

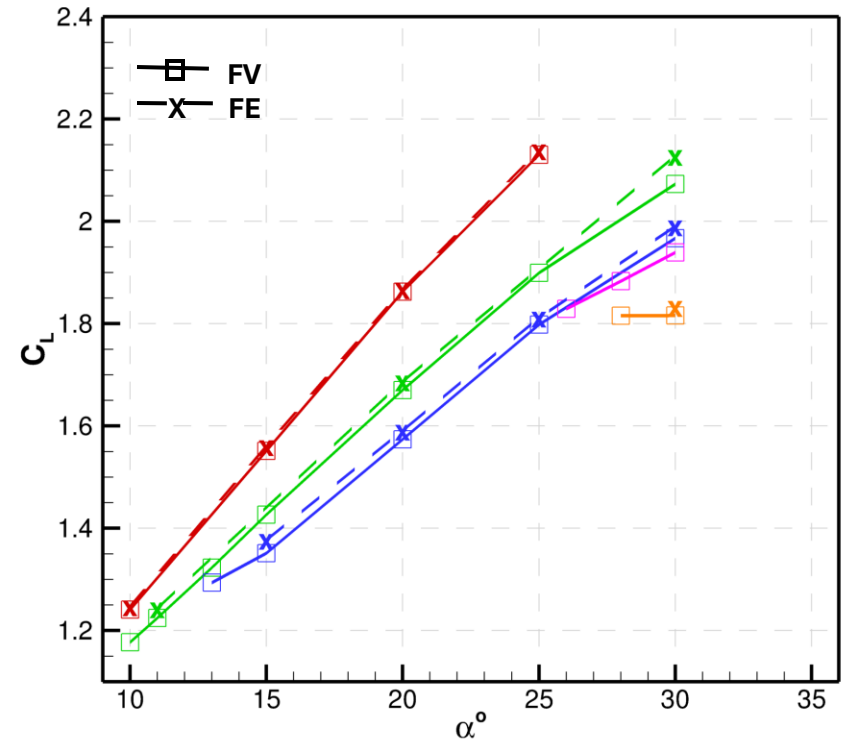
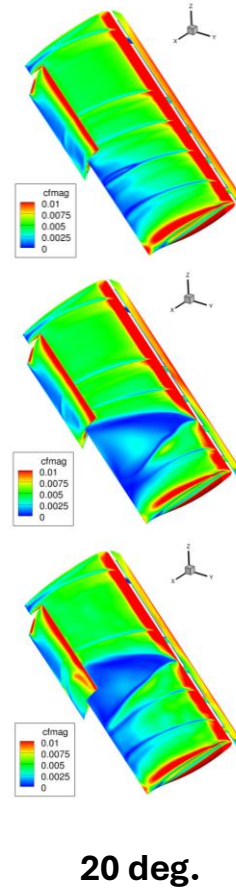
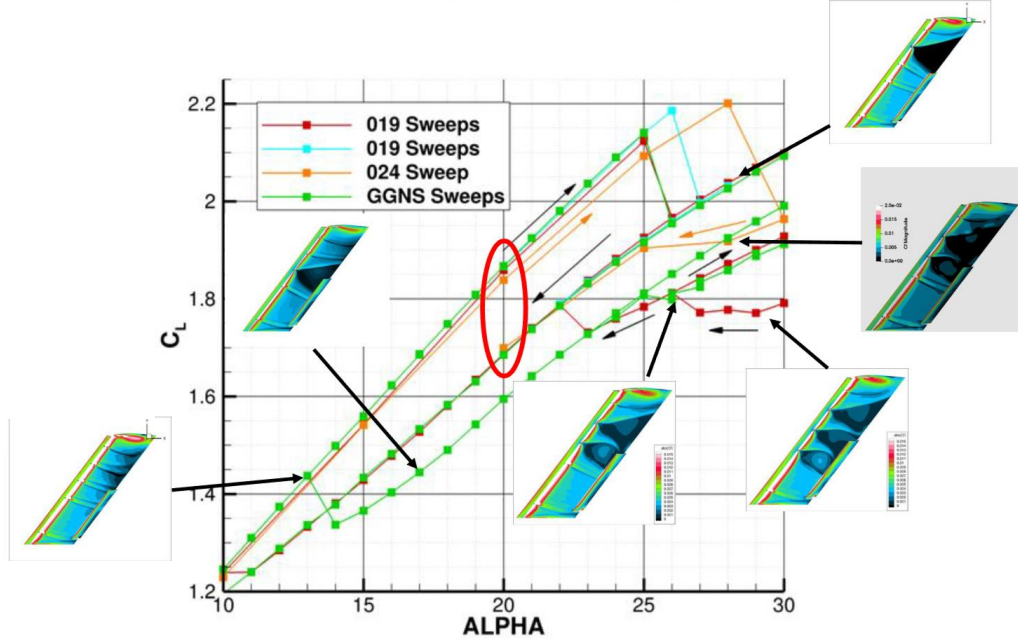
NASA FUN3D Update to HLPW6

(Preliminary Results)

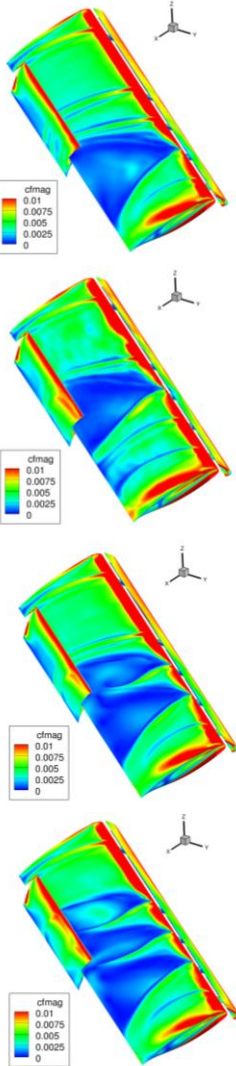
12th August 2026 RANS TFG Meeting

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Computational Aerosciences Branch, NASA Langley Research Center

Multiple Solutions RANS HLPW6 Case 1



30 deg.



- Figure from mini-workshop (left) showing multiple branches.
- FUN3D FV solutions (not residually but iteratively converged) and FE (residually converged) on Helden 3d showing multiple solutions.
- 3 branches at 15, 20 and 25 also observed on coarser and finer grids.

Multiple Solutions RANS HLPW6 Case 1

Cold start (initial) seed solutions

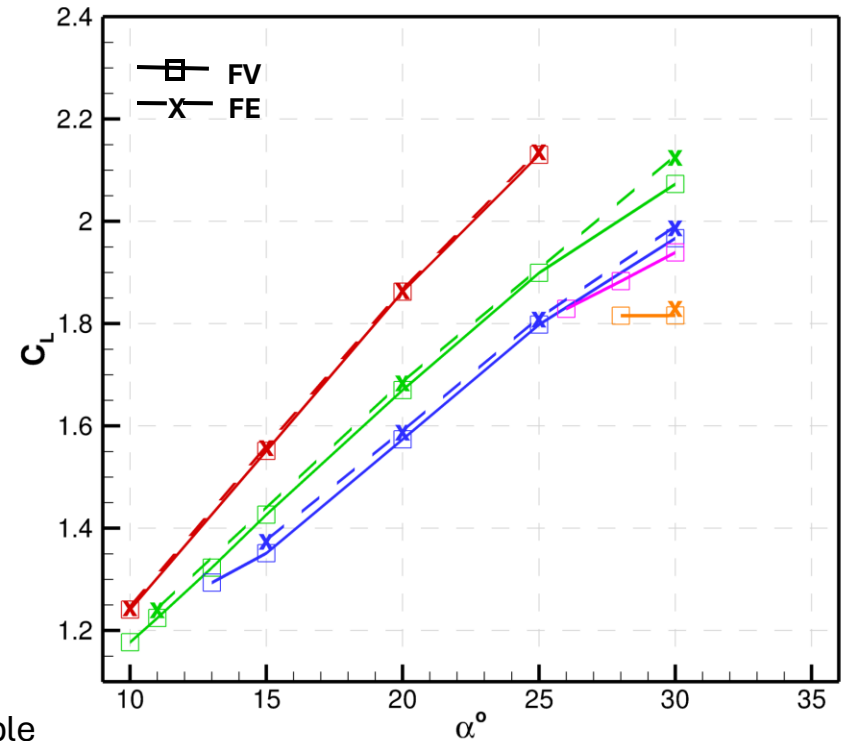
Cold start

3a_25->20_FV

3a_35->25->20_FE

20 deg.

30 deg.



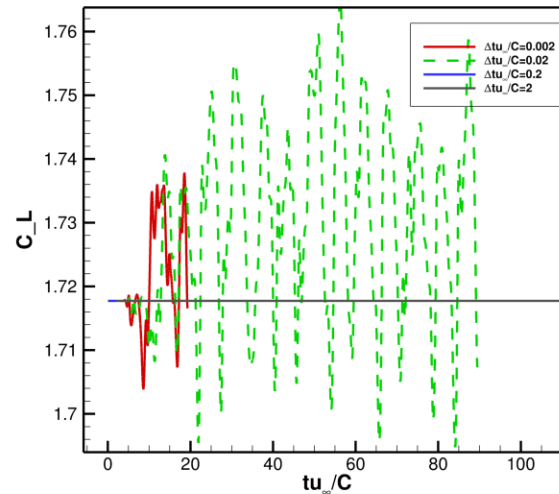
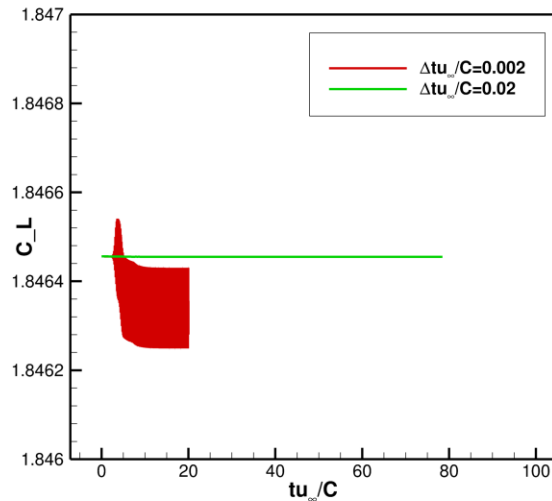
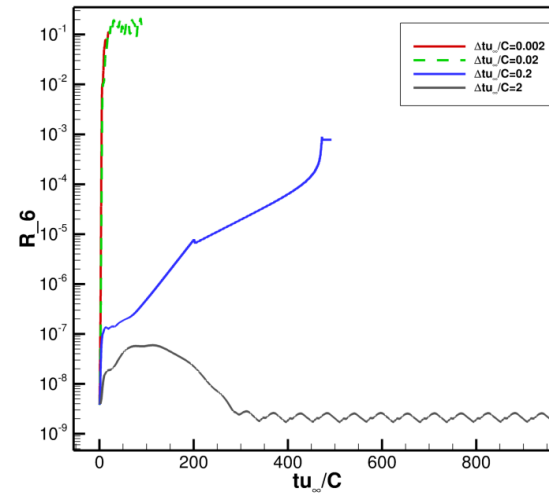
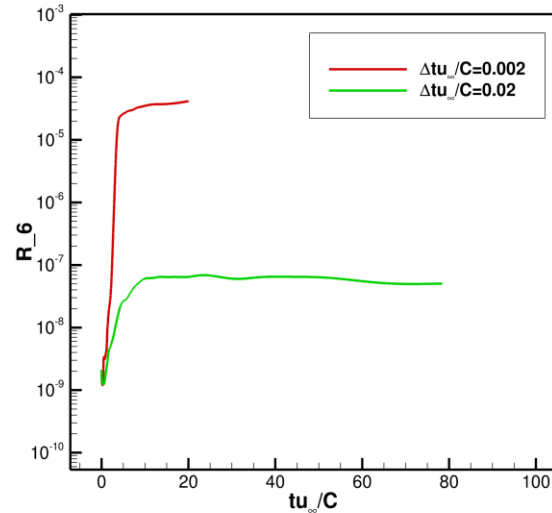
3d_30(5thbrnch)->26_FV

3d_35->30_FV

- Brief description of "methodology" to obtain multiple solutions.
- Coarser grid solutions interpolated to finer grids to test grid convergence.
- Common seed from one angle used for restarting all other angles. Alpha_continuation does not seem to be needed for most of the solutions.

Time-accurate URANS: Preliminary Results 20 deg.

- SFE solver, Helden 3a grid, 20 deg. solution, restarting from steady-state converged ($\sim 1e-9$) solution
- BDF1 scheme, relative_residual_tolerance = $1e-8$, absolute_residual_tolerace = $1e-9$, pseudo_cfl ~ 100 , 5 subiterations.

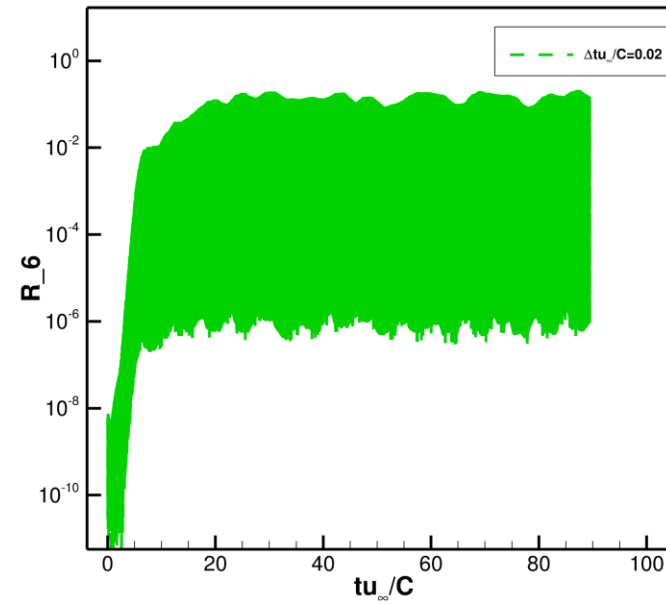
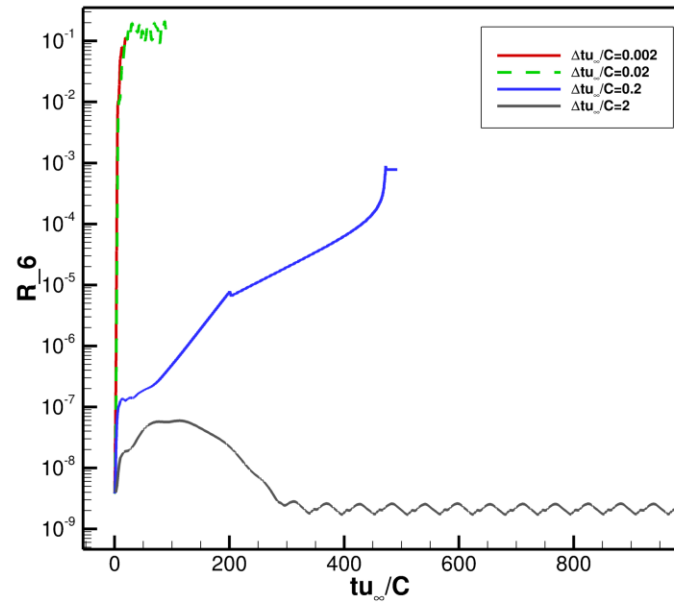


20 deg. upper branch

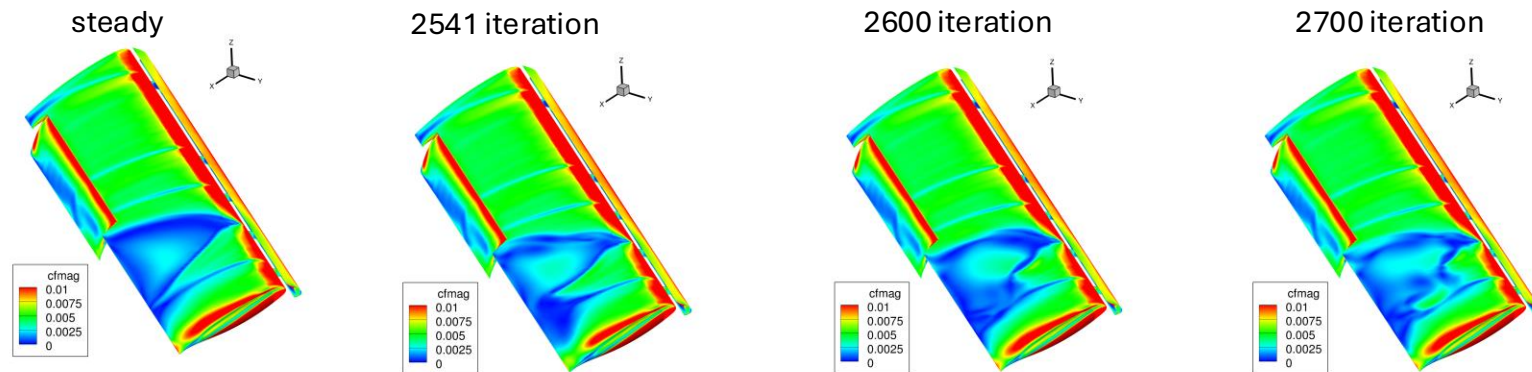
20 deg. 2nd branch

- Results appear to be insensitive to different solver parameters but needs to be verified.
- Need to run on finer grids!

Time-accurate URANS: Preliminary Results 20 deg. 2nd Branch



- Higher time step => steady-RANS behavior



- Transient behavior for $\Delta tu_\infty/C = 0.02$, 5 subiterations.

The logo for Helden Aerospace features a stylized red and black swoosh that frames the company name. The swoosh starts as a thick red shape on the left, curves around the text, and tapers into a thin black line on the right. The text "Helden Aerospace" is written in a bold, black, sans-serif font, centered within the swoosh.

Helden Aerospace

HeldenMesh Grids
Effect of Alpha Continuation and Re-
Initialization

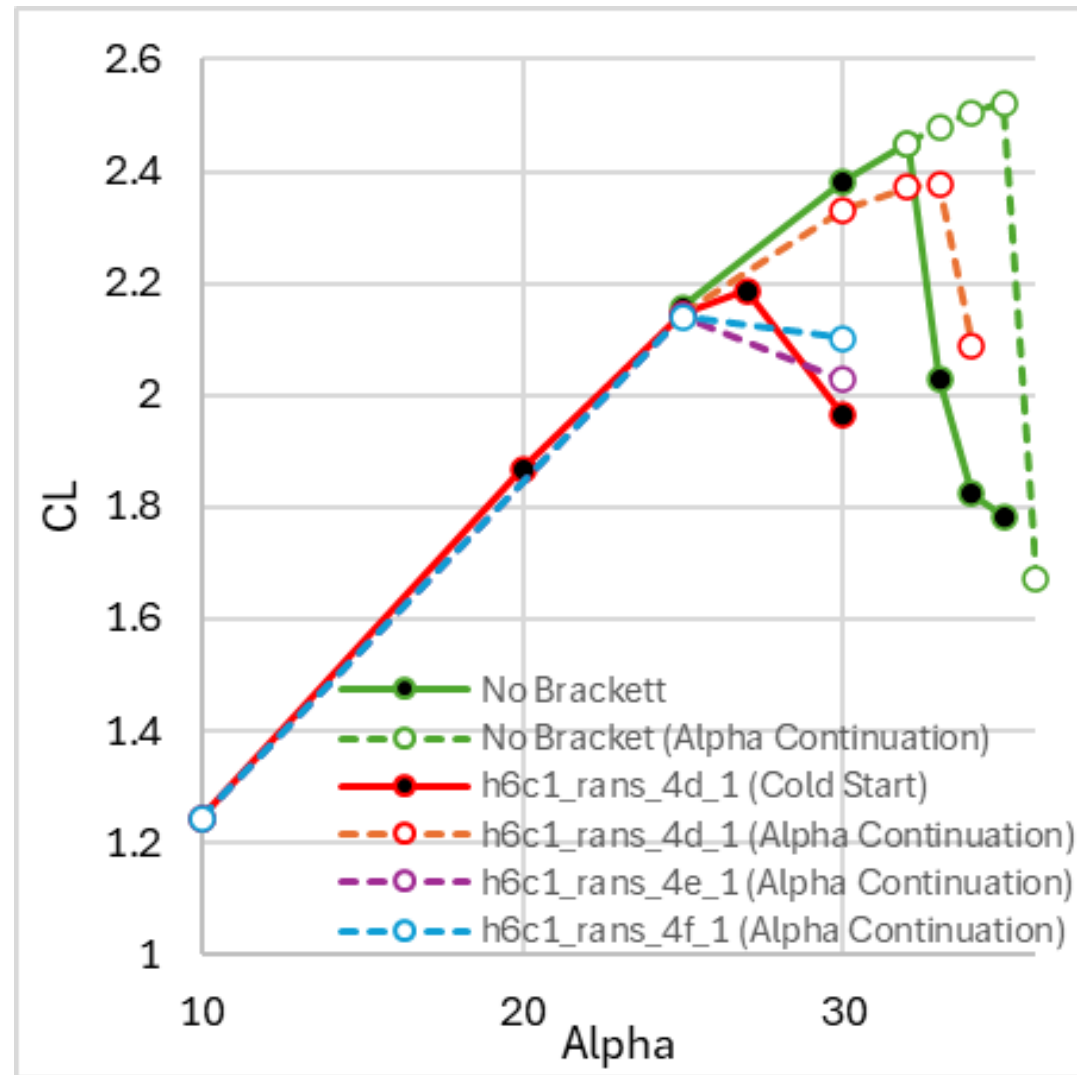
Andrew Wick

Rick Hooker

Effect of Alpha Continuation

Helden Aerospace

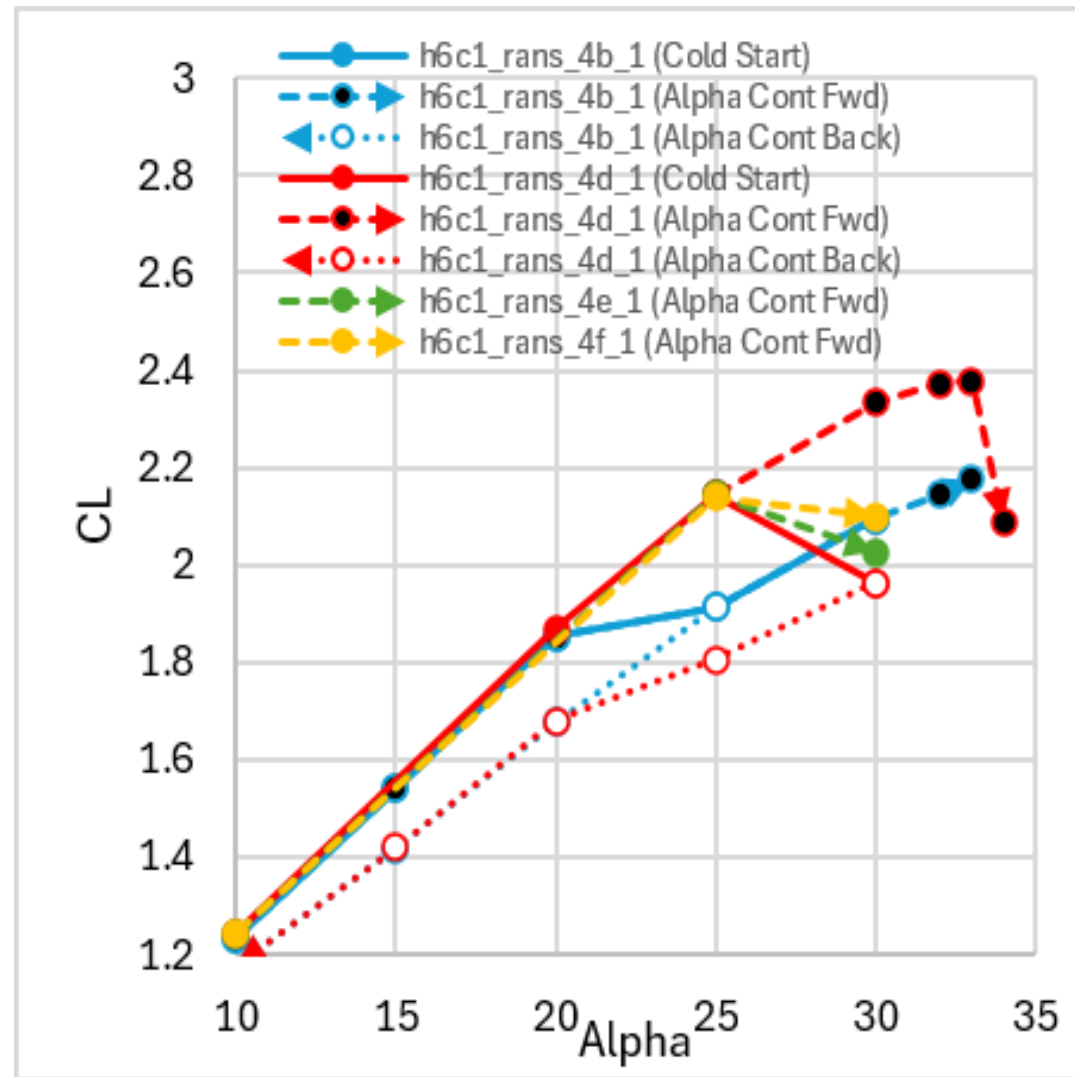
- Effect of using alpha continuation was explored. Alpha 30 simulation was restarted from the pizza-free Alpha 25 deg solution
- Alpha continuation delays stall by 3 deg AoA for the no bracket simulation
 - C_{lmax} at Alpha 32 $\rightarrow$ C_{lmax} to Alpha 35
- For the medium mesh (4D), alpha continuation can be used to get pizza-free solutions at alpha 30
- Finer mesh resolution (4E, 4F) leads to development of pizza separation
- Explorations were also made using heldenadapt to create adapted meshes which were tailored to the pizza-free Alpha 30 simulation. These simulations all led to pizza separation eventually forming
 - Alpha continuation used to simulate alpha 25 deg then restarted at alpha 30. As mesh was refined, pizza eventually formed



High / Low Branch Sims



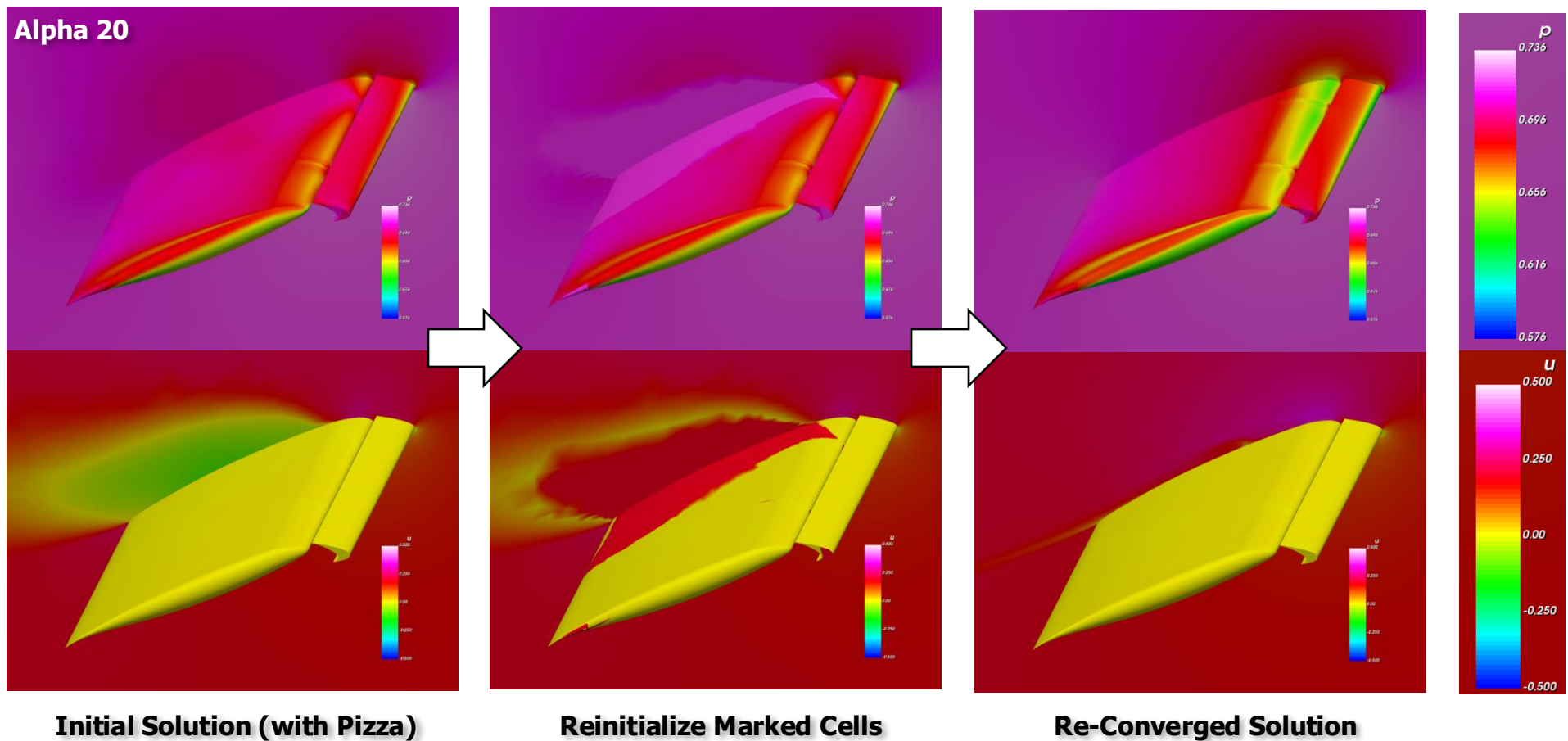
- USM3DME also exhibits multiple solution branches for this case
- Alpha continuation upward from low angles (10 deg) yields high branch
 - Stall past Alpha 30 for grid D
- Alpha continuation downward from high angles (30 deg) yields low branch
 - Pizza seen all the way down to 10 deg
- For the medium mesh (4D), alpha continuation can be used to get pizza-free solutions at alpha 30
- Finer mesh resolution (4E, 4F) leads to development of pizza separation at alpha 30 even with alpha continuation



Effect of Re-Initialization



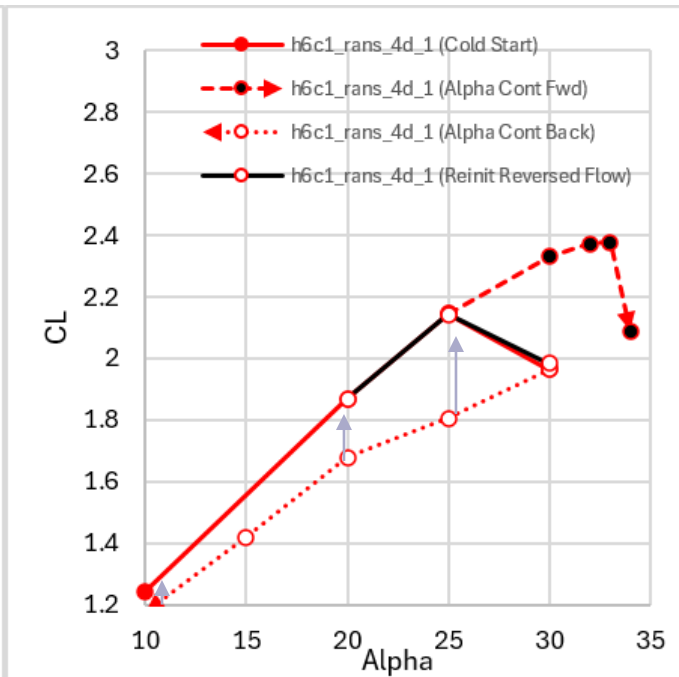
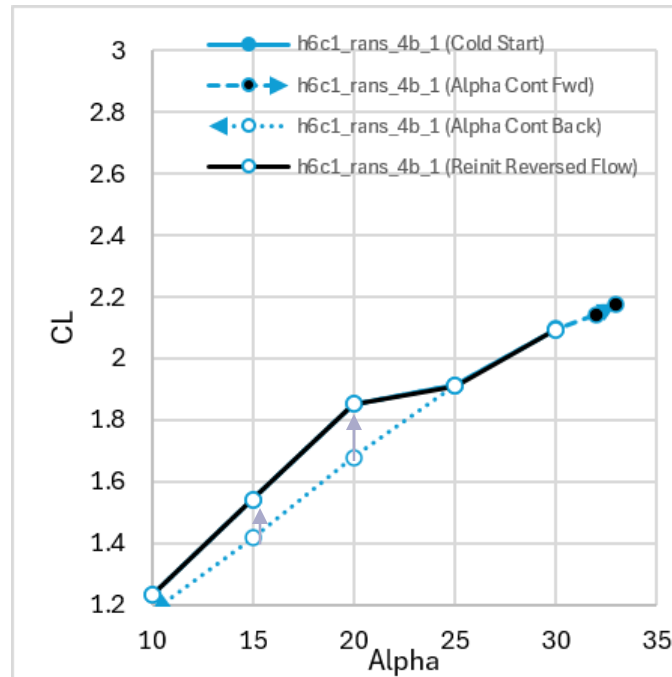
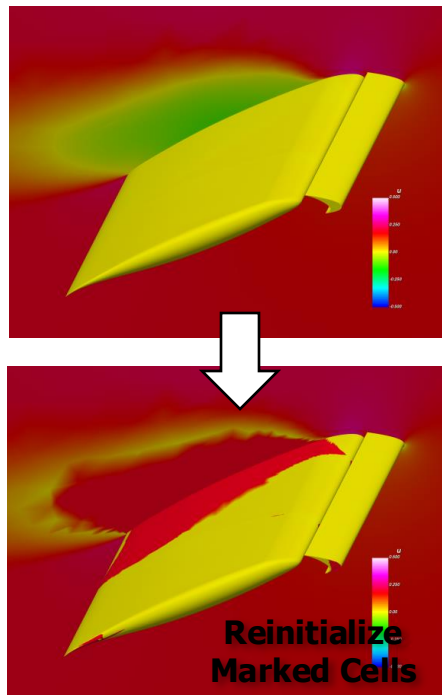
- For each solution, cells with reversed flow ($u \cdot u_{inf} + v \cdot v_{inf} + w \cdot w_{inf} < 0$) were marked and solution at these cells was reinitialized to freestream
- Solutions were then restarted and converged



Effect of Re-Initialization



- For each solution, cells with reversed flow ($u \cdot u_{inf} + v \cdot v_{inf} + w \cdot w_{inf} < 0$) were marked and solution at these cells was reinitialized to freestream
- Solutions were then restarted and converged
- This has the effect of removing pizza for many of the low branch solutions
- Final performance is similar to the cold starts with USM3DME, but may yield improvements for other solvers



USM3D Update

Mohagna Pandya, NASA Langley Research Center

HLPW6, TC1, AoA 10 deg.
USM3D-ME URANS Solution on HeldenMesh Adaptive Grid (4e) with 101 Million Cells

- (a) Restarted from zero-residual RANS solution
- (b) Five time steps per CTU
- (c) Lines show rms of residuals at the first and last nonlinear iteration of each time step
- (d) Residuals are combined meanflow and SA model residuals

