The Fluid Dynamics Conference/ The Aerospace Numerical Simulation Symposium 2020 Online
28th September 2020

FaSTARを用いた低速・高迎角条件における NASA-CRMの定常・非定常流体解析

Steady and Unsteady computation on NASA-CRM with FaSTAR at low speeds and high angles of attack

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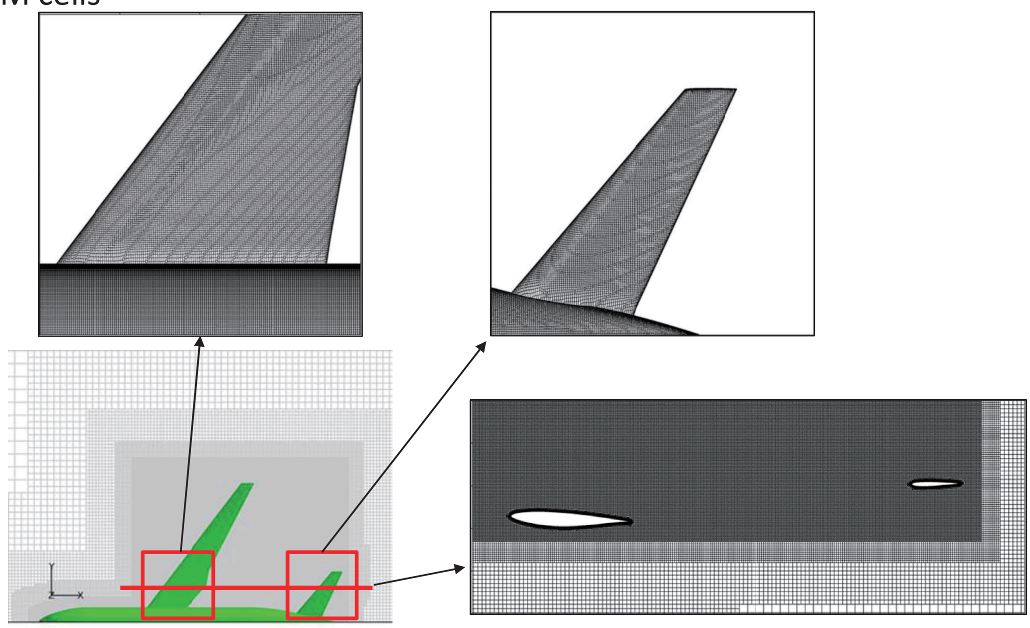
Computational Grid

- Computational Grid
  - BOXFUN grid **with hanging nodes**
    (The provided BOXFUN grid does not include the hanging nodes)
  - 39M cells



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Computational conditions, methods

- Computational conditions
  - M = 0.168, Re_c = 1.06 x 10^6, T_{ref}=310K
  - AoA=-3.22˚, -0.67˚, 2.89˚, 5.95˚, 9.01˚, 10.03˚, 11.05˚, 12.06˚, 13.08˚, 14.08˚, 18.08˚ for steady computation
  - AoA=11.05˚, 13.08˚ for unsteady computation
- Computational methods
  - Code: FaSTAR
    - Inviscid flux: SLAU
    - Gradient: GLSQ, Limiter: Hishida(van Leer)
    - Spatial accuracy: Second order with MUSCL
    - Time integration: LU-SGS
    - Turbulence model:

      SST-2003 without controlled decay for steady computation,

      SST-2003-IDDES without controlled decay for unsteady computation

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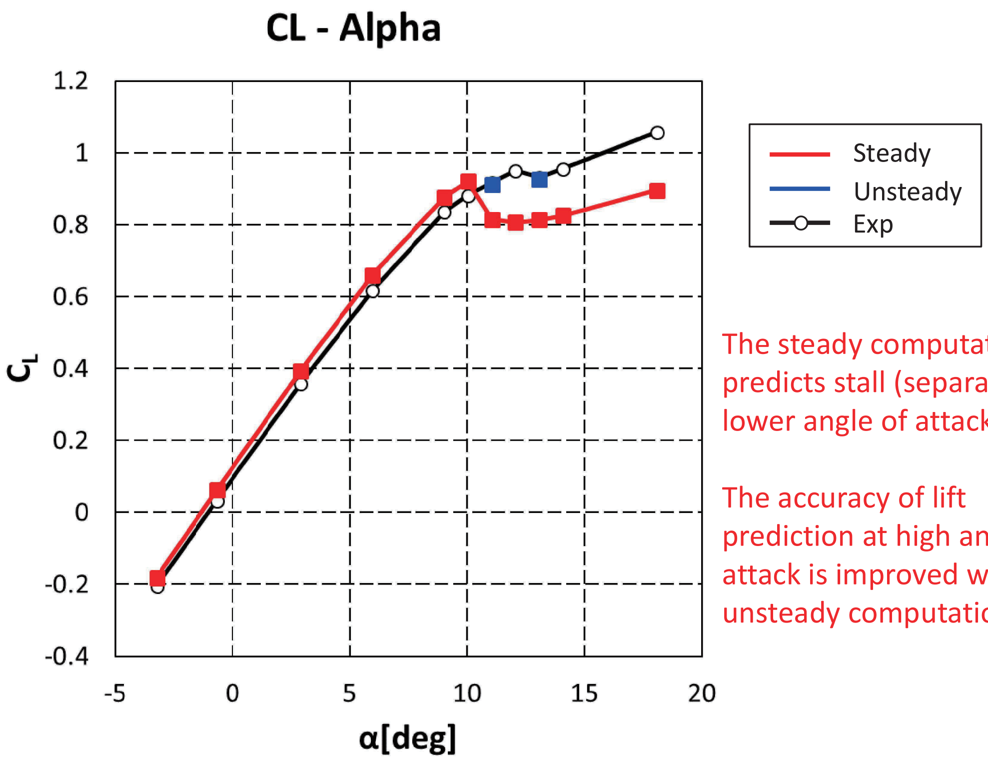
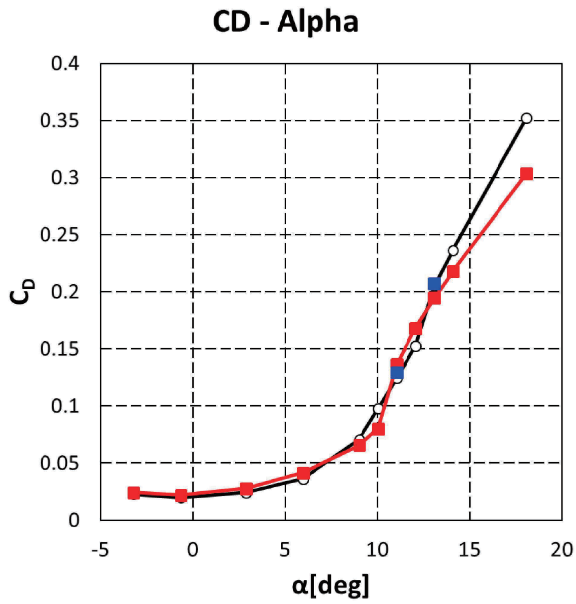
CL-alpha

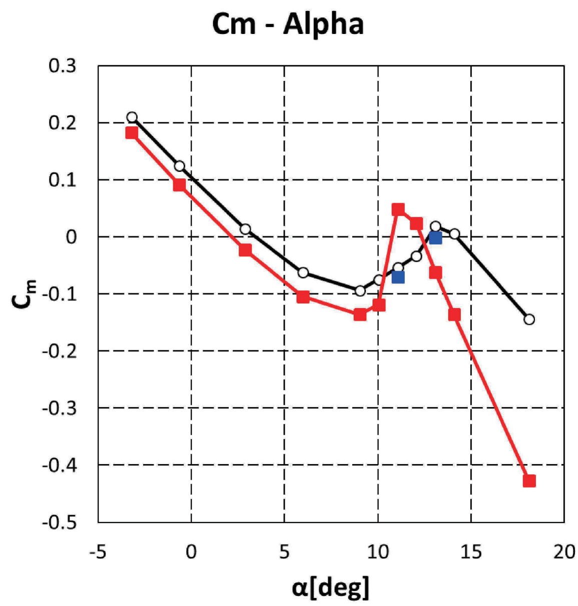


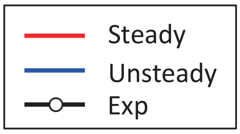
The steady computation predicts stall (separation) at lower angle of attack.

The accuracy of lift prediction at high angles of attack is improved with unsteady computation.

CD-alpha, CM-alpha

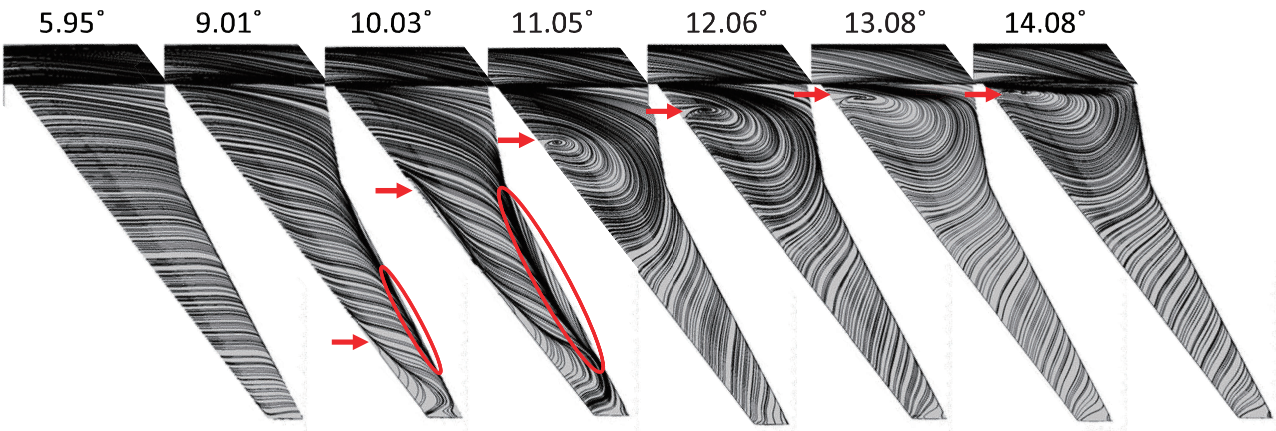


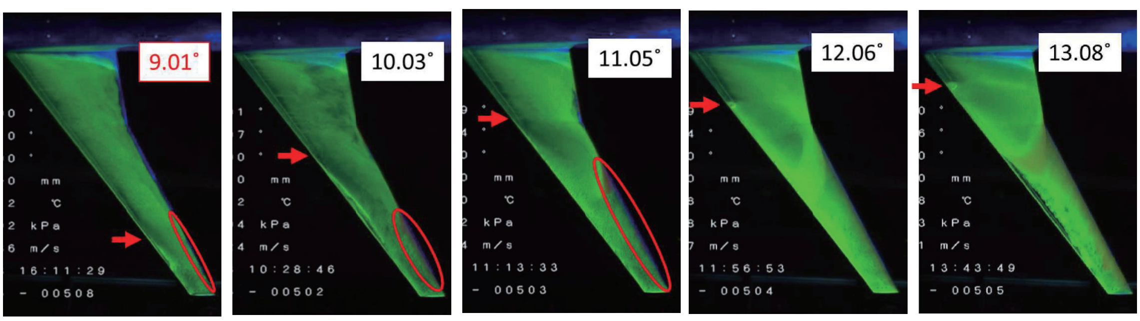




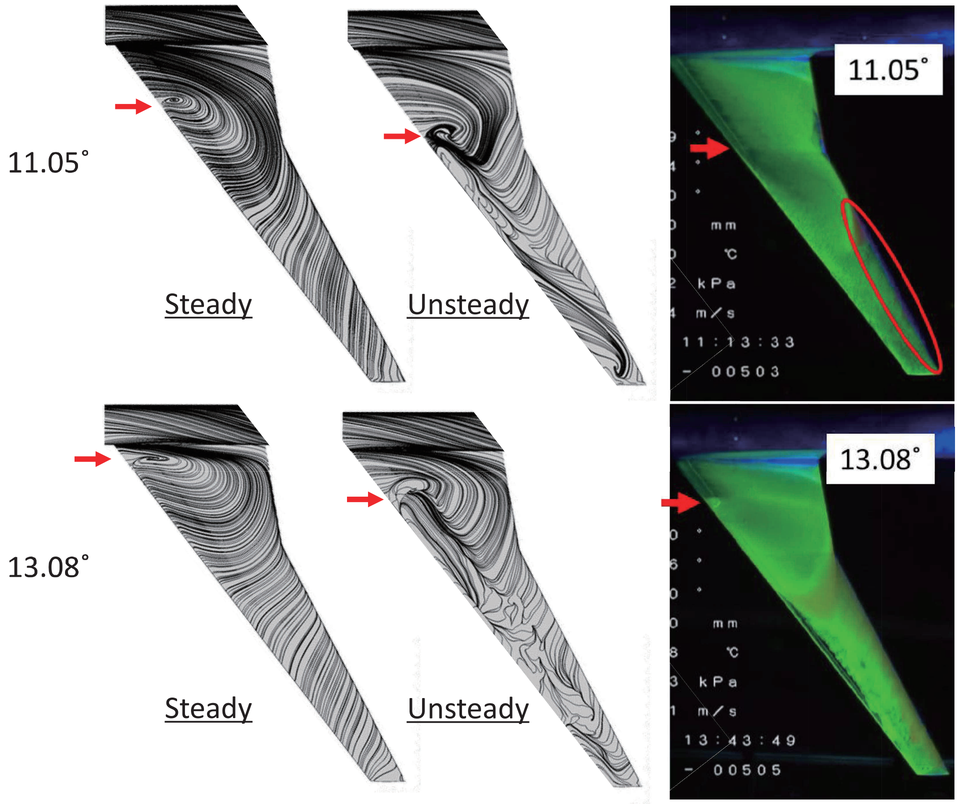
The accuracy of drag and pitching moment prediction is also improved with unsteady computation.

Streamline (Steady)





Streamline (Steady vs Unsteady)



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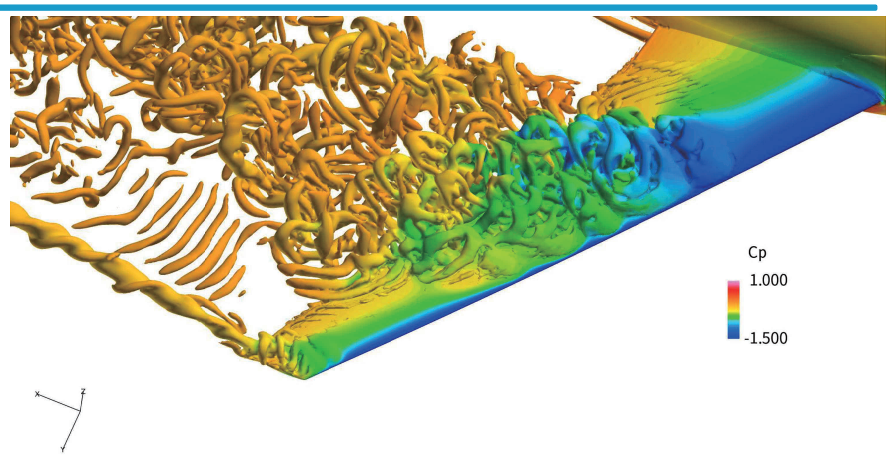
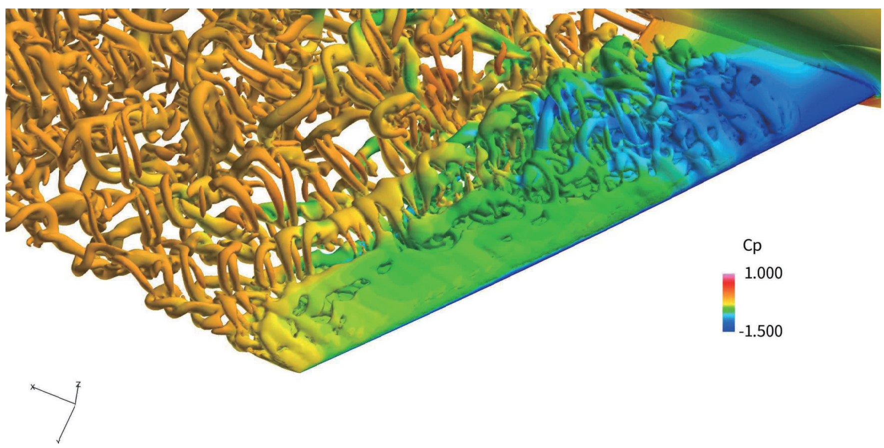
Q criterion

11.05deg

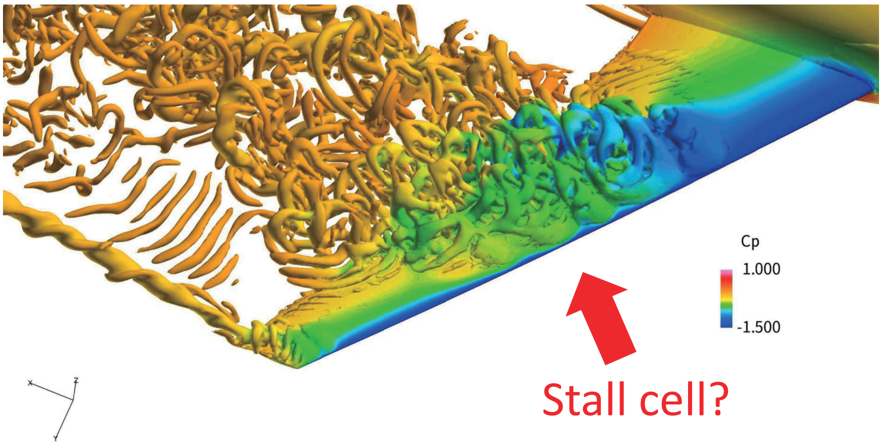


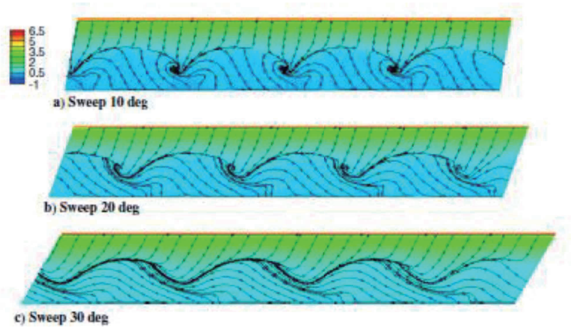
13.08deg



Q criterion

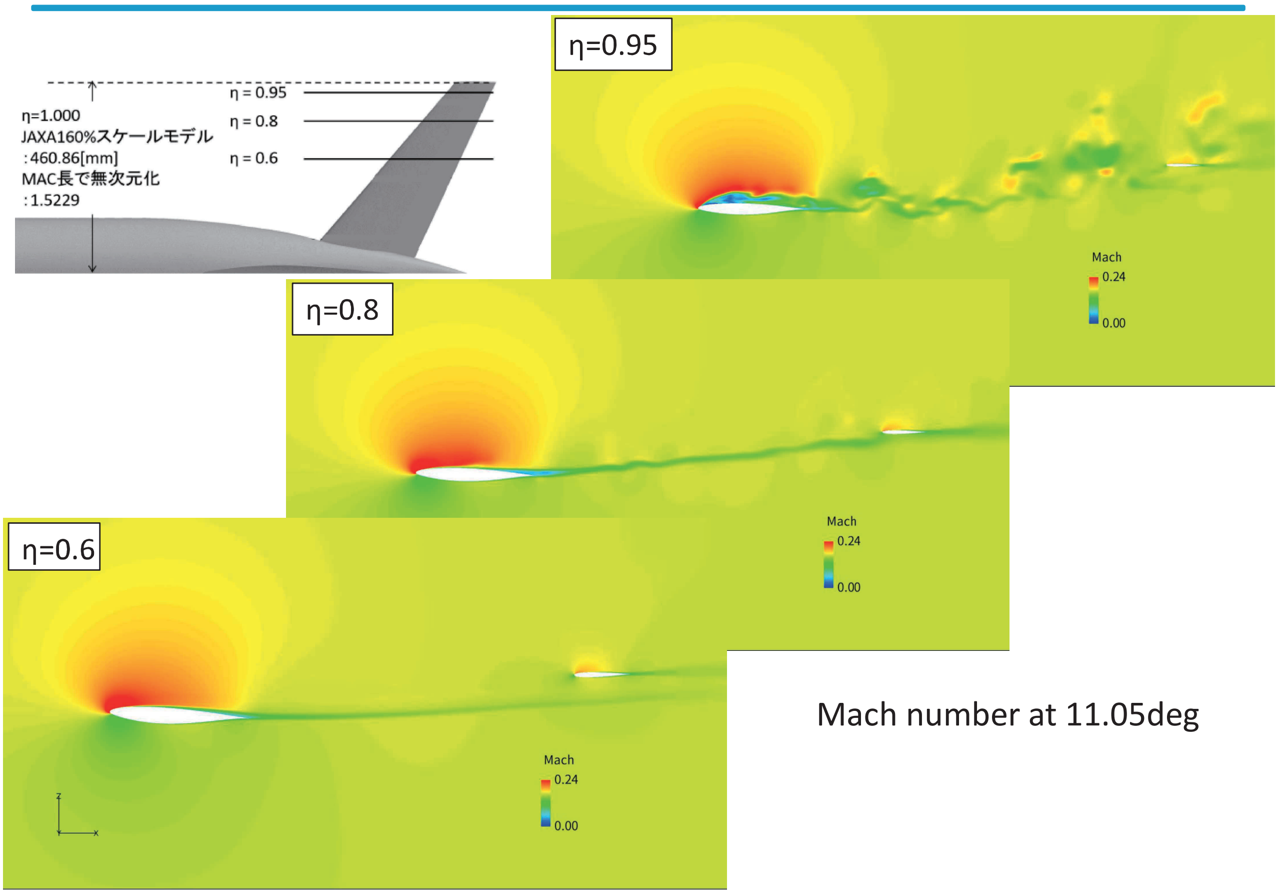
11.05deg





Frédéric Plante, et al., “Similarities Between Cellular Patterns Occurring in Transonic Buffet and Subsonic Stall,” AIAA JOURNAL Vol. 58, No. 1, January 2020.

Wake interference with tail

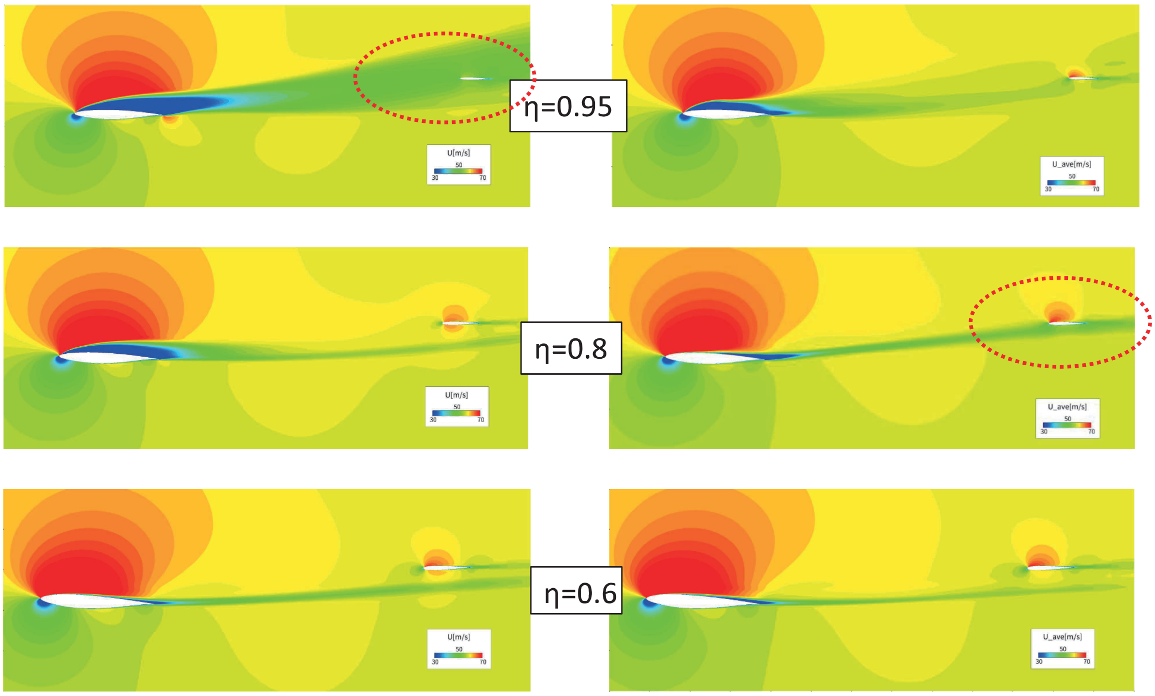


Mach number at 11.05deg

Wake interference with tail

Mach number contours at 11.05deg

Steady Unsteady



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Summary

- The accuracy of aerodynamic prediction (CL, CD, and CM) at high angles of attack is improved with unsteady computation. The SST-IDDES model works well for this problem.
- The computed surface streamline is similar to that observed in the experiment.
- The stall-cell phenomenon was observed at attack angle of 11deg.
- The wake behind the main wing and its interference with the tail wing are different between steady and unsteady computations.

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