RANS TFG: Current Status and Thoughts

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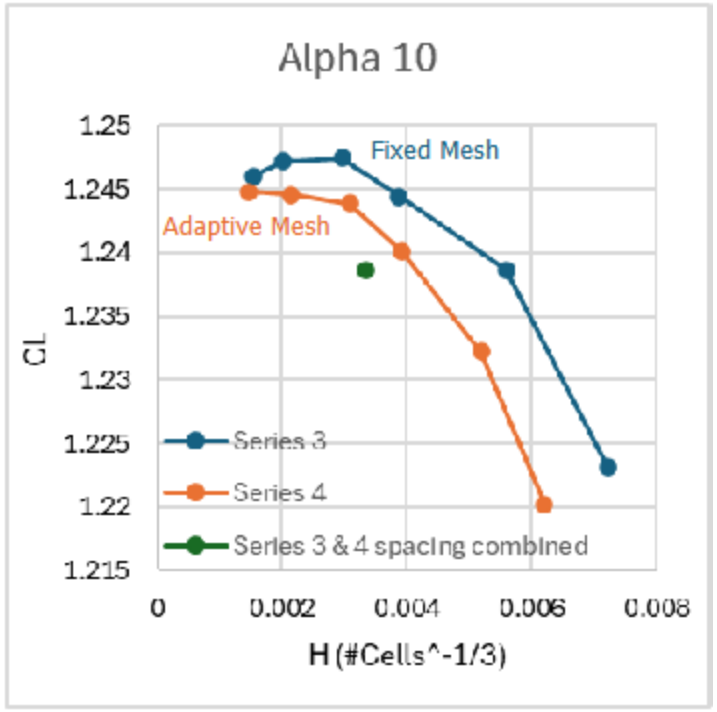
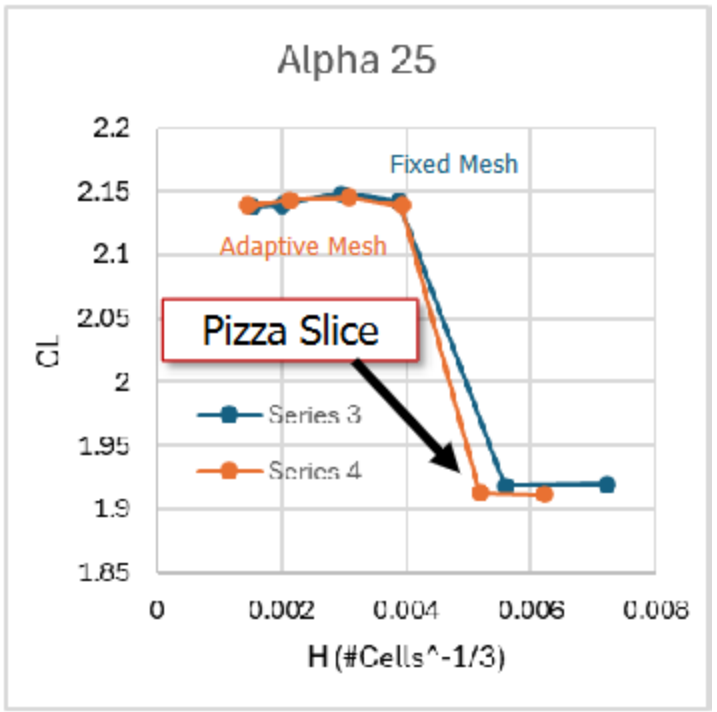
RANS TFG – Insights/Focus areas since Jan 2026

- Grid design for RANS
- Slat bracket shape
- Multiple solutions – nomenclature established
- Comparison of only high-lift branch from different participants
- Effects of numerical scheme, grid adaptation, URANS to mitigate pizza wedges

Grid Influence on Results



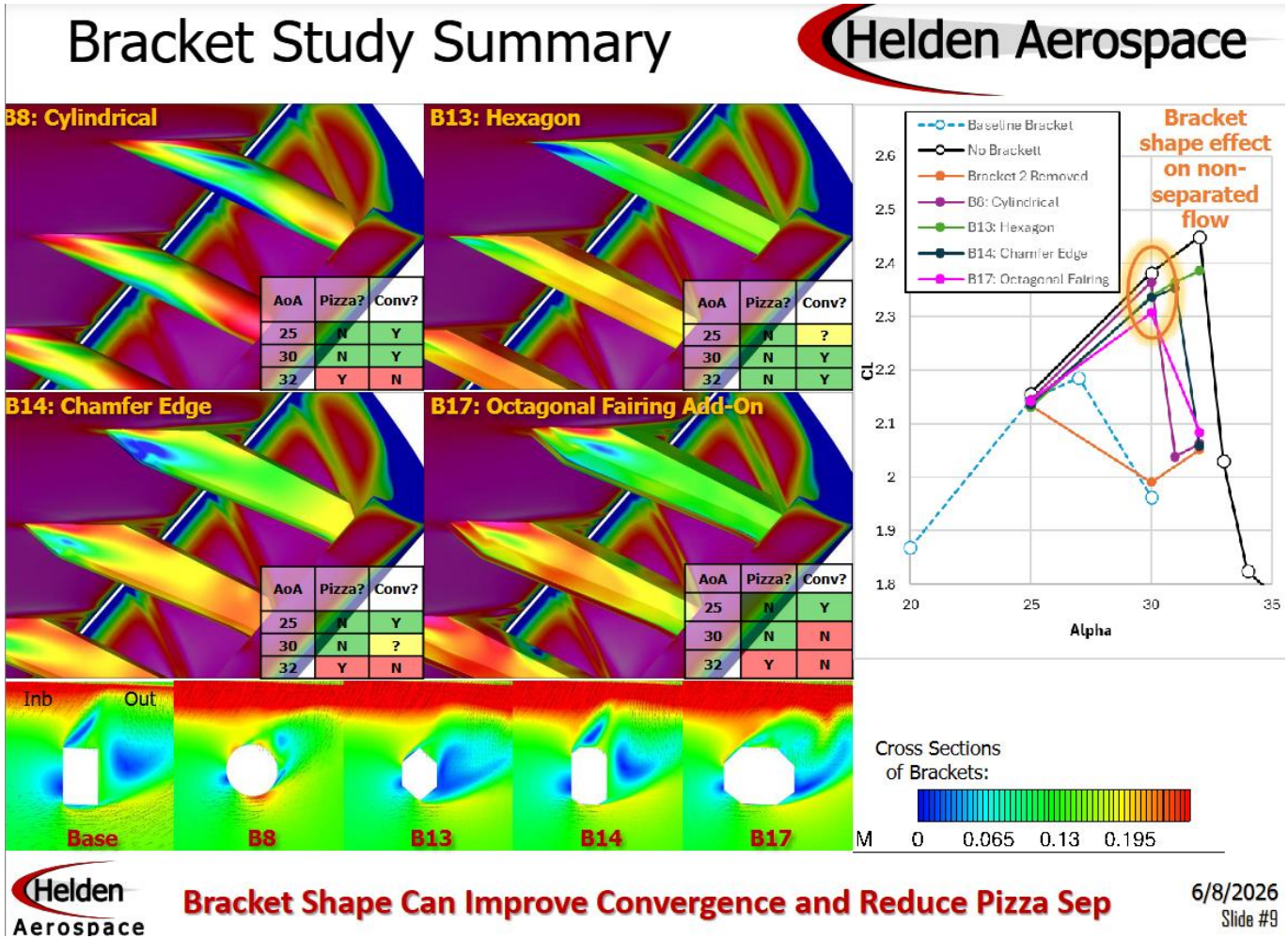


- Visually, the adapted meshes seem to resolve more features including flow near the brackets
  - Should prove interesting for study of pizza slice separation

- Many codes appear to get rid of pizza wedge at 25 deg. with grid refinement, but not for 30 deg.!

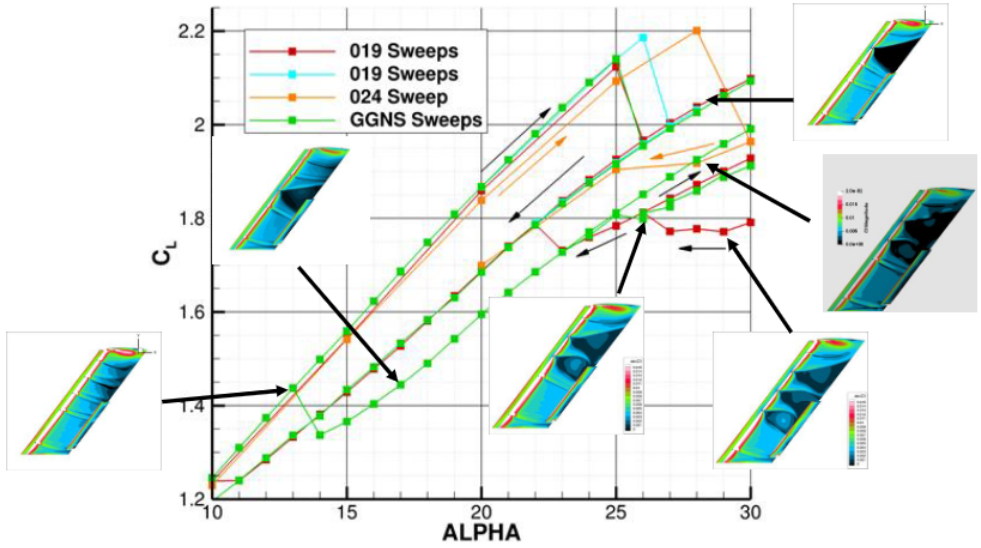
- Should we target alpha=30 deg. and try to get a high-quality expert-crafted mesh with solution-based adaptation to get rid of pizza wedge?

Slat Bracket Shape Study



- Is it just the RANS solution methodology that is very sensitive to bracket shape?
- Is there any insight from here that can be used for the baseline bracket shape?

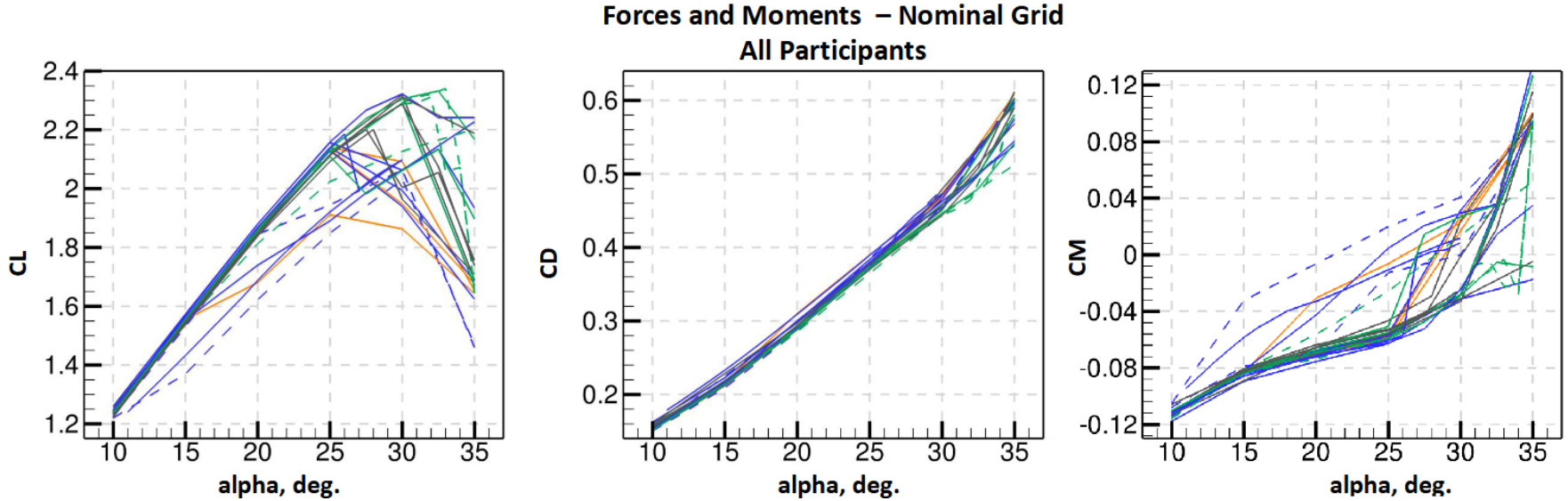
Multiple Solutions Establishment and Nomenclature



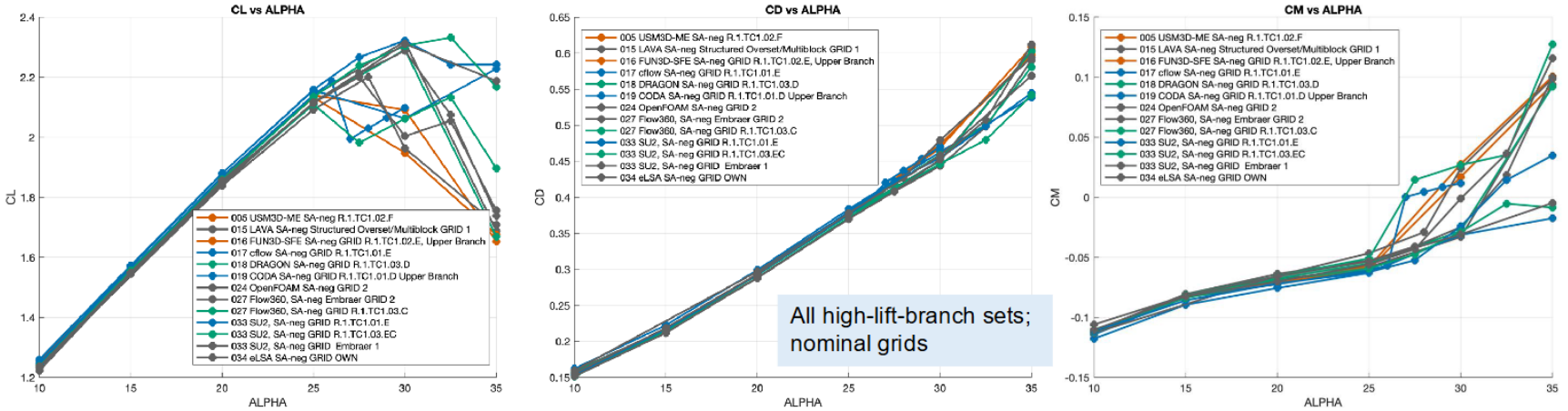
Branch 0	:	upper branch, no pizza slice shaped separation
Branch 1_2	:	one pizza attached to the second bracket
Branch 1_3	:	one pizza attached to the third bracket
Branch $2_{2,3}$	:	two pizzas attached to the second and third brackets
Branch $3_{1,2,3}$	:	three pizzas attached to the first, second, and third brackets
Branch $3_{2,3,4}$	:	three pizzas attached to the second, third, and fourth brackets

- Multiple groups (including those not listed here) can obtain at least 5 different branches for this case. For 10 < alpha < 20, 3 branches observed.
- Potential utility: weed out the low-lift branches to improve consistency among participants.
- Issue: different groups use different strategies to obtain these – no clear deterministic/rational path to obtain a specific branch.
- Strong solvers are able to converge well for all branches and show grid independence (at least for some branches).

Consistency among high-lift branch from different participants



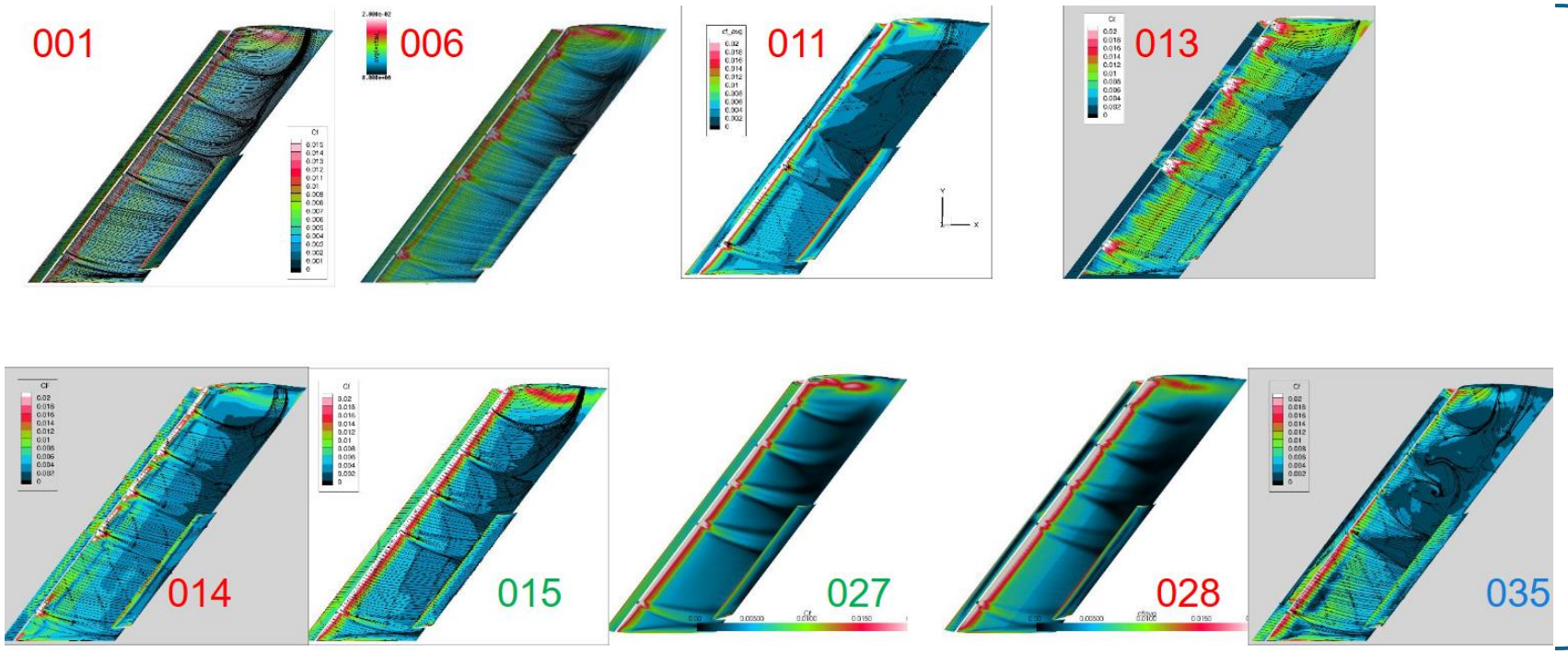
All branches



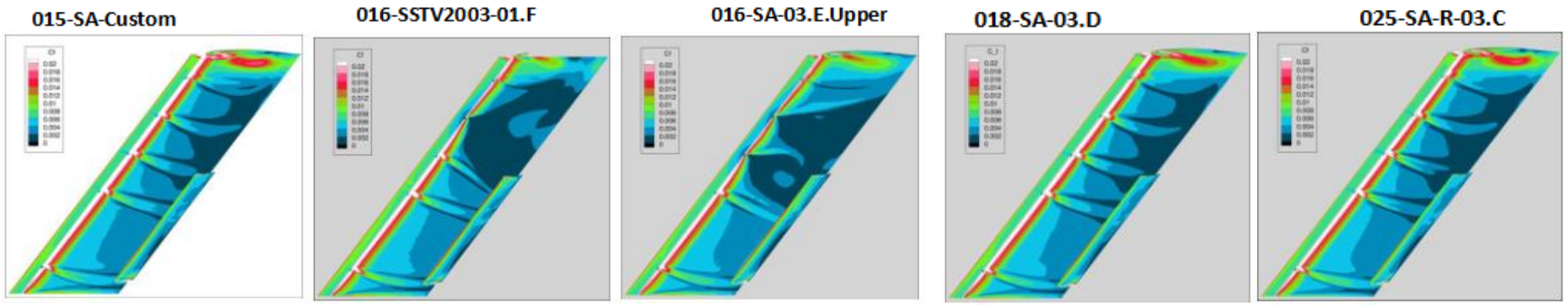
High-lift branch only

- Scatter reduced for alpha < 25, but not beyond.
- Truly grid and iteratively converged solution at 10 deg. should show lower lift variation than what is currently observed?

Comparing SRS vs. RANS at 30 deg.



Scale-resolving Results



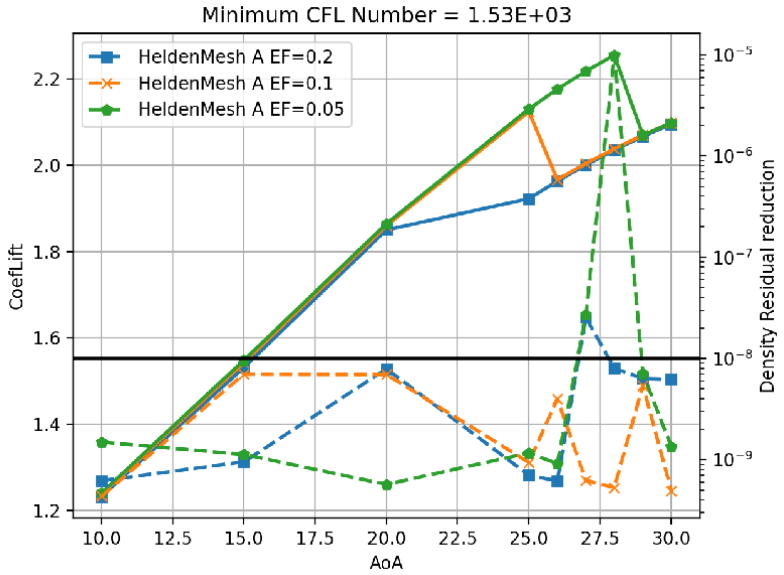
RANS Results

- Some RANS solutions are pizza-free at 30 deg. What are they (LAVA,Dragon,JAXA_TAS) doing special?

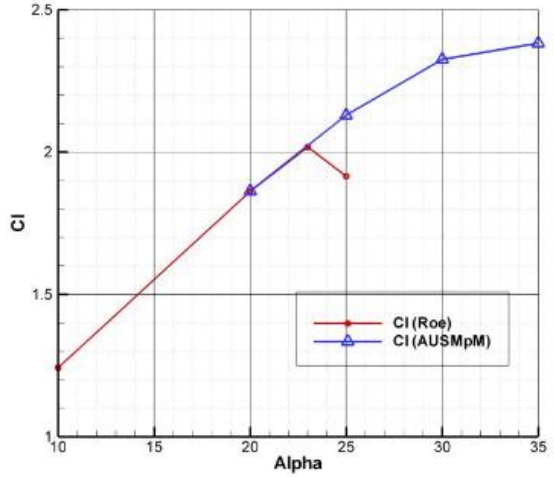
Effect of Numerical Scheme

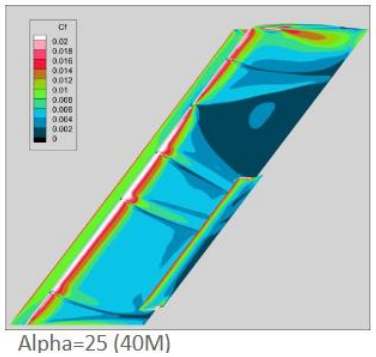
Λ-separation for varying numerical dissipation

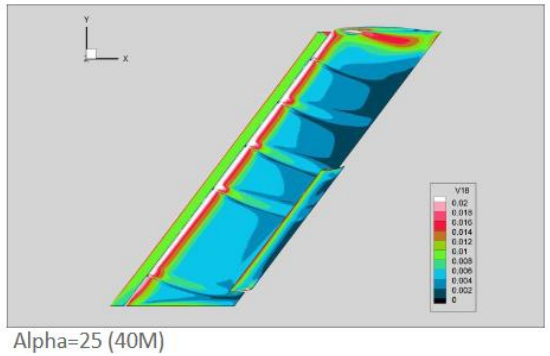
- Use entropy-fix fraction (EF) to control numerical dissipation
  - On Mesh A
- All datapoints except $C_{L_{max}}$ of EF=0.05 are converged
- Increasing EF triggers earlier Λ-separation
- Decreasing EF leads to later Λ-separation
- => Lower dissipation might be beneficial, but brings stability issues (EF<0.05 did not converge)



CODA




Alpha=25 (40M)

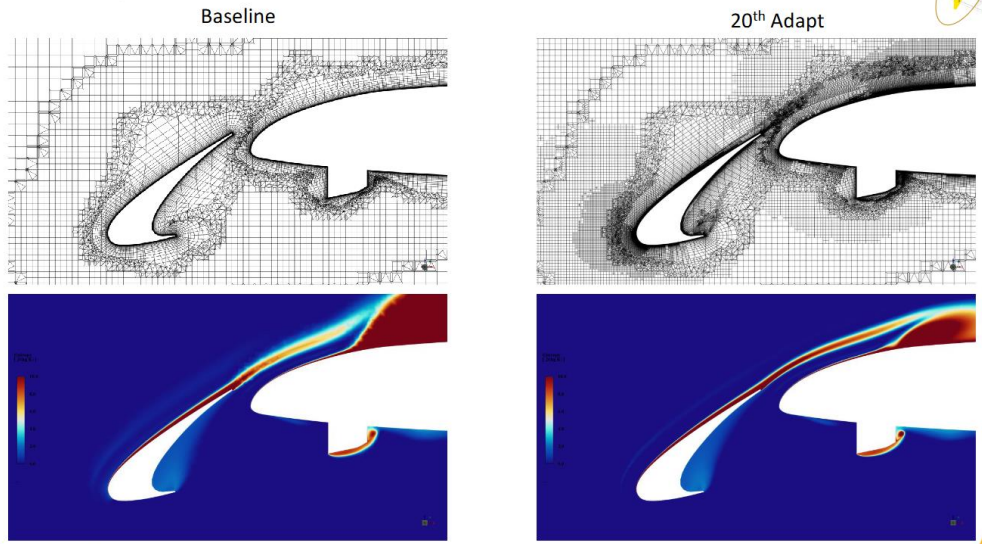

Alpha=25 (40M)

HEMLAB

- Numerical dissipation parameter (CODA) or upwind flux choice (HEMLAB) appears to have a significant impact at higher alpha.

Effect of Grid Adaptation

Mesh Adaption on Level A Mesh at AoA = 30° - CFL = 20



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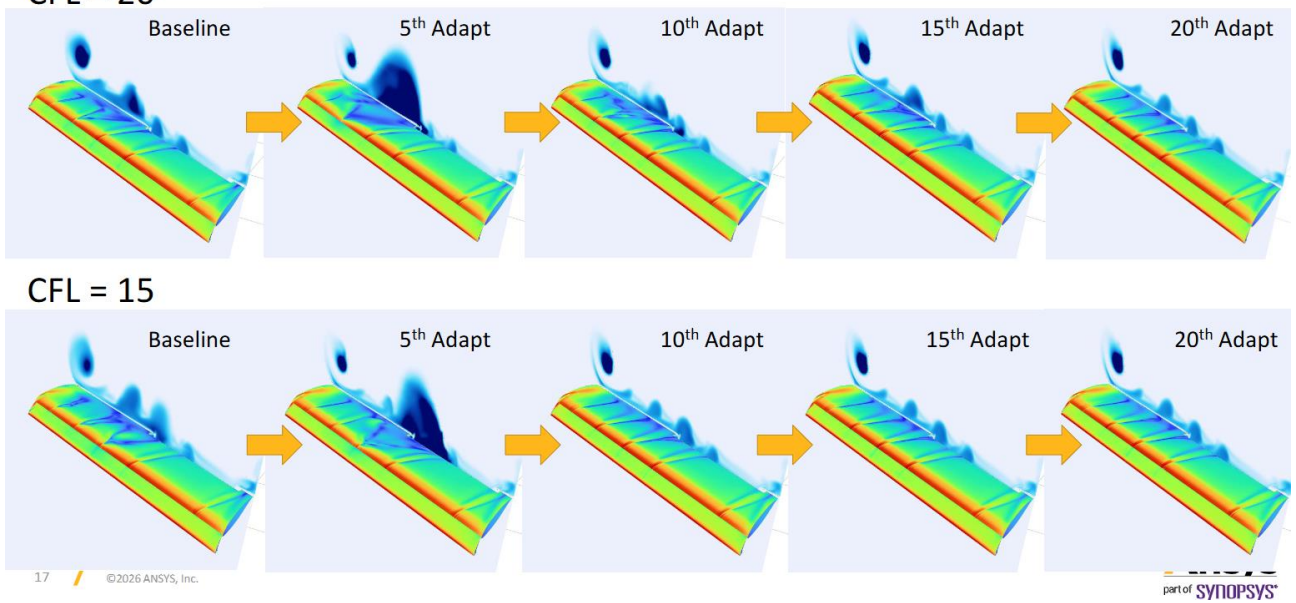
- ANSYS mesh adaptation shows some promise at 30 deg.
- Need other participants to replicate this result, ideally with their own adaptation method and codes.
- Does it contradict the experience of other tetrahedral-dominant mesh adaptation groups who may be using different adaptation metrics?

Mesh Adaption on Level A Mesh at AoA = 30°



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Other Avenues / Future Plan

- URANS on RANS grid: can't remove pizza if initial solution contains it. Can use newer formulations such as xRANS (DLR) [possibly with eddy viscosity limiting] to get pizza-free solutions from cold start?
- Newer SA variants (SA-SG26 Very Late Separation Model, others) may be useful in analyzing these cases. Suggestions to hybridize SA-baseline with newer models?
- Use of AI/ML for this test case: any success stories?
- Expert-crafted mesh design teams (Helden, Cadence, etc.): Do you need any specific input from participants to potentially create a new grid or family that may provide more accurate results? Or for the U. Washington experimental configuration.
- Insights from Visualization subgroup: ?
- Are we going to learn anything new (compared to HLPW5) by simulating Case 2 ?

Only for <= 25 deg.

RANS TFG Key Questions:

Question(Q), Tentative Answer (TA)

Q: Can we compute iteratively and grid converged RANS solutions for TC1?

TA: Yes

Q: Can we achieve agreement between converged RANS solutions computed by different solvers for TC1 at low, middle, and high angles of attack?

TA: Yes

Q: Is TC1 geometry prone to spurious 'pizza slice' separation patterns similar to those observed in RANS solutions at high angles of attack for the HLPW-5 TC 2.2-2.4?

TA: Yes

Q: Can spurious separation be mitigated with better grid resolution and/or iterative convergence? If yes, what are requirements for grid resolution (both on surface and in volume) and levels of convergence to avoid spurious separation?

TA: Different opinions

Q: Do we observe multiple solutions of the Spalart-Allmaras (SA) turbulence model for TC1 and, if we do, what changes in the turbulence model should be made to ensure well-posedness?

TA: We observe multiple solutions. Regularization constraints are required

Q: What lessons learned from TC1 can be applicable to more complex CRM-HL configurations, e.g., TC 2.4?

TA: To be decided

Optional:

Q: How do geometrical features (bracket shape / spacing between brackets, anything else) affect spurious separation in the RANS solutions?

TA: Strong influence