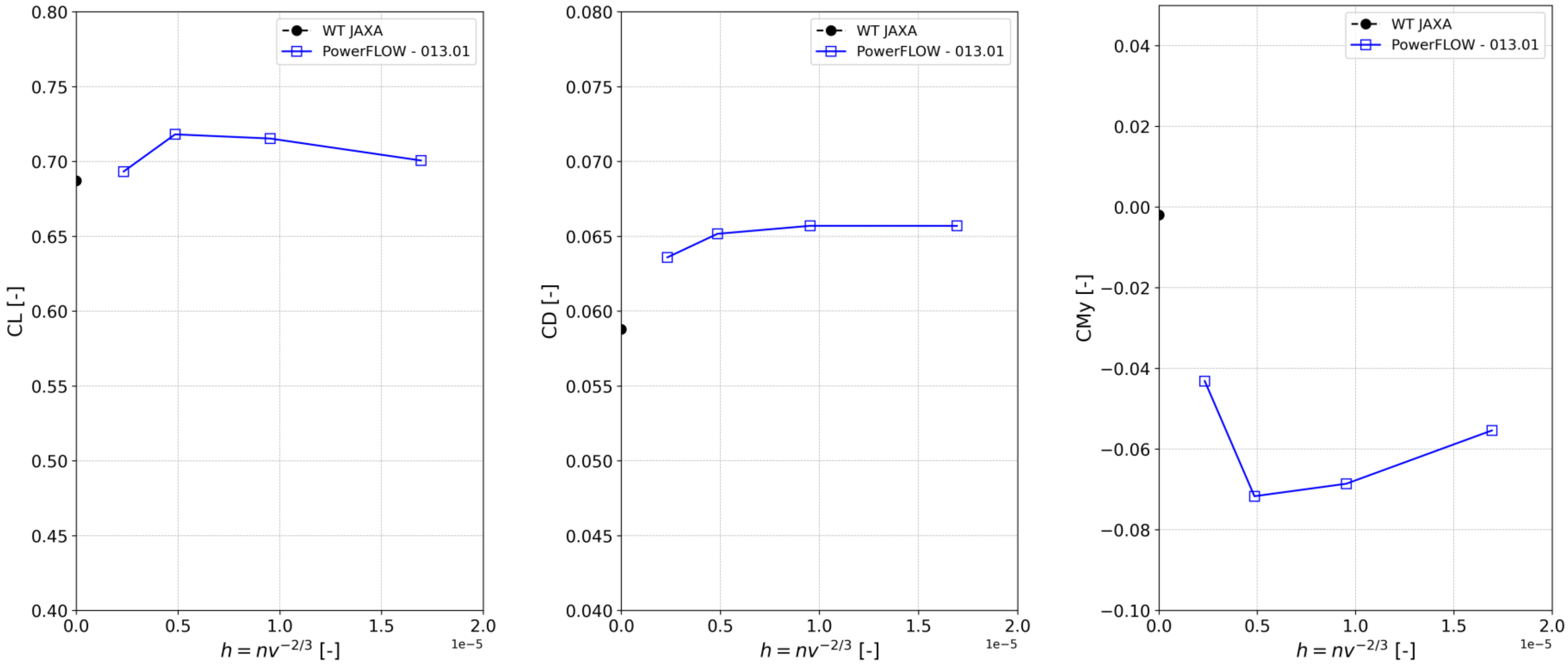
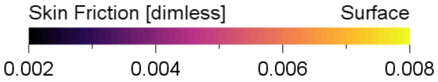


LAMINAR / TURBULENT FLOW EFFECT

Grid L4



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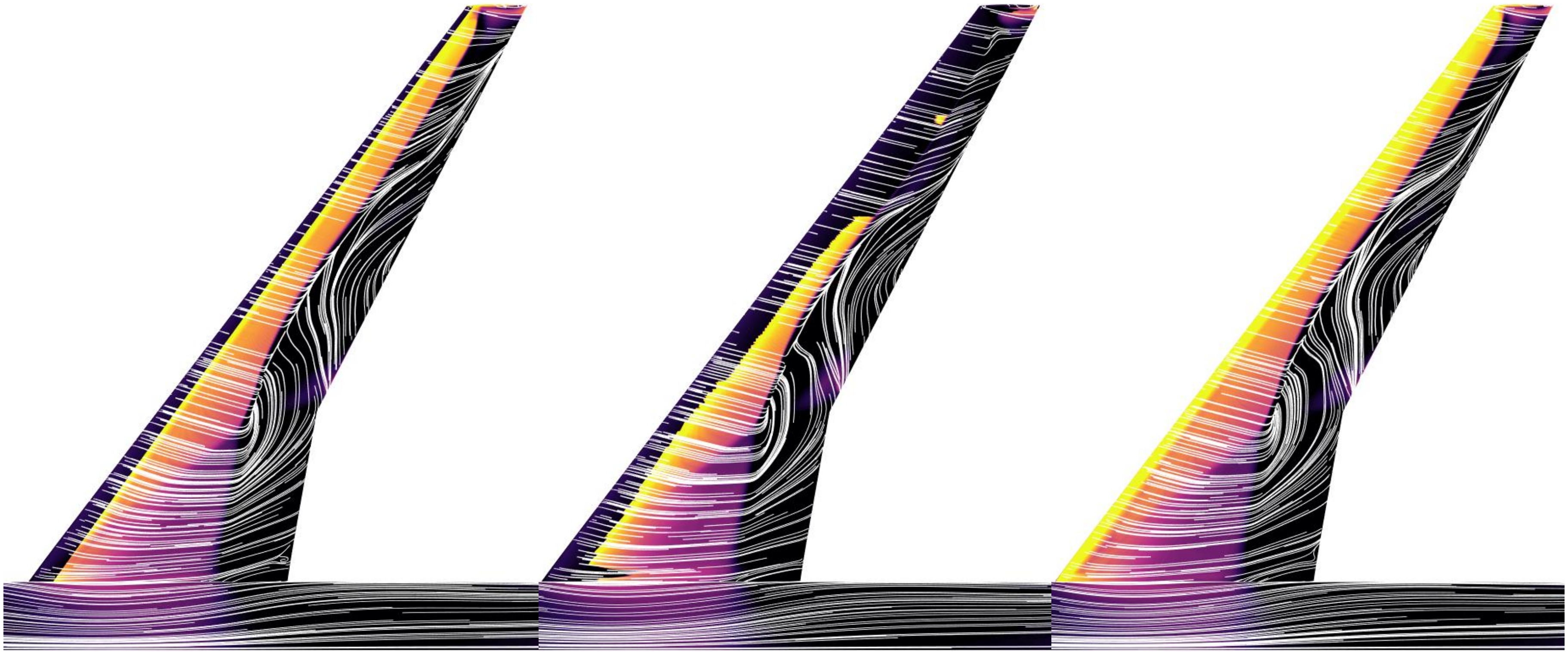
Laminar Patch | **Laminar-Turbulent Transition** | **Fully Turbulent**



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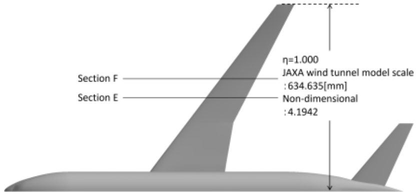

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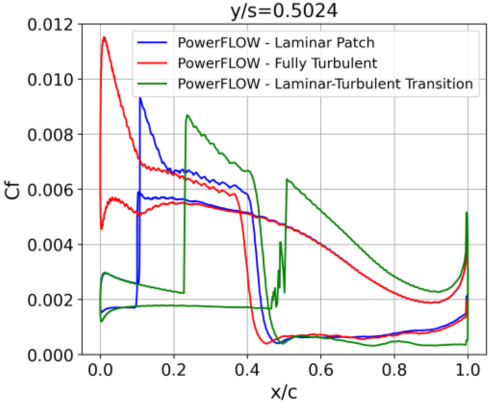

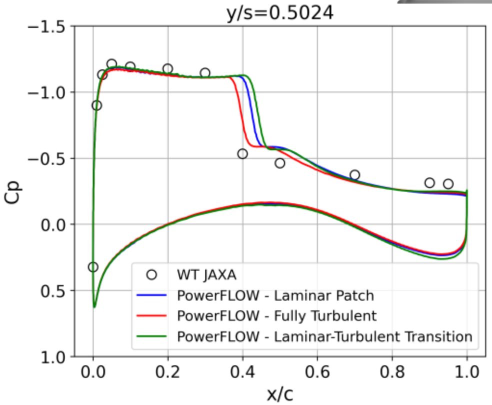

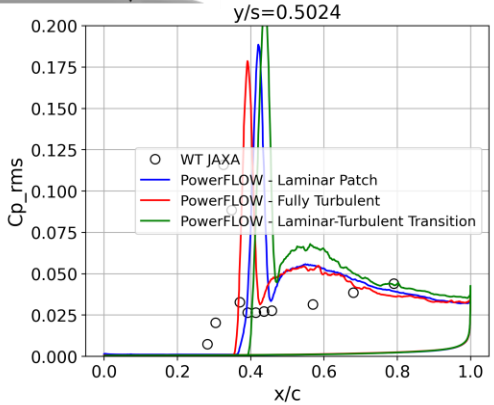

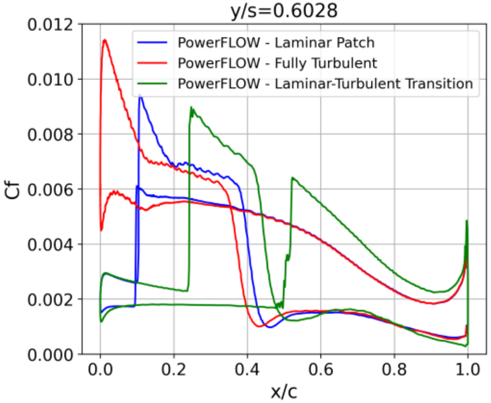

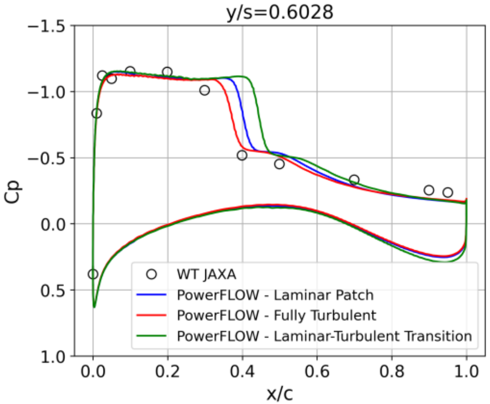

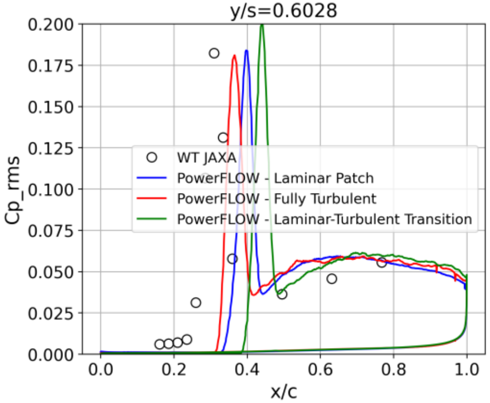

STING EFFECT

Grid L4

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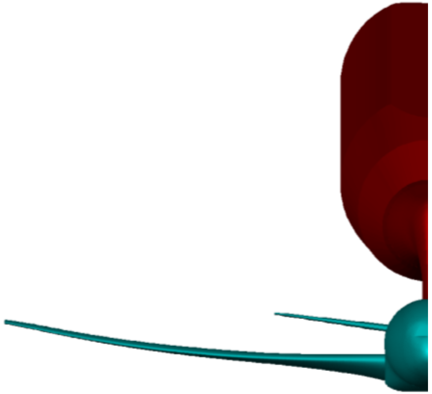

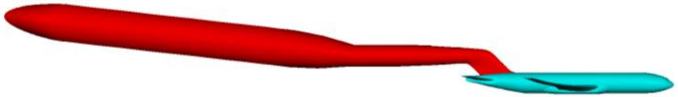

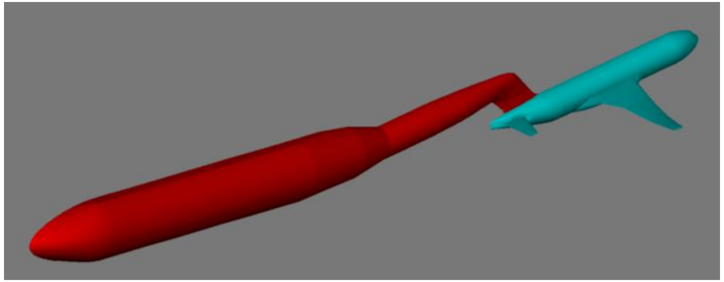

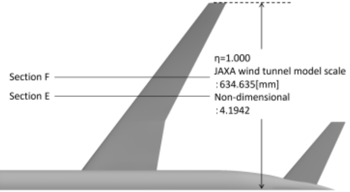

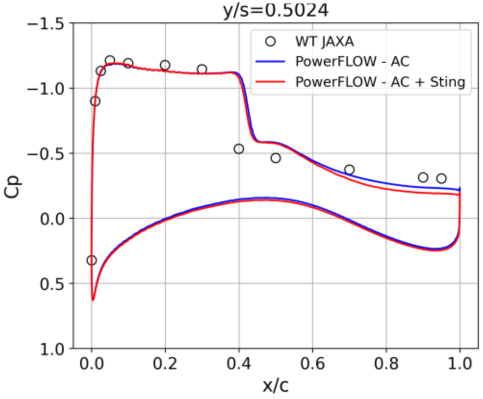

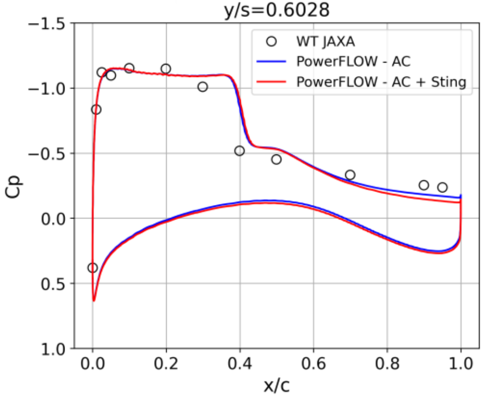

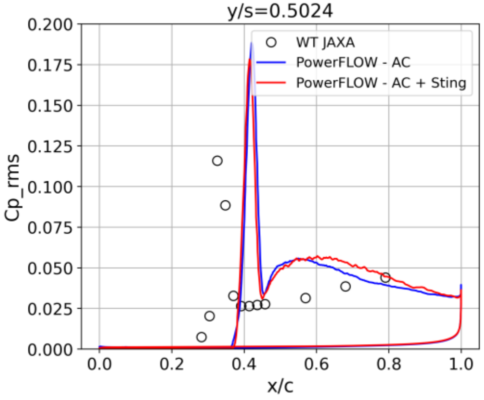

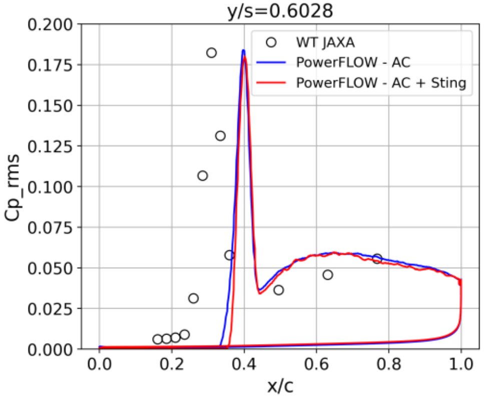

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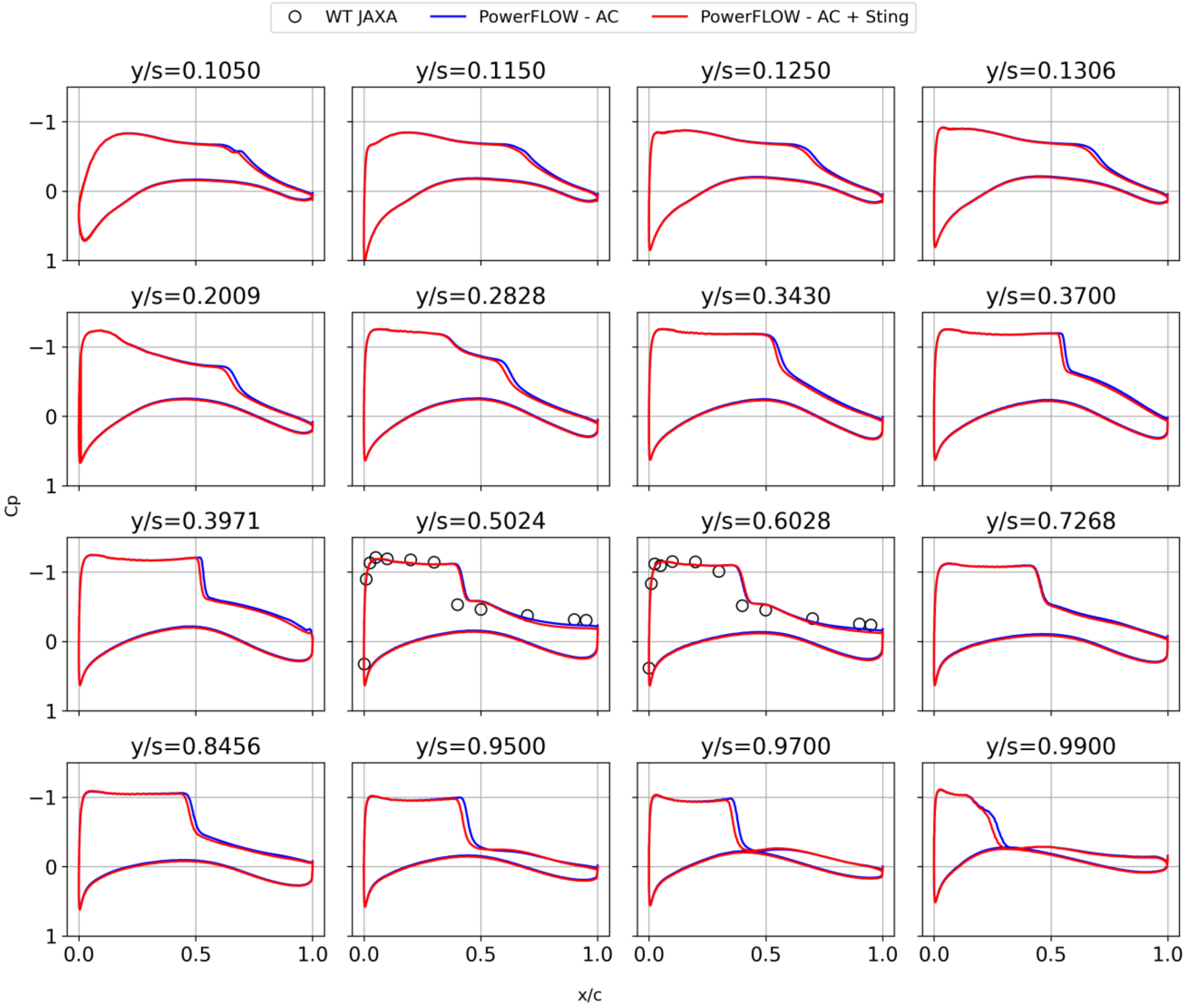

WING DEFLECTION EFFECT

Grid L4

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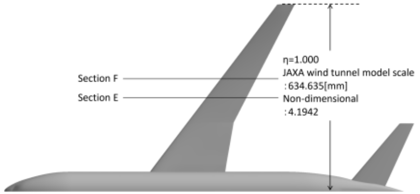
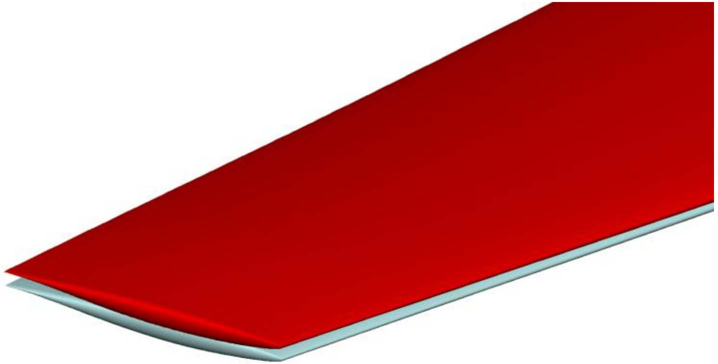
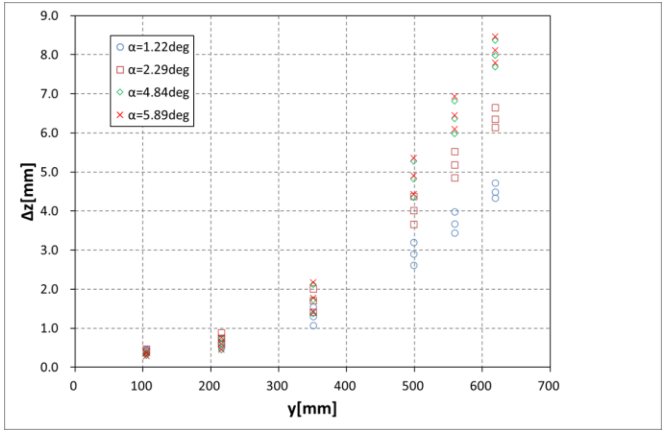
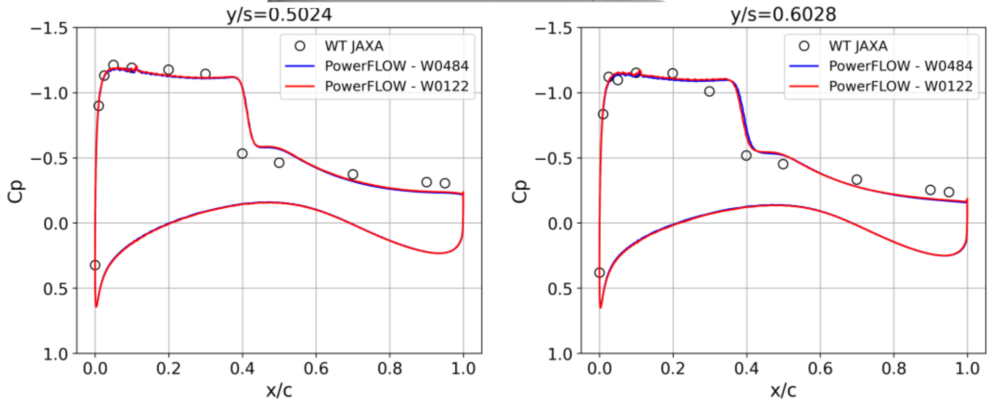
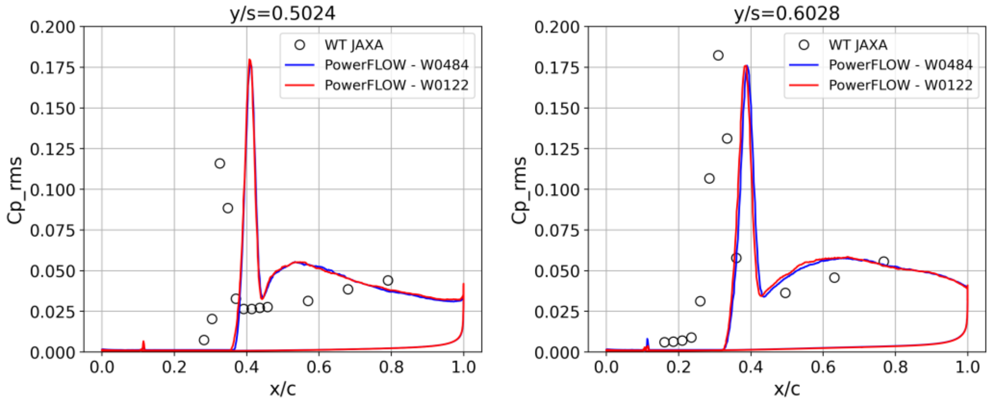


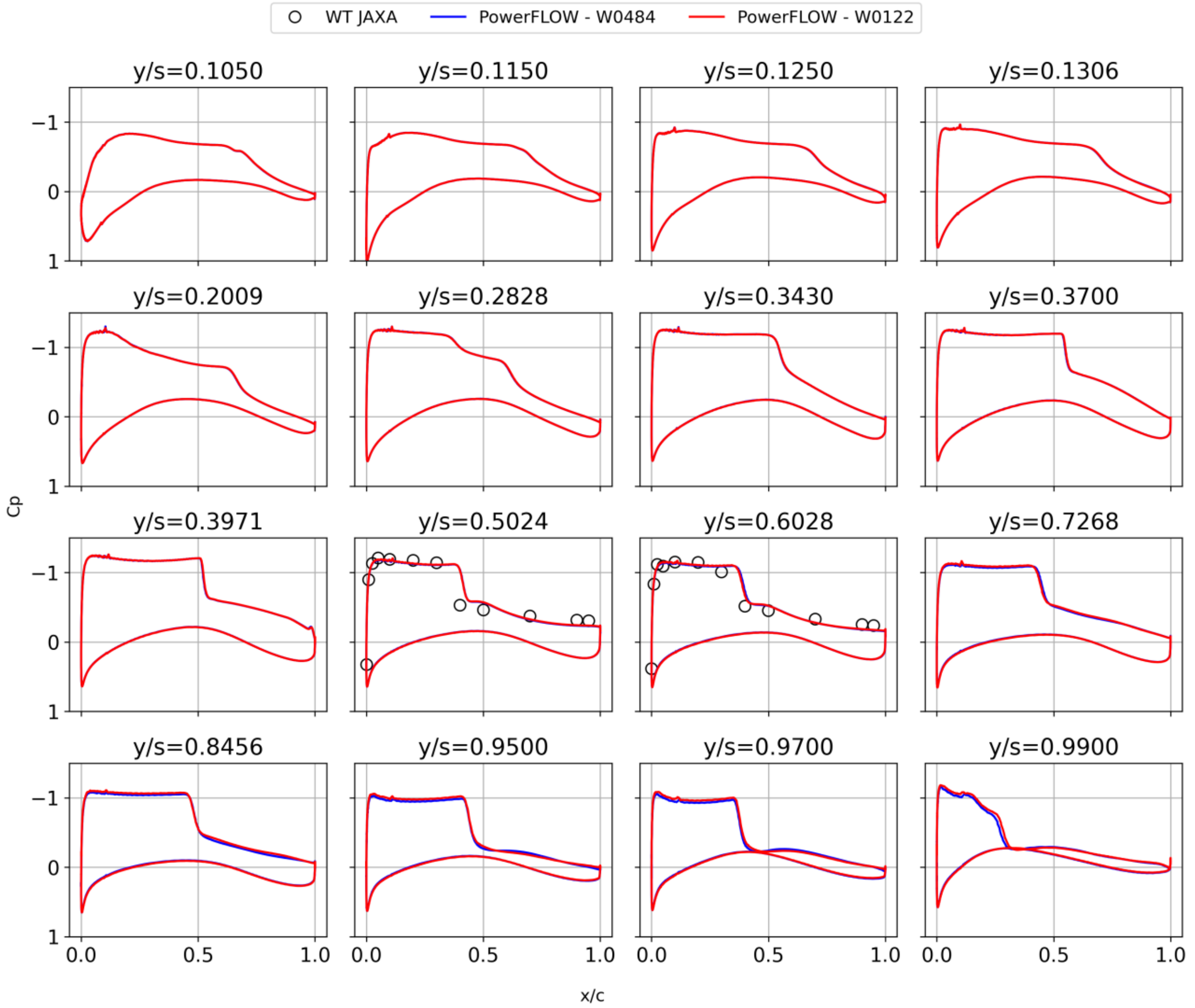








https://cfdws.chofu.jaxa.jp/apc/dpw/geometry.html



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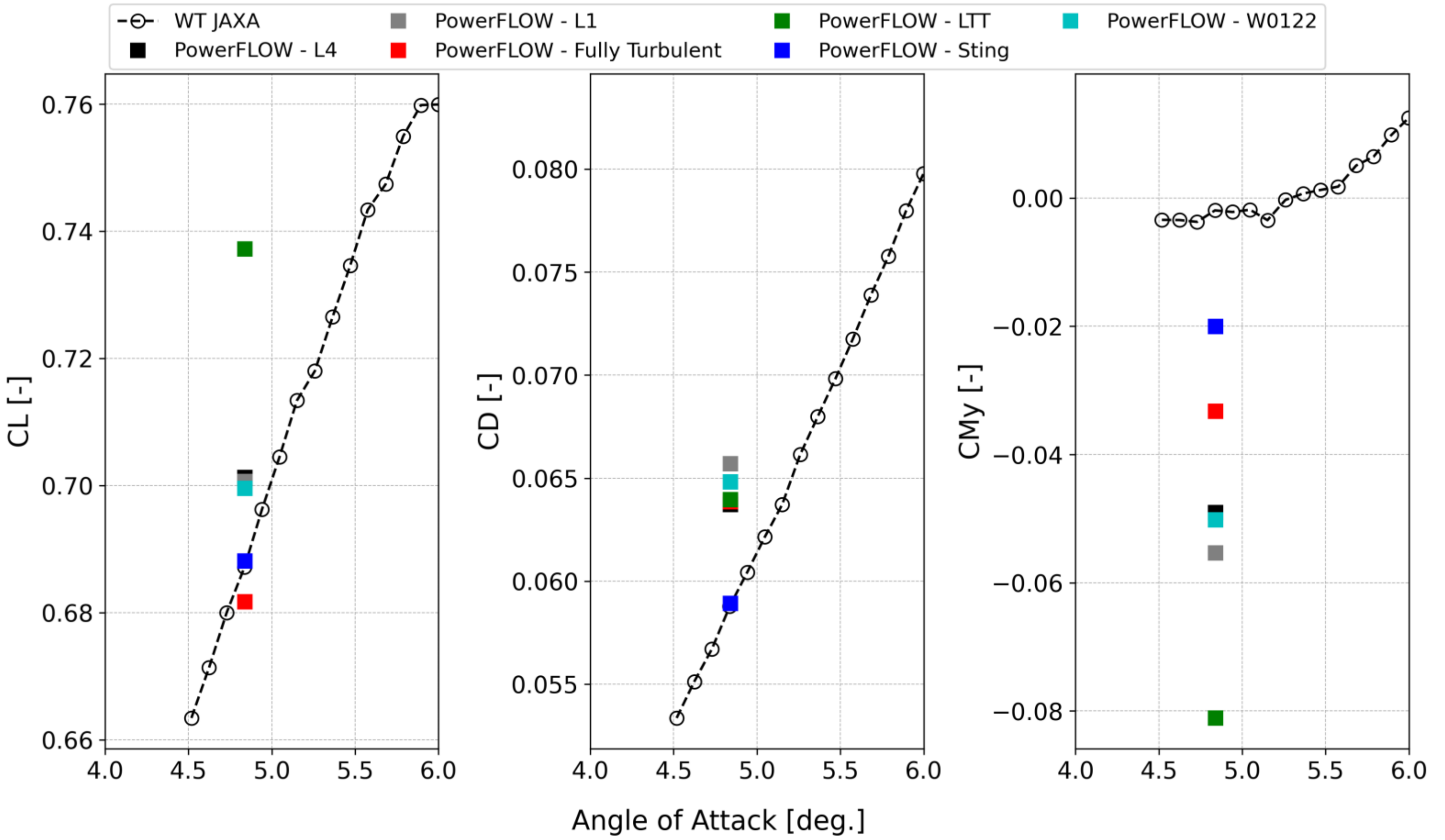
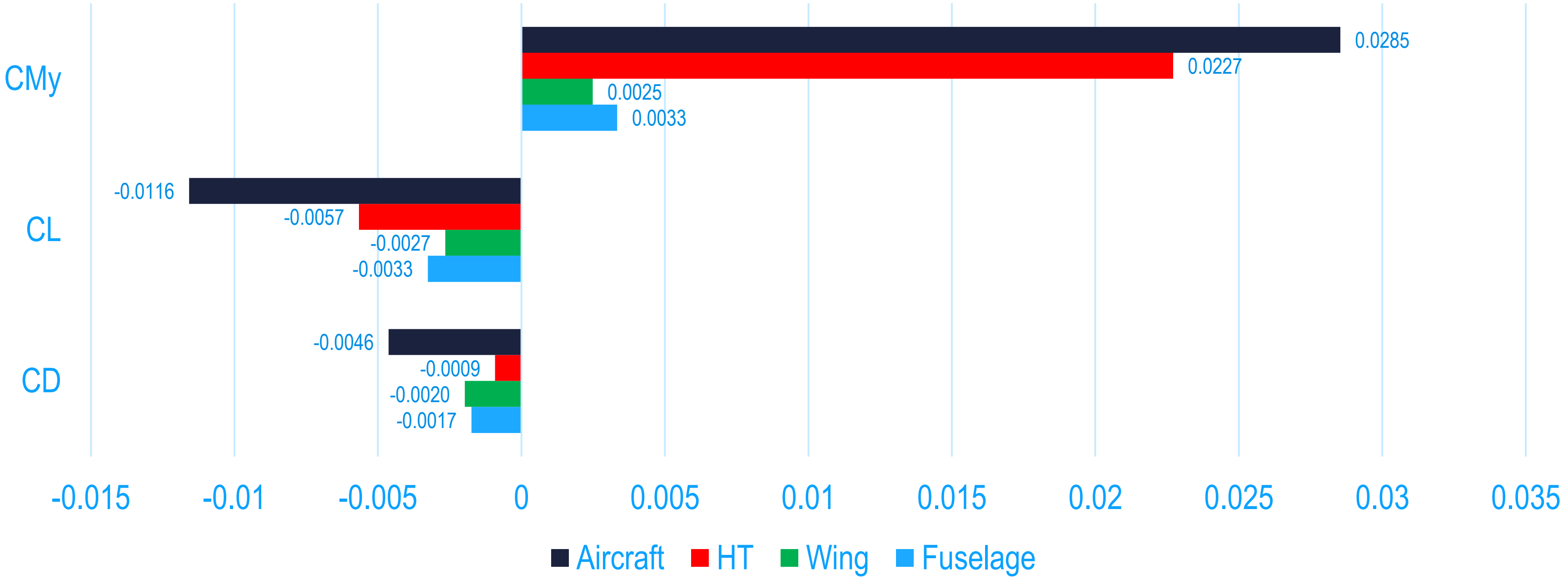
Grid L4

SENSITIVITY STUDIES



STING EFFECT



CONCLUDING REMARKS

- PowerFLOW accurately predicts buffet phenomena.
- Simulation results show qualitative agreement with experimental data.
- Predicted aerodynamic coefficients exhibit a systematic offset relative to the WT measurements, which can be related to several factors, including:
  - The high sensitivity of aerodynamic coefficients to shock-wave position.
  - Wind-tunnel interference effects, with free-air simulations predicting a more downstream shock location.
  - The extent of laminar and turbulent flow regions, which strongly influence the shock-wave position and skin friction levels.
- Sensitivity studies indicate that:
  - grid resolution, laminar–turbulent transition modeling, and sting-mounting have a considerable impact on transonic aerodynamic coefficients and shock-wave location.
  - Static wing deflection effects are relatively small.

THANK YOU