

022-OVERFLOW

Contribution to HiLiftPW-3

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The Boeing Company

James G. Coder

University of Tennessee, Knoxville,

3rd High Lift Prediction Workshop, Denver, CO June 3-4, 2017

Summary of cases completed: OVERFLOW2.2I, Committee Grids, SA-RC-QCR2000

Case	Alpha=8, Fully turb, grid study	Alpha=16, Fully turb, grid study
1a (full gap)	yes	yes
1b (full gap w adaption)	no	no
1c (partial seal)	yes	yes
1d (partial seal w adaption)	no	no

Case	2D Verification study
3	no

Case	Polar, Fully turb	Polar, specified transition	Polar, w transition prediction
2a (no nacelle)	yes	no	no
2b (no nacelle w adaption)	no	no	no
2c (with nacelle)	yes	no	no
2d (with nacelle w adaption)	no	no	no

Summary of cases completed: OVERFLOW2.2I, Committee Grids, SA

<i>Case</i>	<i>Alpha=8, Fully turb, grid study</i>	<i>Alpha=16, Fully turb, grid study</i>
<i>1a (full gap)</i>	<i>no</i>	<i>no</i>
<i>1b (full gap w adaption)</i>	<i>no</i>	<i>no</i>
<i>1c (partial seal)</i>	<i>no</i>	<i>no</i>
<i>1d (partial seal w adaption)</i>	<i>no</i>	<i>no</i>

<i>Case</i>	<i>2D Verification study</i>
3	<i>yes</i>

<i>Case</i>	<i>Polar, Fully turb</i>	<i>Polar, specified transition</i>	<i>Polar, w transition prediction</i>
<i>2a (no nacelle)</i>	<i>yes</i>	<i>no</i>	<i>no</i>
<i>2b (no nacelle w adaption)</i>	<i>no</i>	<i>no</i>	<i>no</i>
<i>2c (with nacelle)</i>	<i>yes</i>	<i>no</i>	<i>no</i>
<i>2d (with nacelle w adaption)</i>	<i>no</i>	<i>no</i>	<i>no</i>

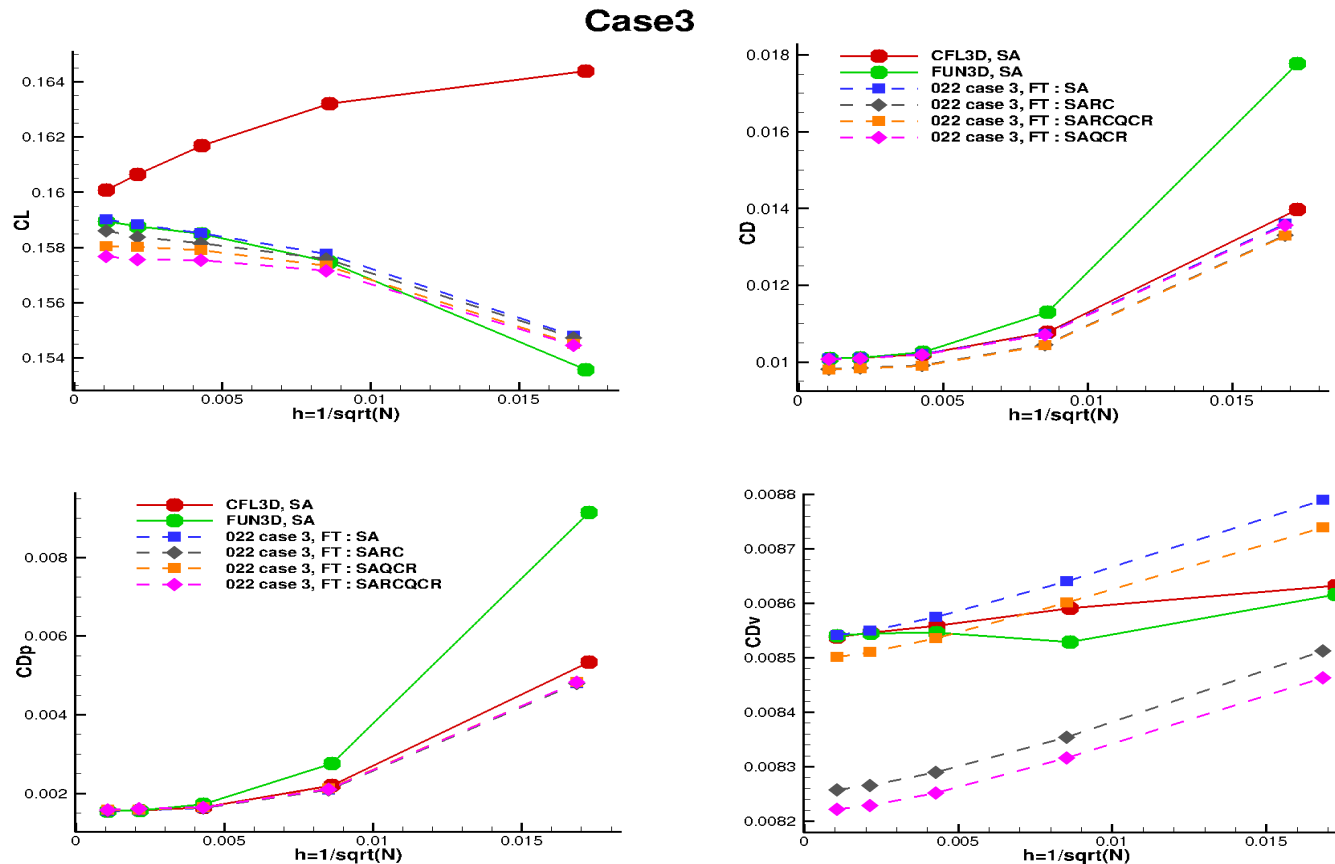
Summary of Code and Numerics Used

- OVERFLOW2.2I: Structured Overset
 - Pegasus, DCF or C3P Domain Connectivity
 - Implicit Finite-Difference
 - Roe 3rd Order, Diagonalized Implicit AF
 - Low Mach Preconditioning
 - Spalart-Allmaras Turbulence Model
 - SA
 - SA-RC-QCR2000
 - Non-time accurate accelerated Steady-State
 - Multigrid, Variable Time Stepping, etc
 - Dual Time Stepping - Time Accurate Capability
 - Typical case:
 - Pleiades 420 Cores
 - Steady-State: 24-36 Hours Wall Clock Time per Case
 - Unsteady: 96 Hours Wall Clock Time per Case
- NASA OVERFLOW Overset Grid CFD Flow Solver, <https://overflow.larc.nasa.gov/>
- Nichols, R. H. and Buning, P. G., "User's Manual for OVERFLOW 2.2," NASA LARC, Hampton, VA, Aug. 2010.
- Jespersen, D., Pulliam, T.H., and Buning, Recent Enhancement to OVERFLOW, AIAA paper 97-0644

Case3: Verification Study Results

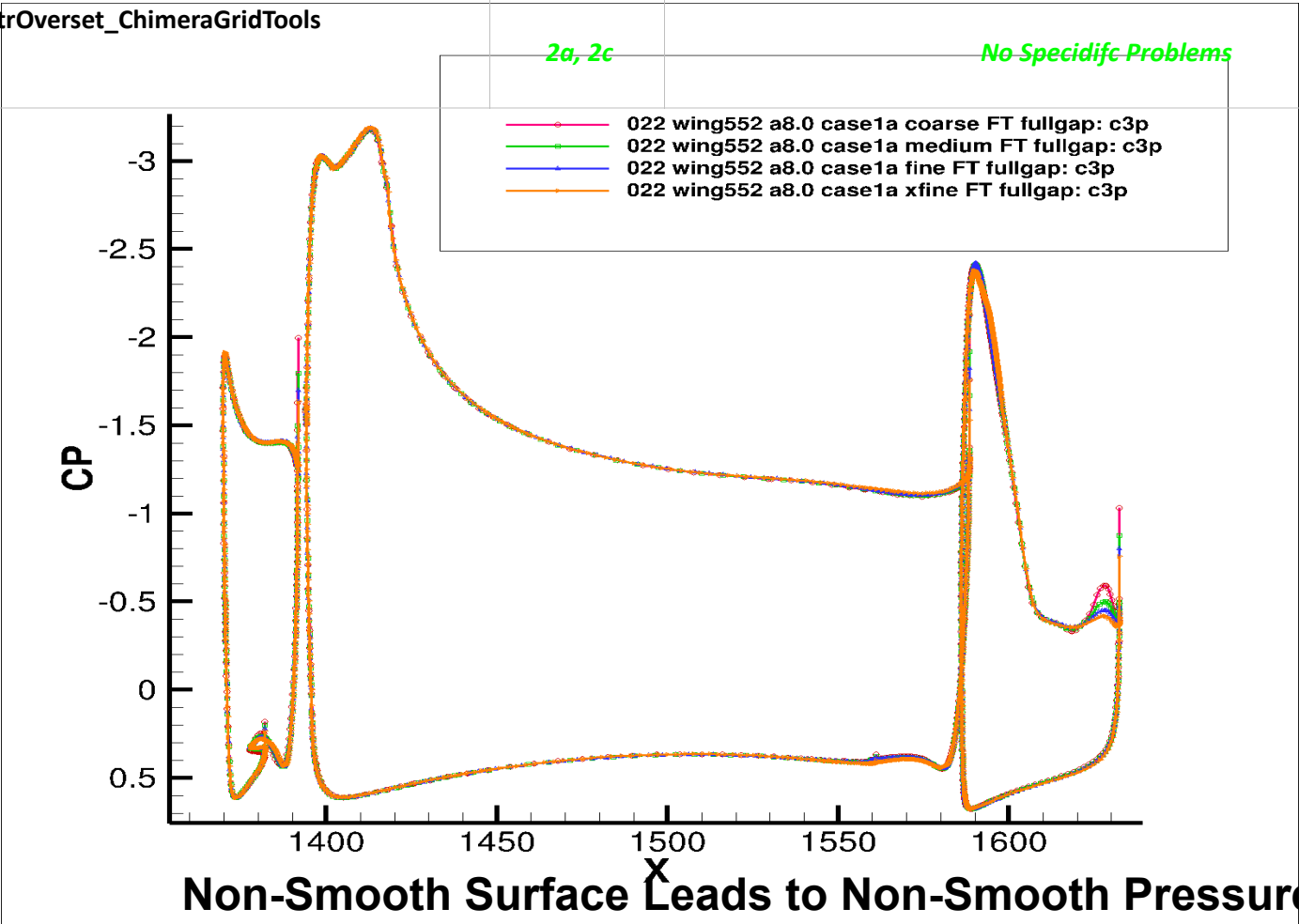
- Verified : OVERFLOW Turbulence Model Resource Verification Results, Technical Report NAS-2014-03, June 2014
- Validated: OVERFLOW Turbulence Modeling Resource Validation Results, NAS Technical Report NAS-2016-01, August 2016
- Submitted Results for Turbulence Model: SA
- Evaluated effects for: SA, SA-RC, SA-QCR2000, SA-RC-QCR2000

NAS



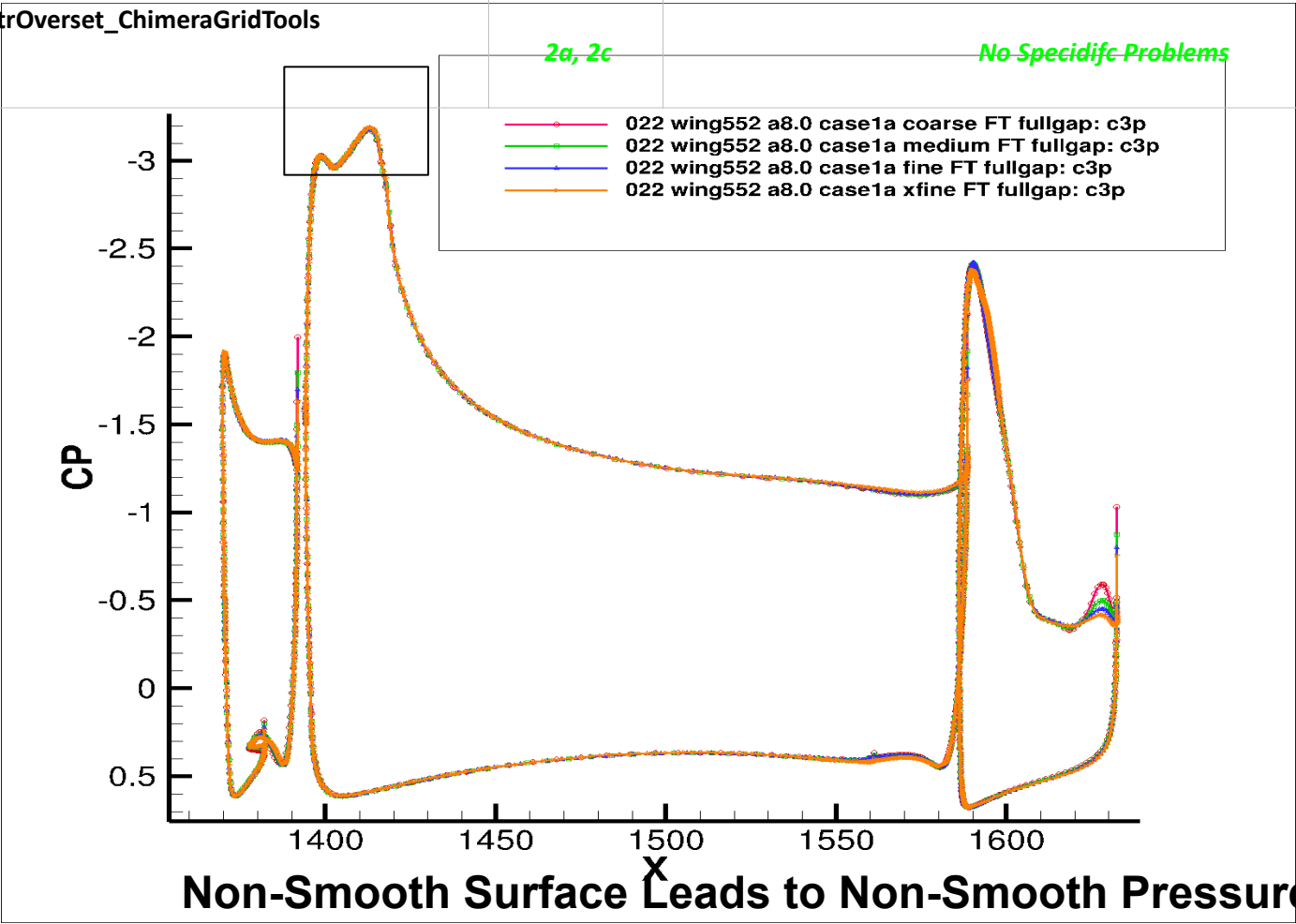
Brief overview of grid system(s)

Grid System	Case(s)	problems/issues
A-HLCRM_StrOverset_ChimeraGridTools	1a,1c	Non-Smoothness, especically leading edge surfaces
A-JSM_StrOverset_ChimeraGridTools	2a, 2c	No Specidifc Problems



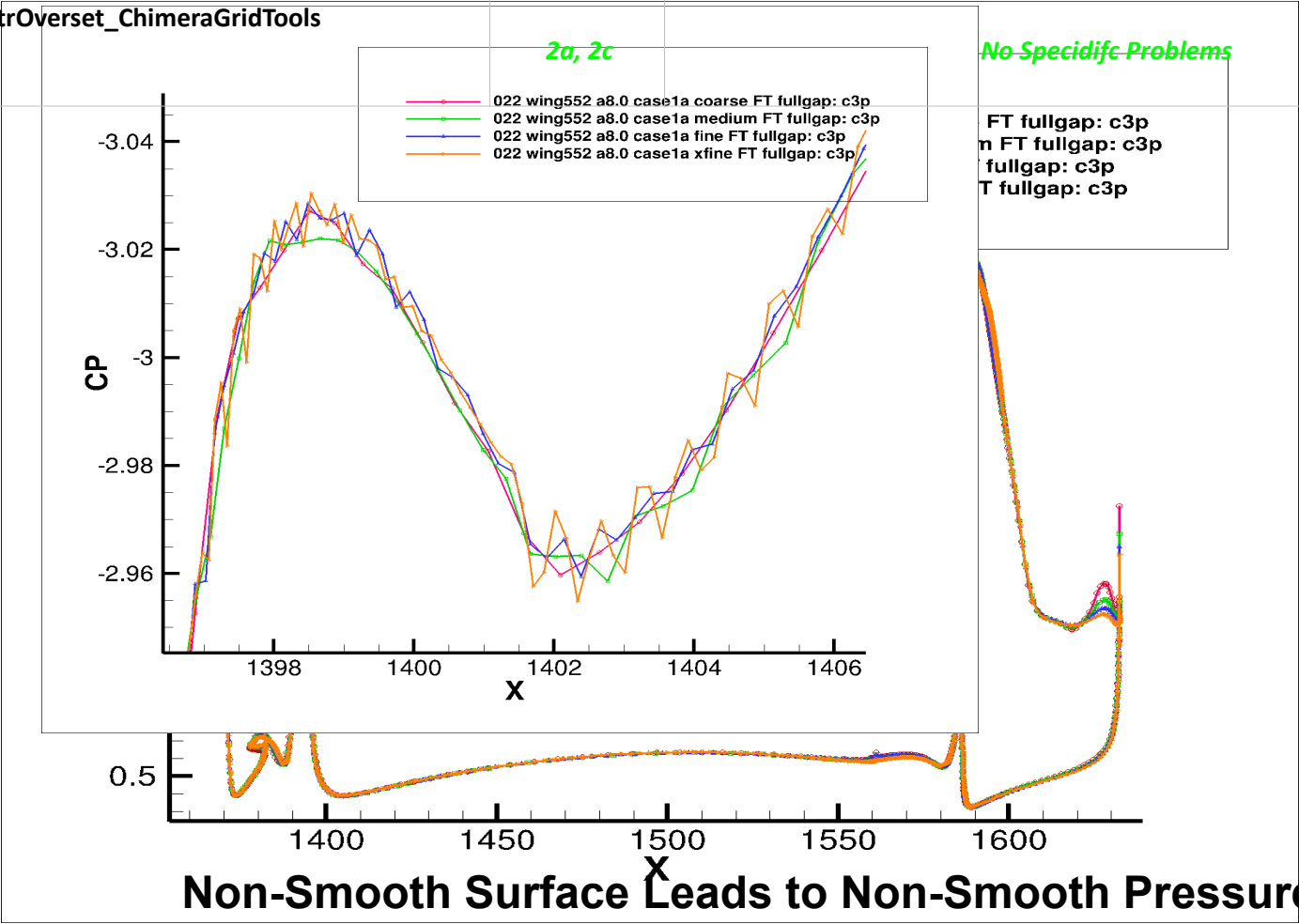
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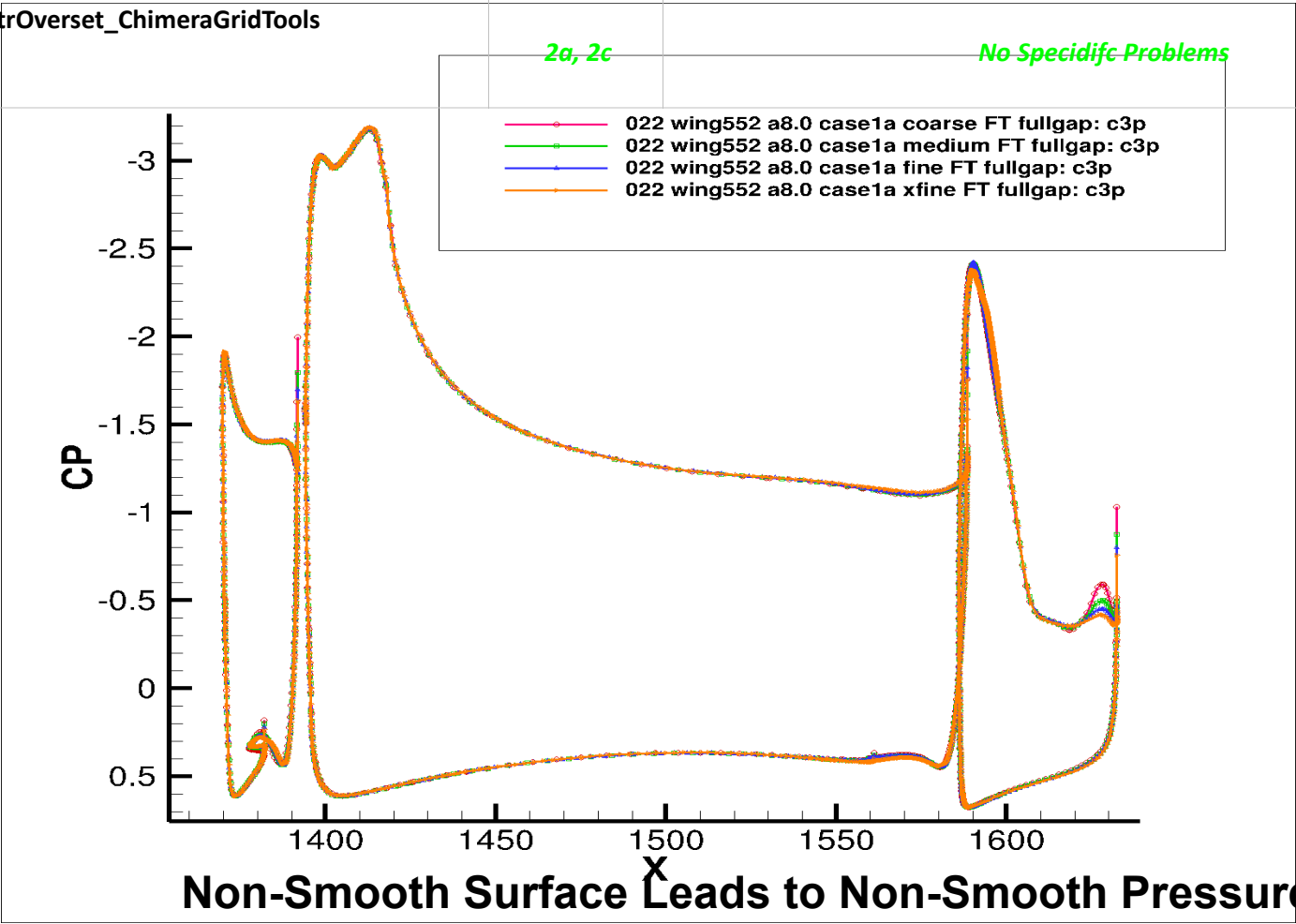
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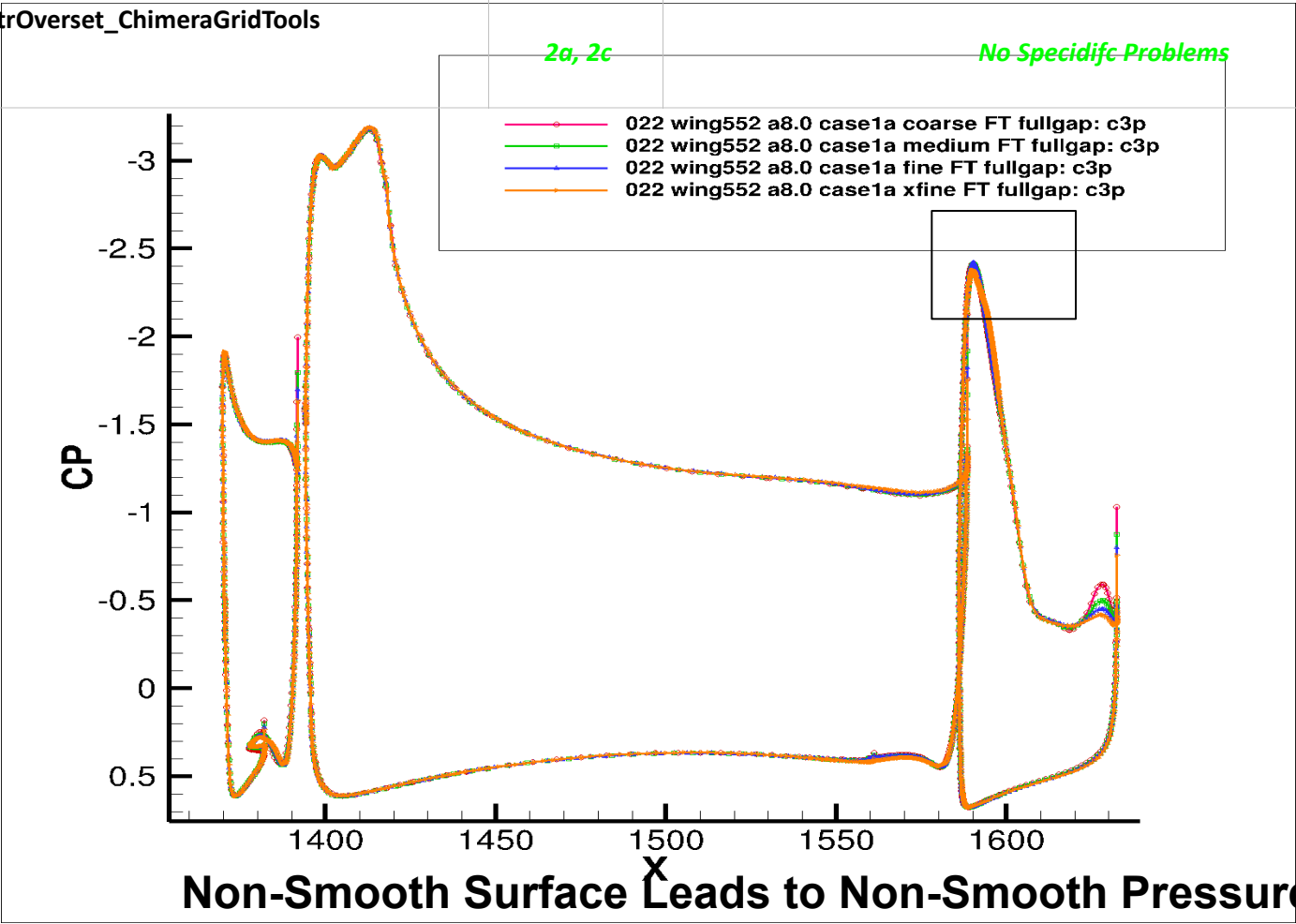
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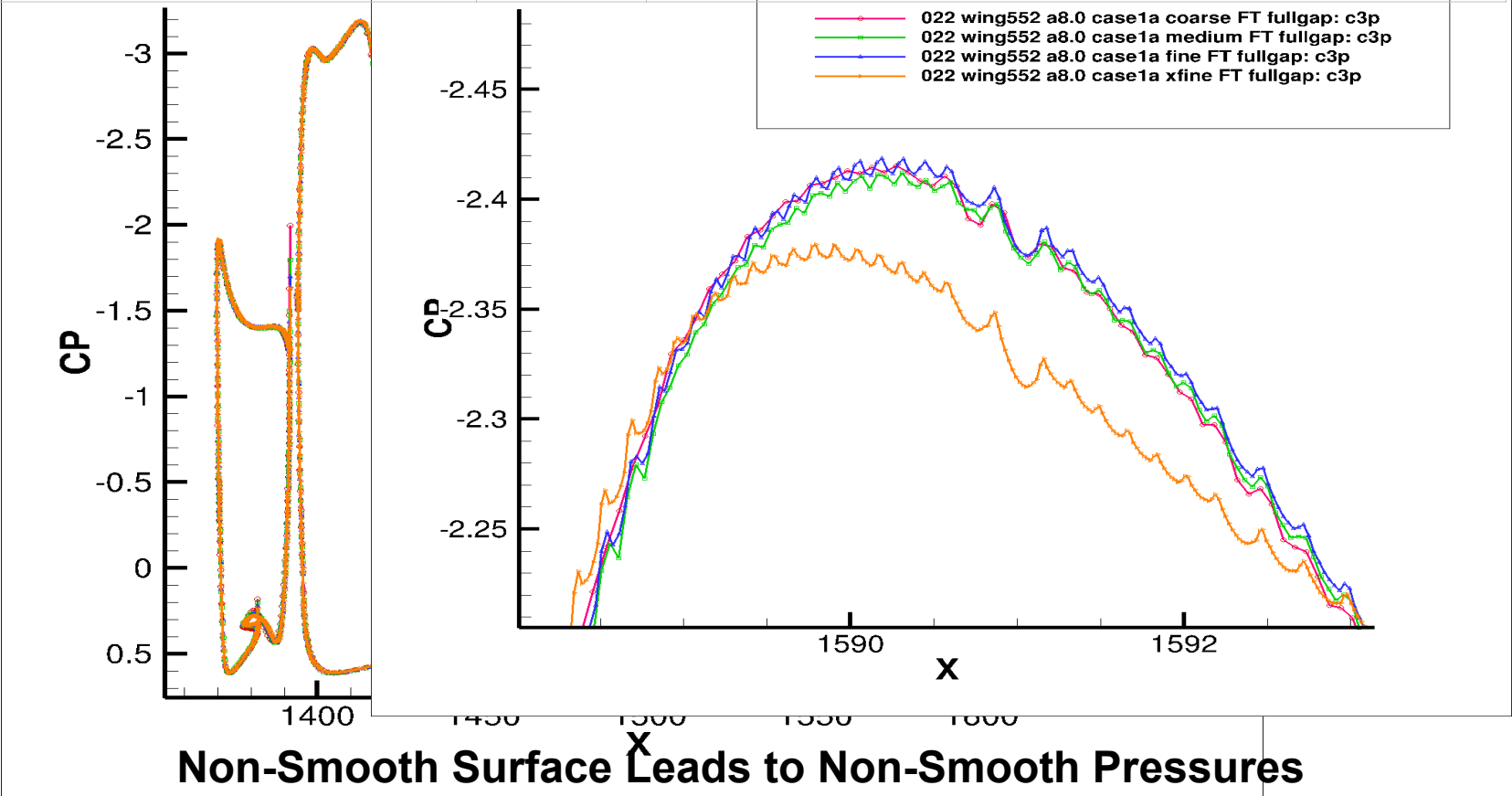
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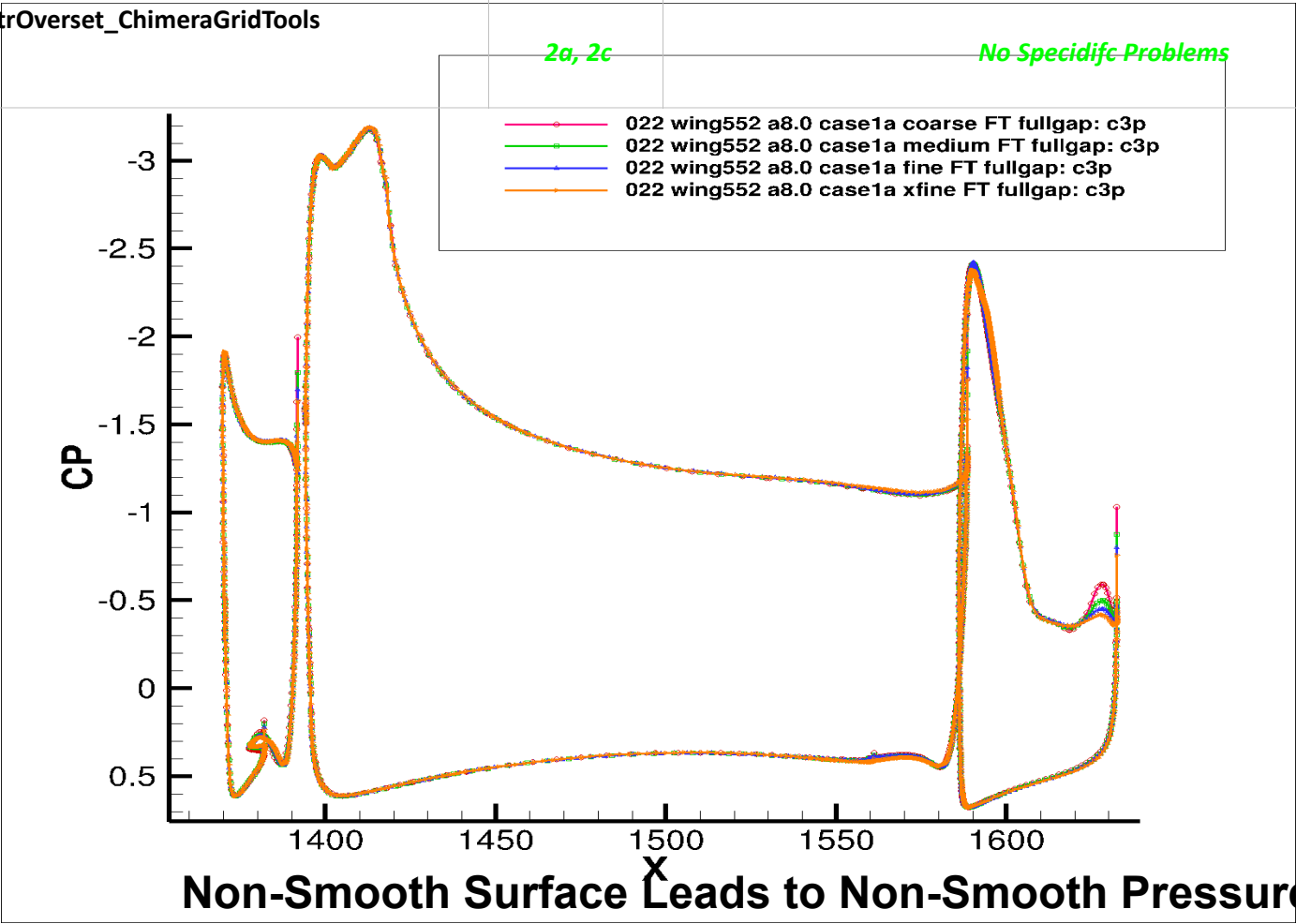
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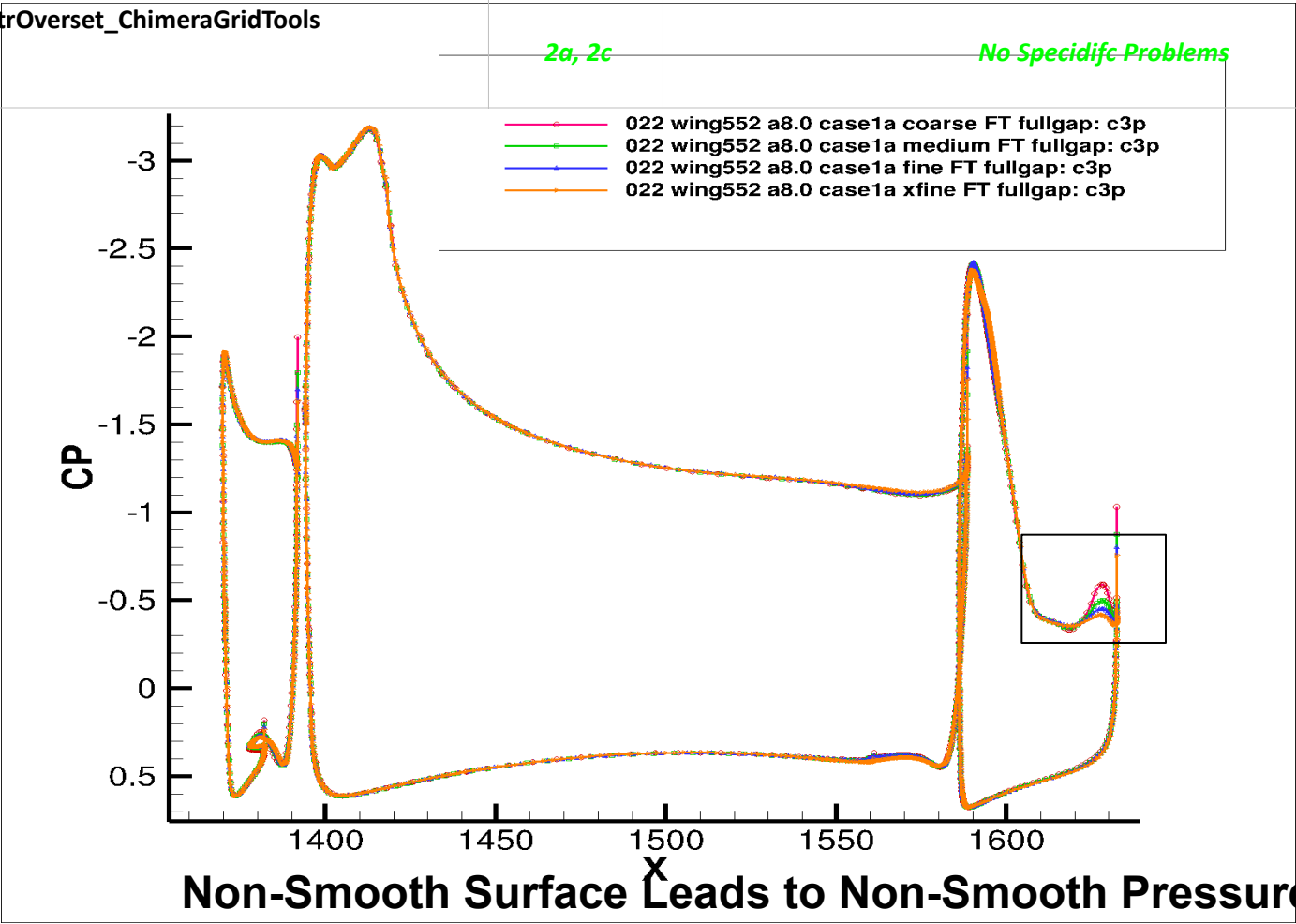
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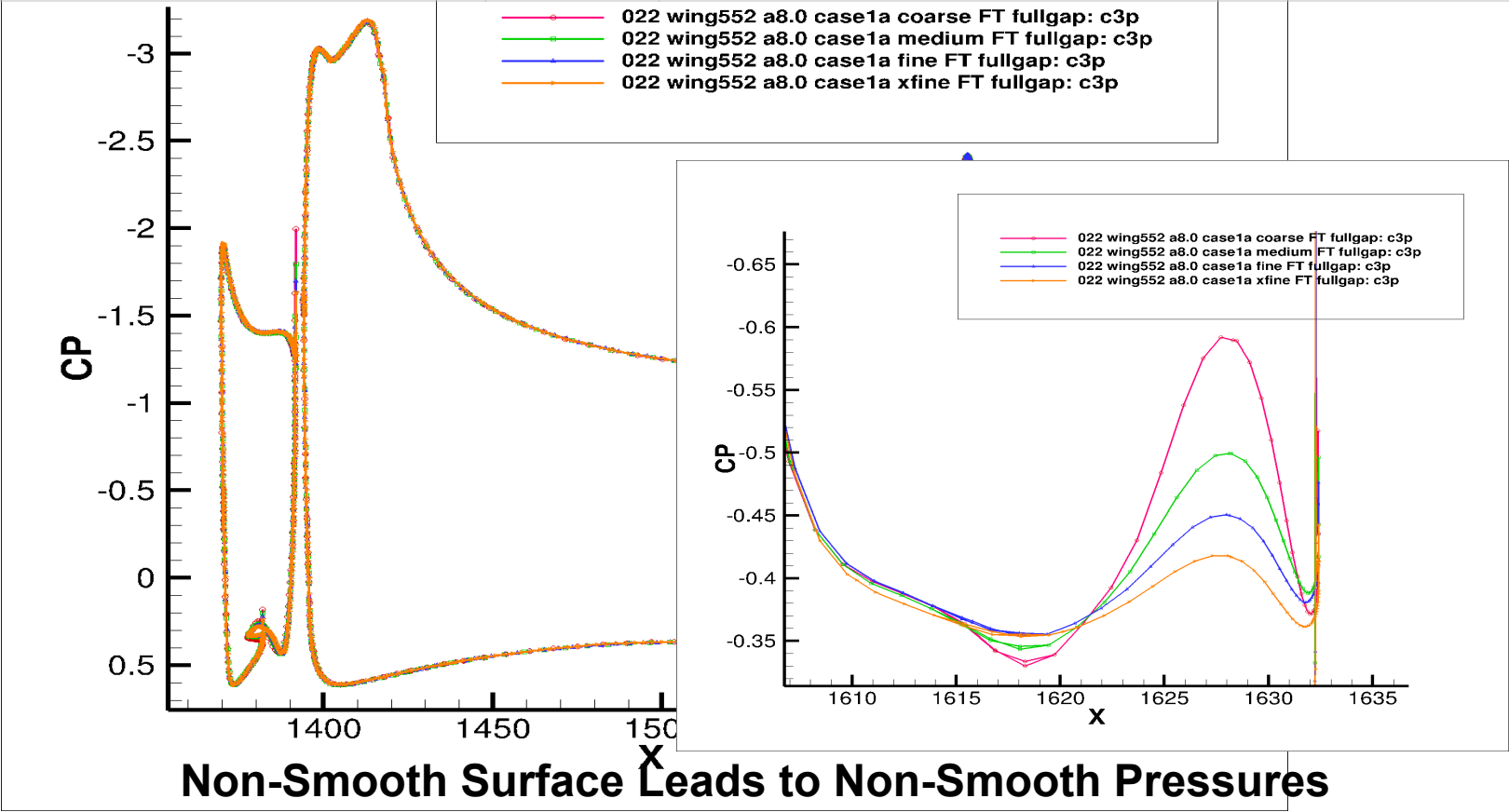
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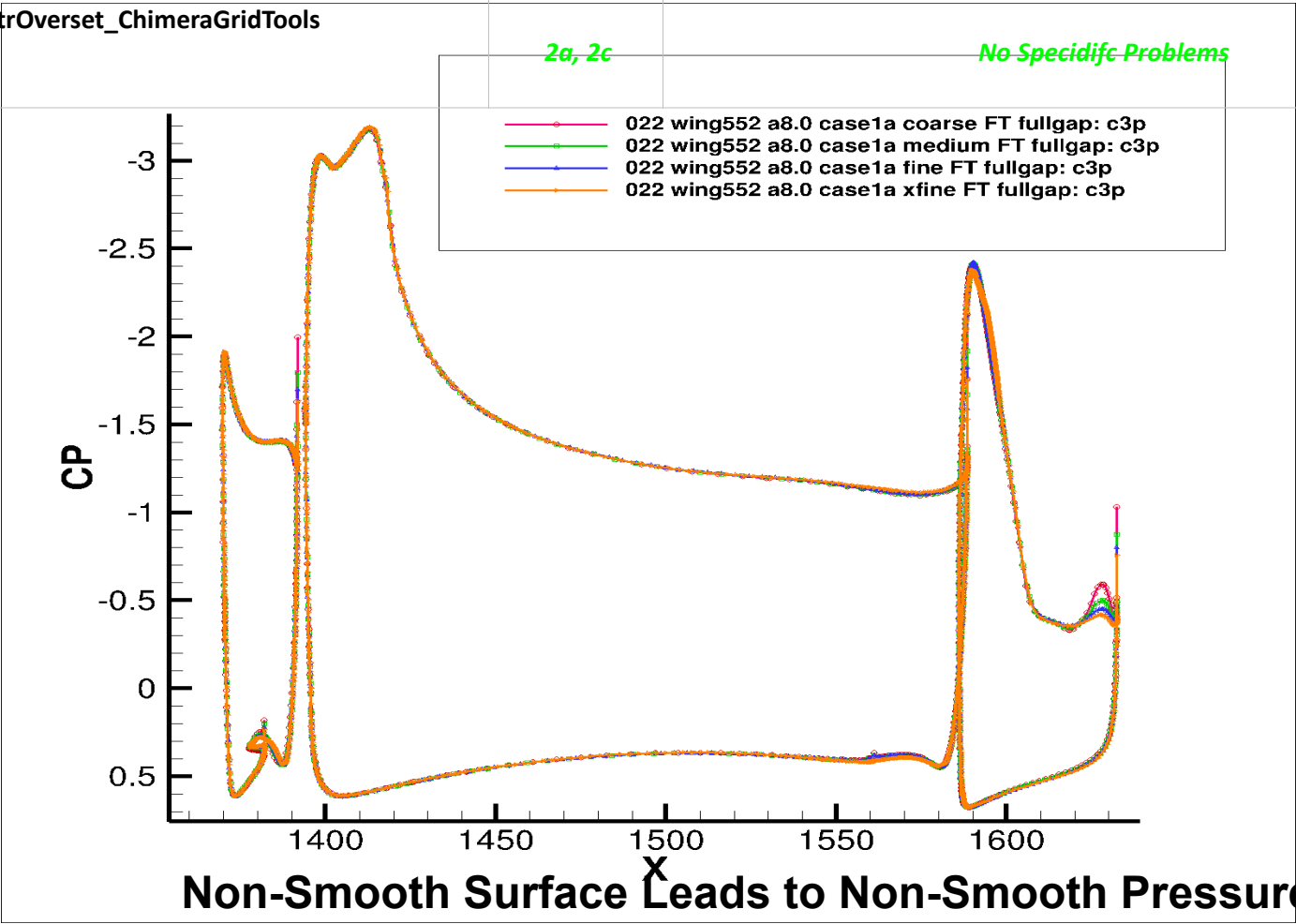
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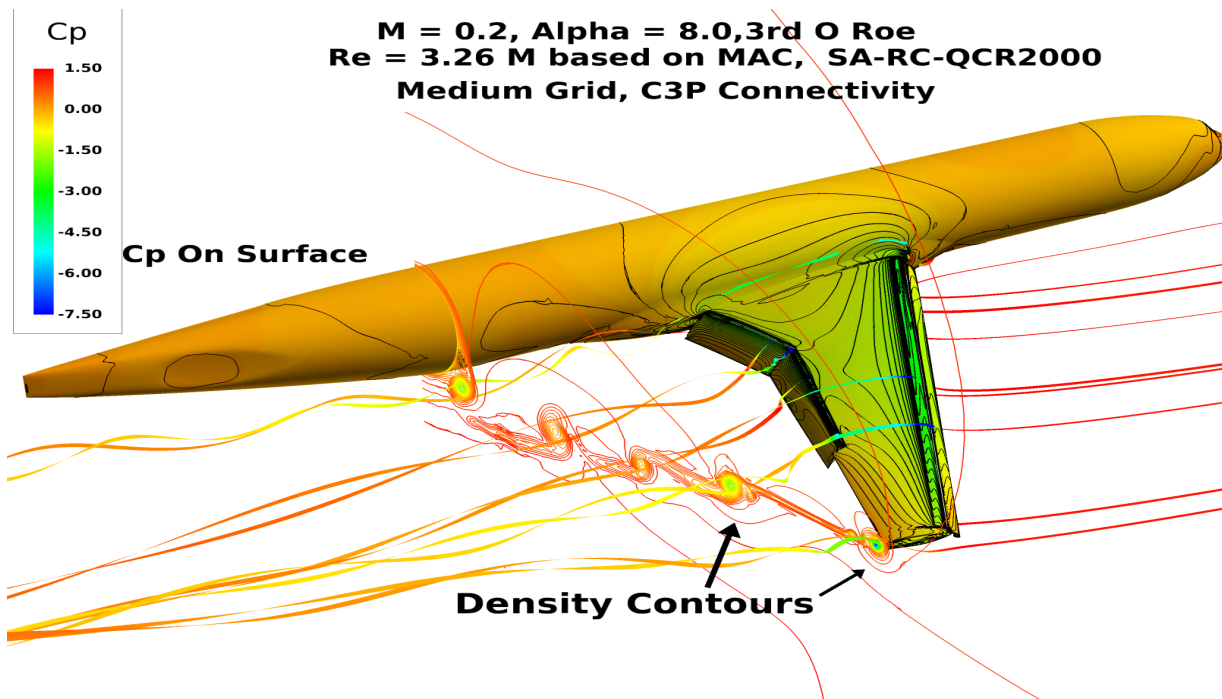
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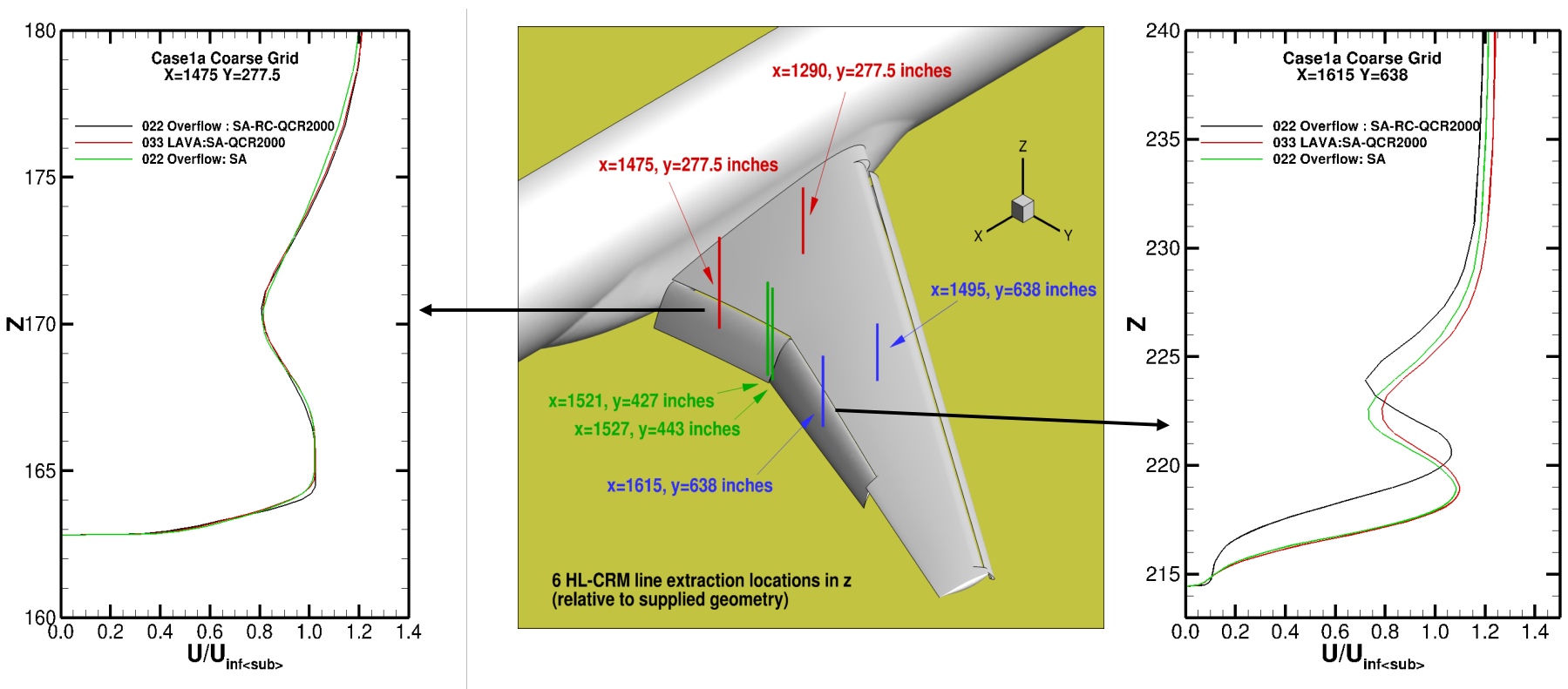
Overview of HL-CRM results: OVERFLOW SA-RC-QCR2000

- Submitted: Case1a,1c
 - C3P Connectivity
- Results computed for other connectivities
 - DCF: xrays, minimum hole cutting
 - Pegasus: peg5 XINTOUT optimized hole cuts



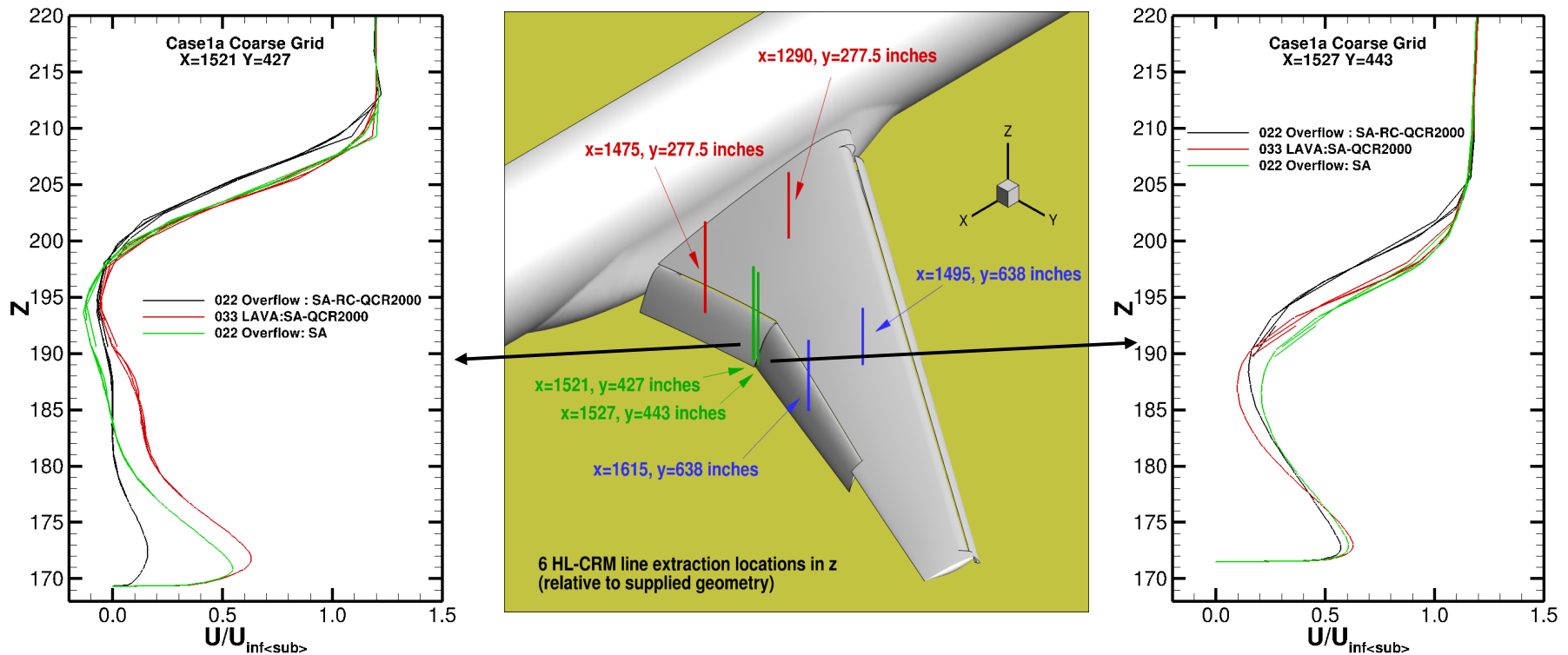
Overview of HL-CRM results: Issues and Review

- Taking Advantage of Unique Access to 033-LAVA Results
- Requested Data Showed
 - Mostly Good Consistency of Loads, Cp's and Velocities
 - Differences Lead to Closer Examination of Certain Effects.



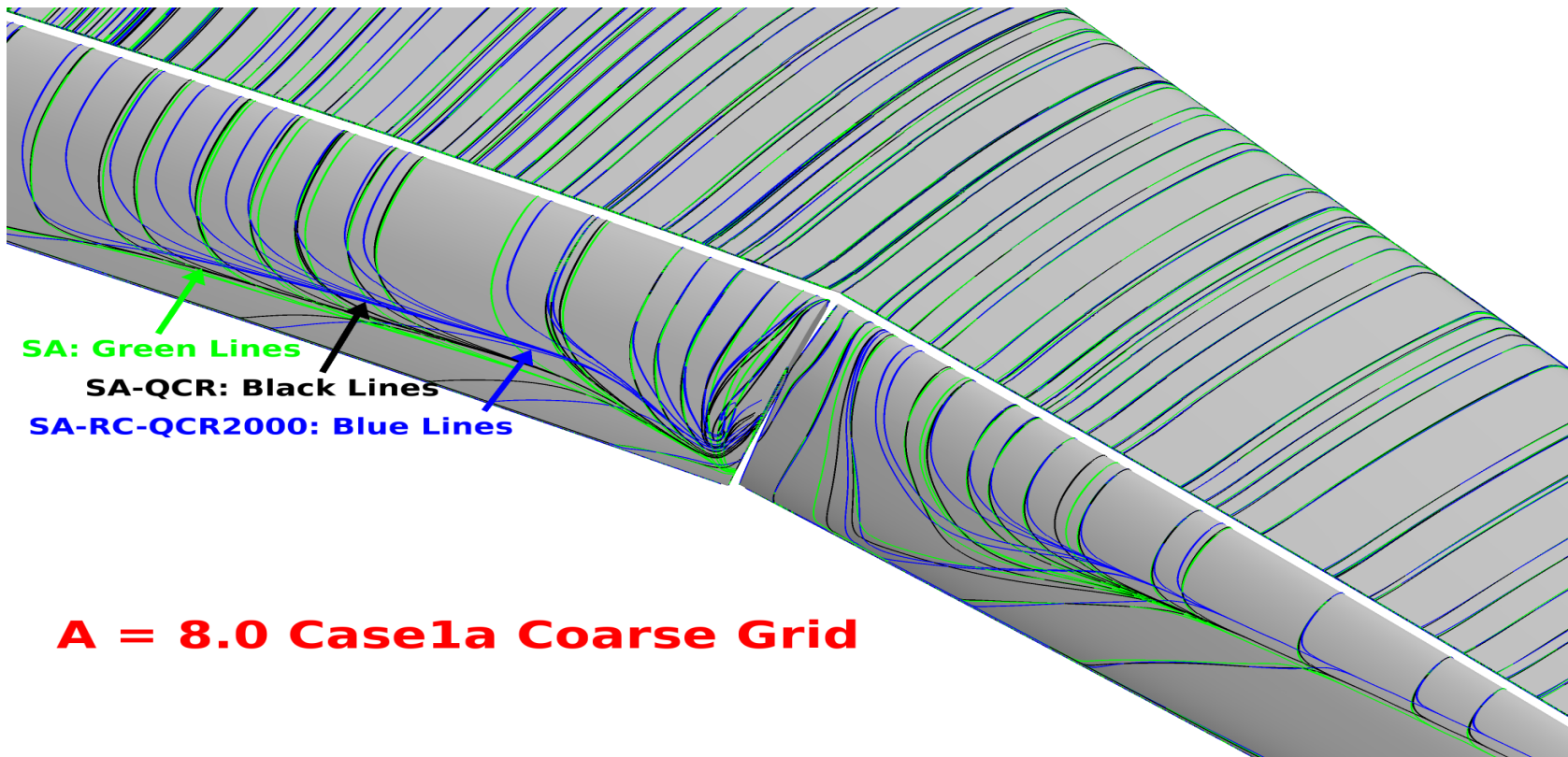
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Overview of HL-CRM Results: Turbulence Model Effect

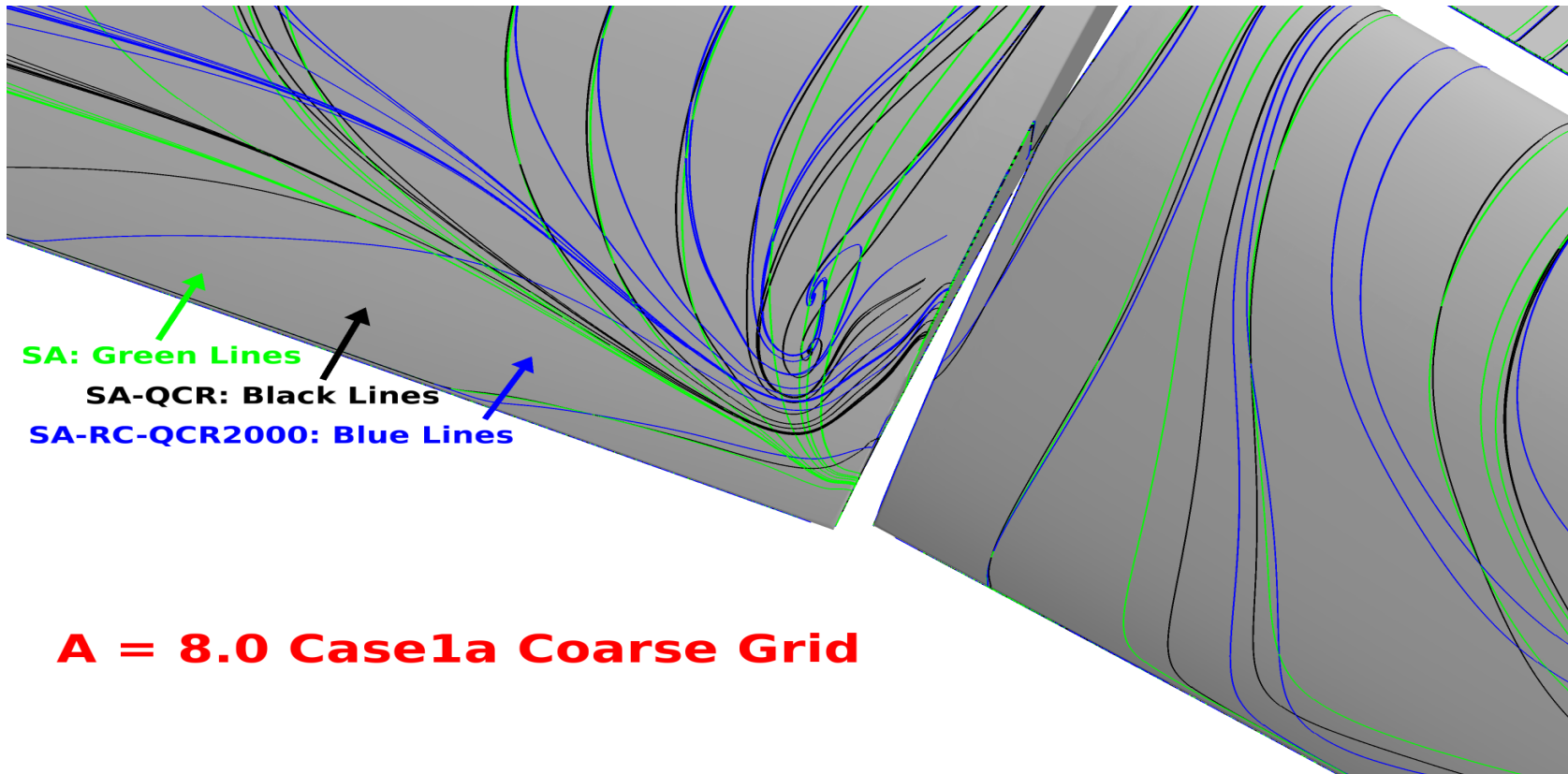
- 022-OVERFLOW: **SA-RC-QCR2000** : Outboard Region Inboard-Flap Separation
- 033-LAVA: **SA-QCR**: No Separation in that region
- 022-OVERFLOW: Comparison SA. SA-QCR2000, SA-RC-QCR2000
 - Affects Inboard-Flap Separation



A = 8.0 Case1a Coarse Grid

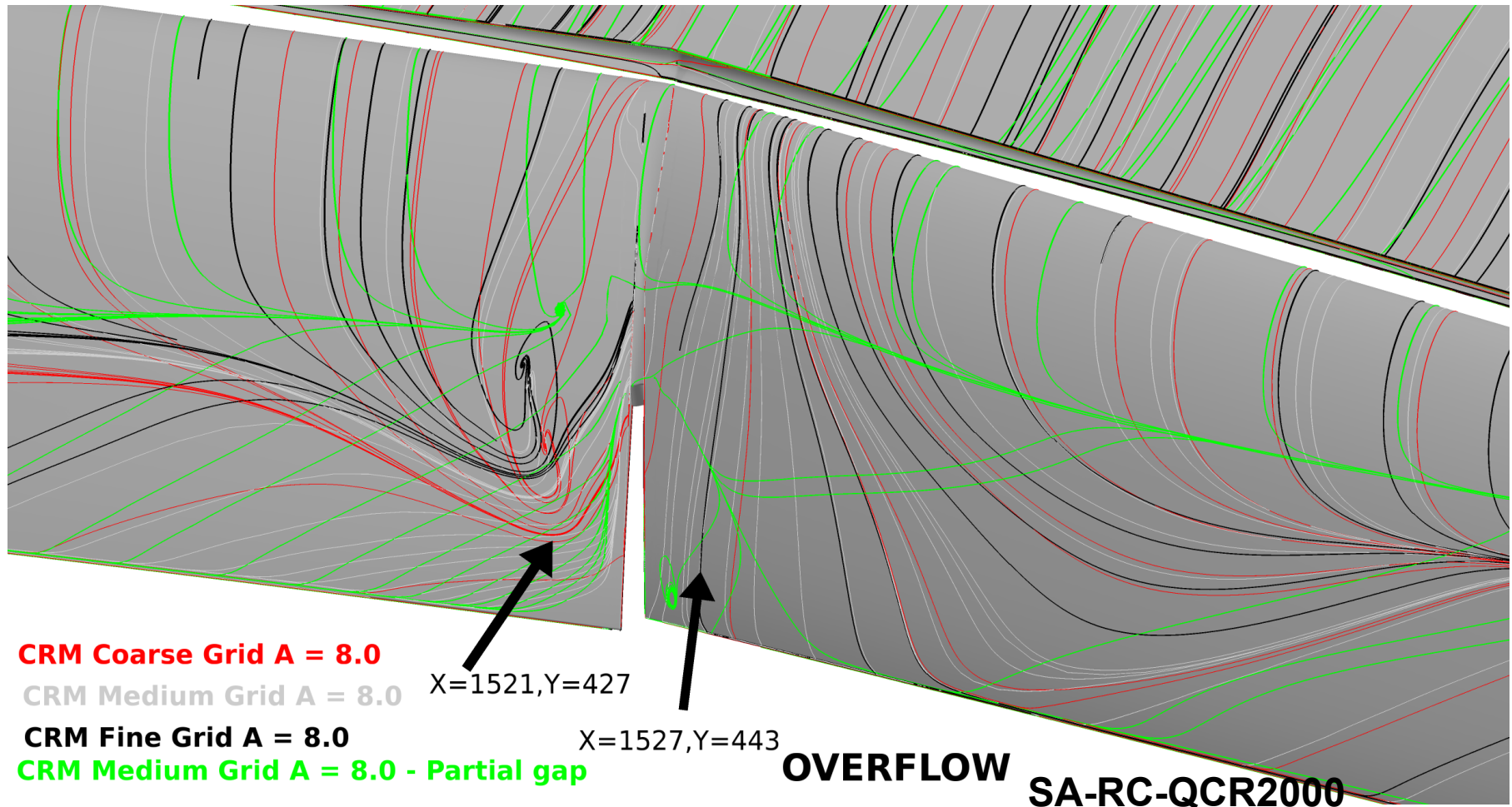
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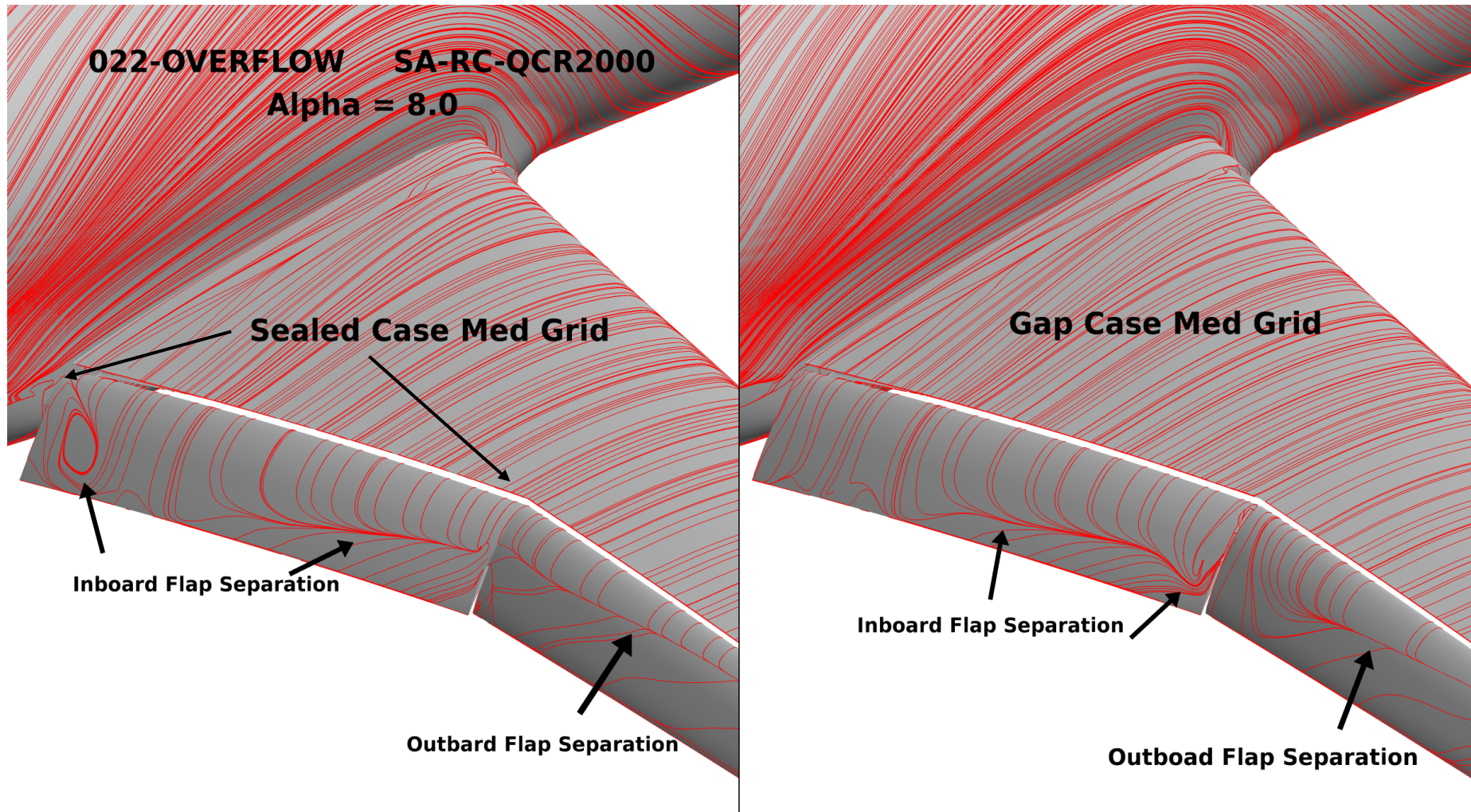
Overview of HL-CRM results: Grid Refinement, Sealed Gap Effects

- Grid Refinement Affects Separation on Flap
- Sealed Gap Solution Has Different Flap Separation Pattern



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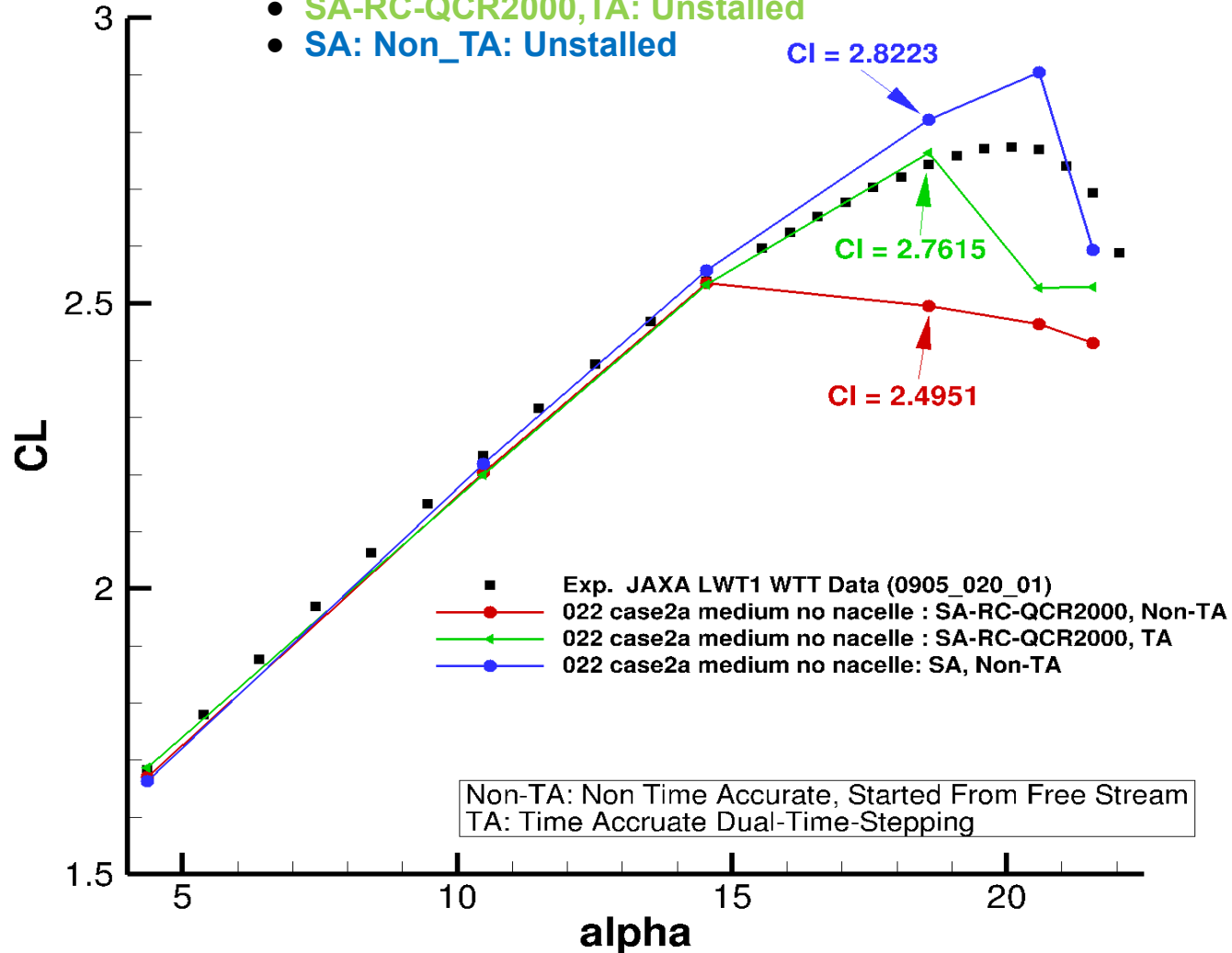
Overview of JSM results: Summary

- Submitted Cases:
 - Pegasus Connectivity
 - SA-RC-QCR2000: Case2a, Case2c
 - SA: Case2a
 - Mainly Started from Free-Stream
 - Some Cases at High Alpha's Restarted from Previous Alpha
 - Observed Some Dependency of Stall on Starting Process
 - Can Get Multiple Results: Separation, Loads at Same Alpha
- Results Not Submitted:
 - Time accurate: Case2a
 - Run with Dual-Time-Stepping
 - Total Time = 80 X the Time it Takes a Particle to Travel MAC distance
- 033-LAVA Presentaion Will Show Comparisons for Case2a,Case2c
 - 022-Structured-Overset, 033-Structured-Overset, 033-Unstructured

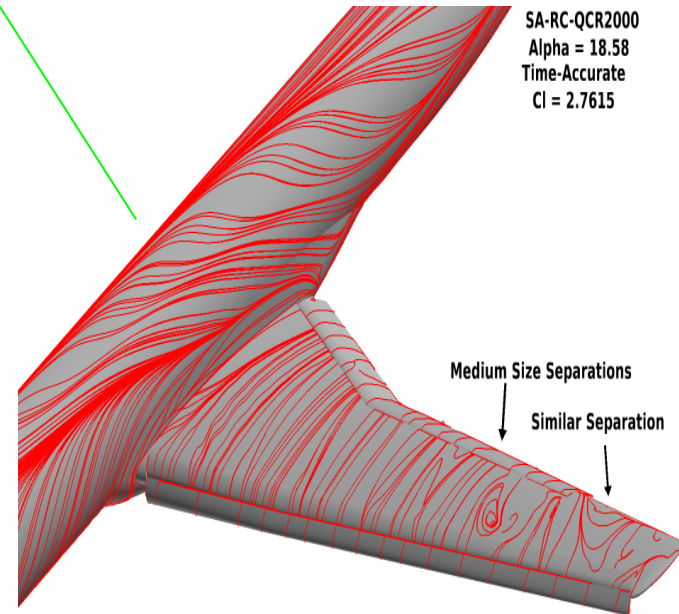
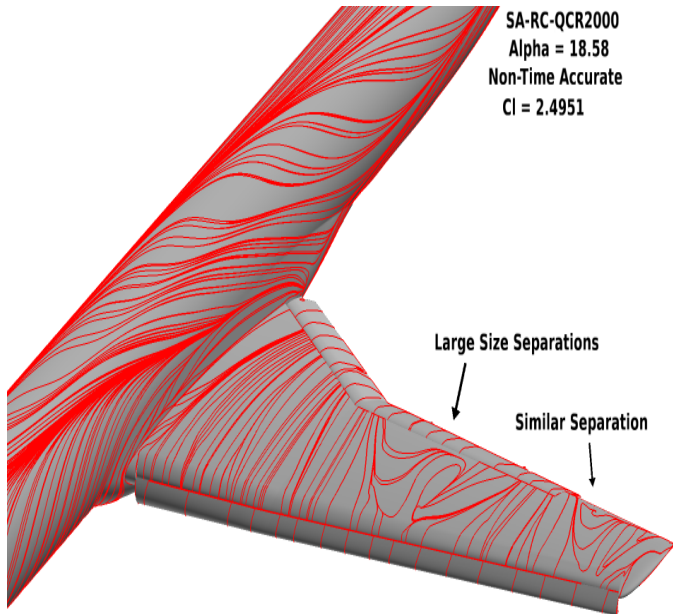
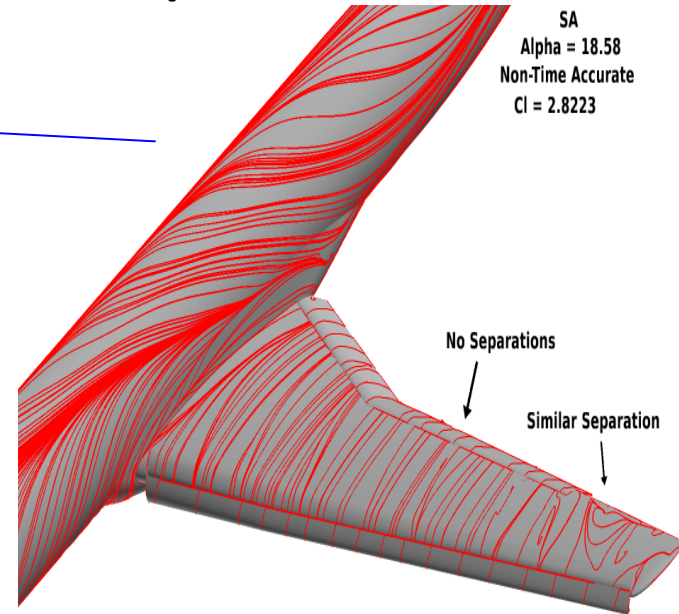
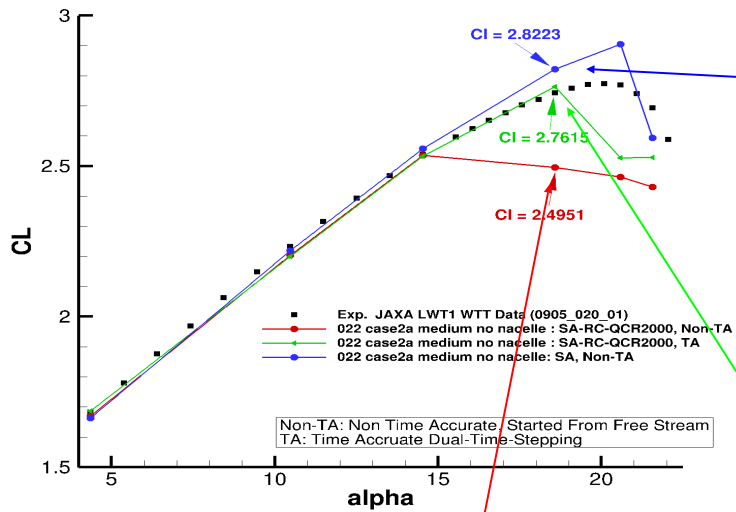
Overview of JSM results: Case2a

- Alpha 18.58

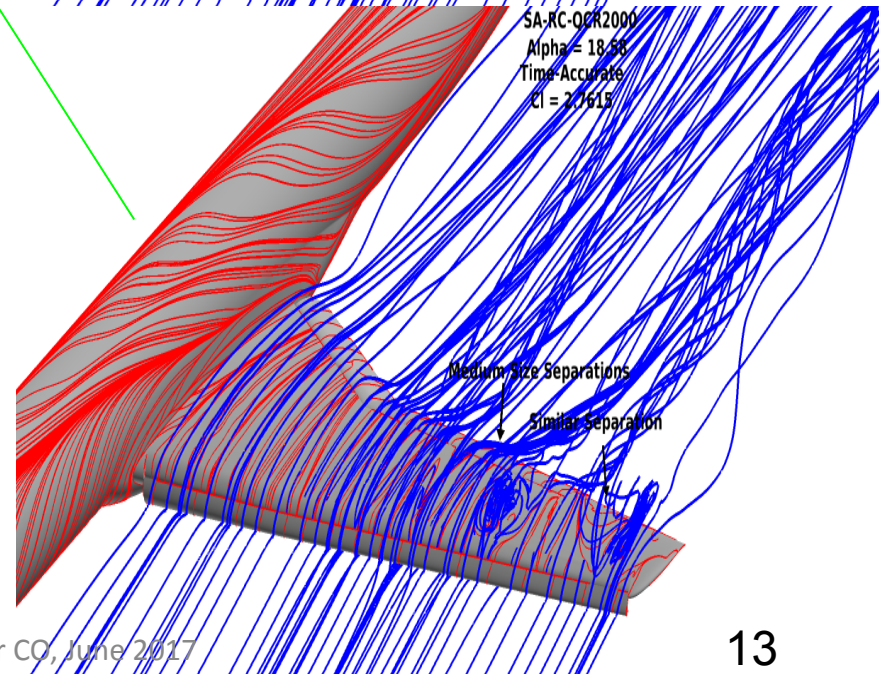
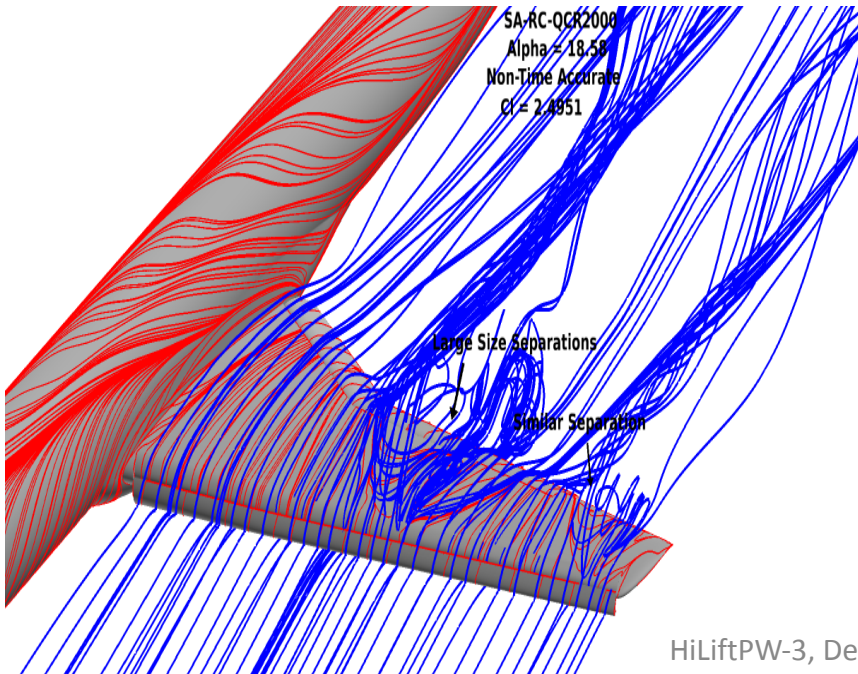
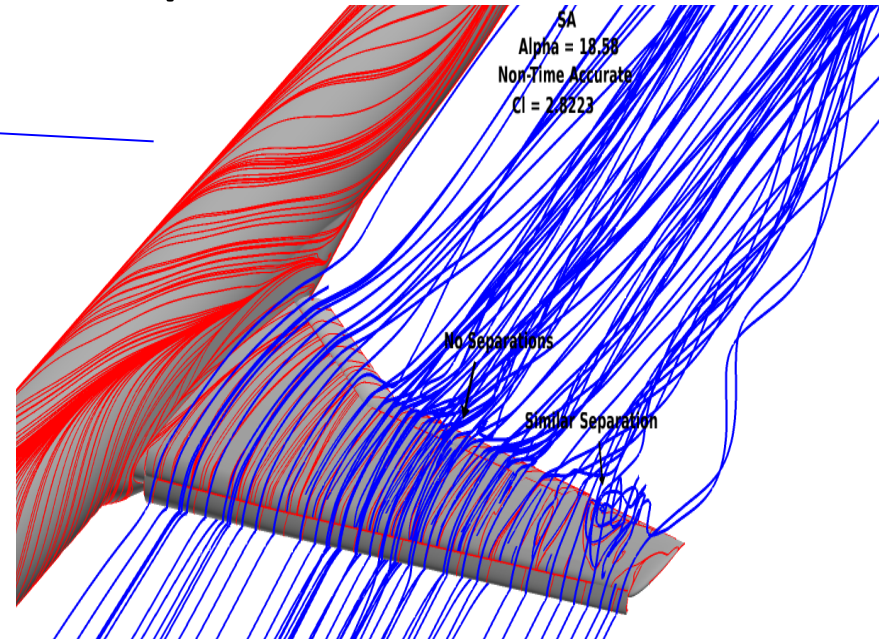
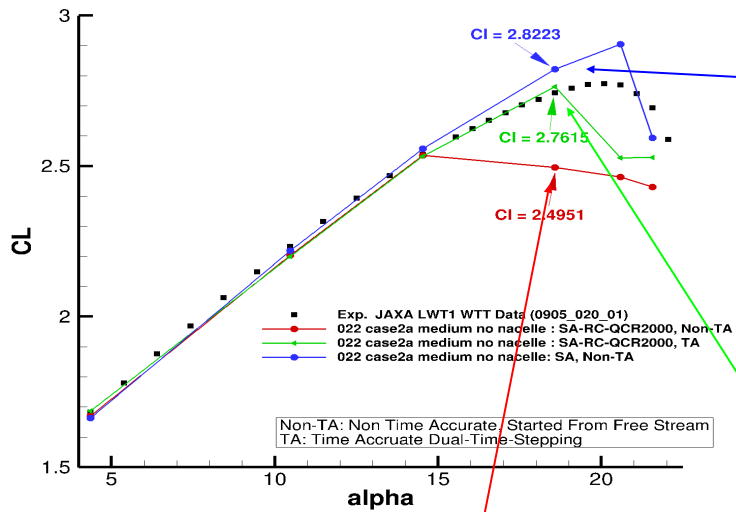
- Exp: Unstalled
- SA-RC-QCR2000, Non-TA: Stalled
- SA-RC-QCR2000,TA: Unstalled
- SA: Non_TA: Unstalled



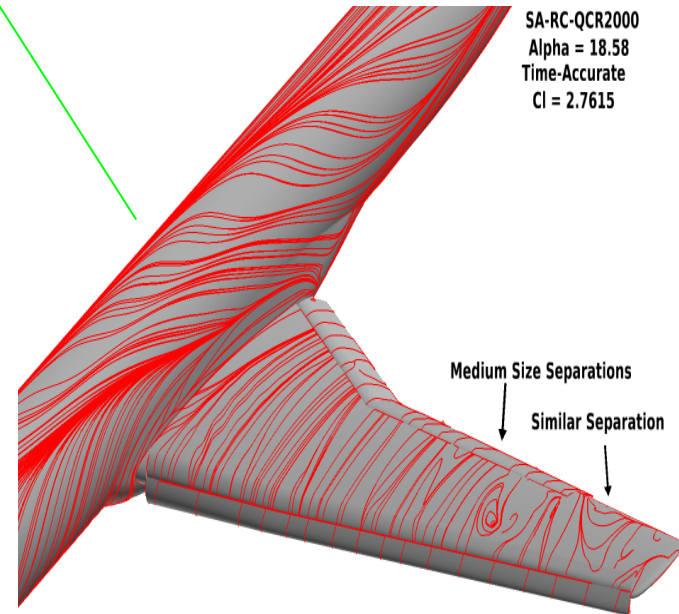
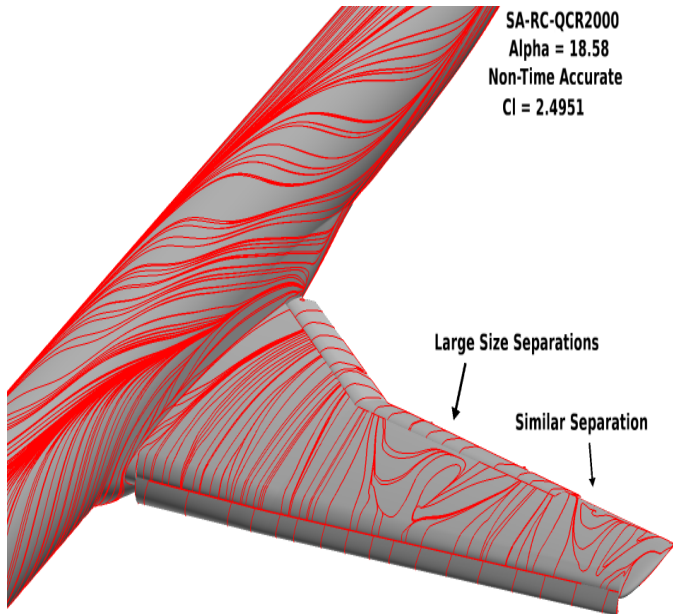
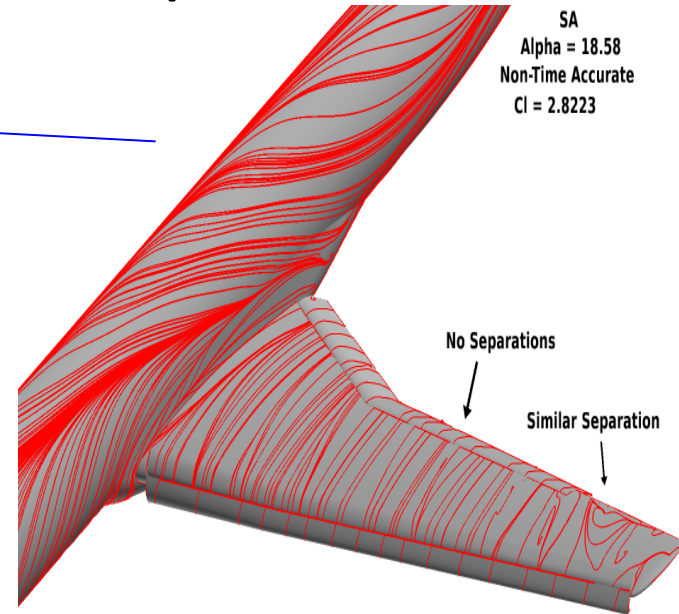
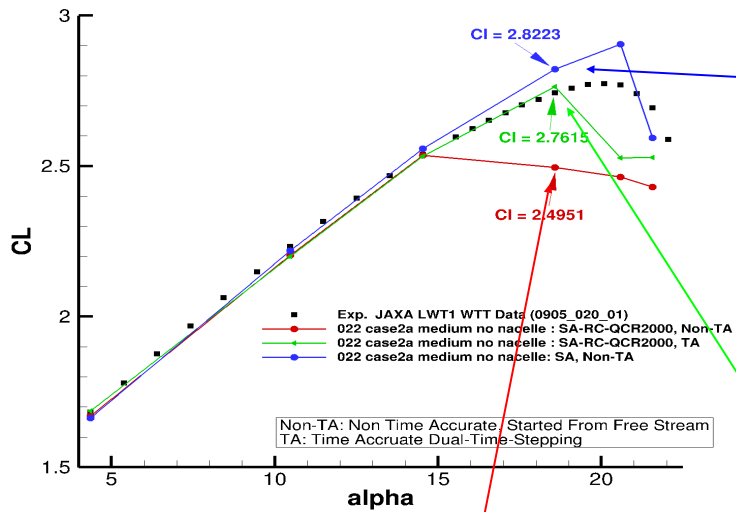
Overview of JSM results: Case2a: Alpha = 18.58



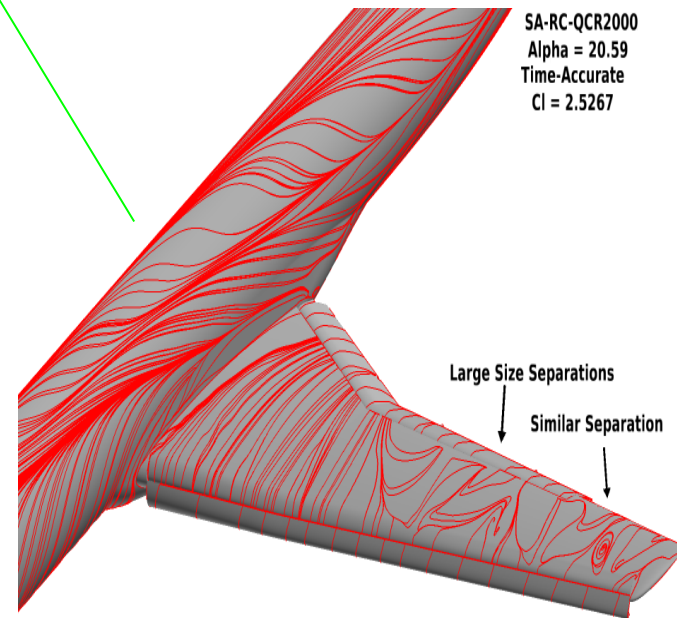
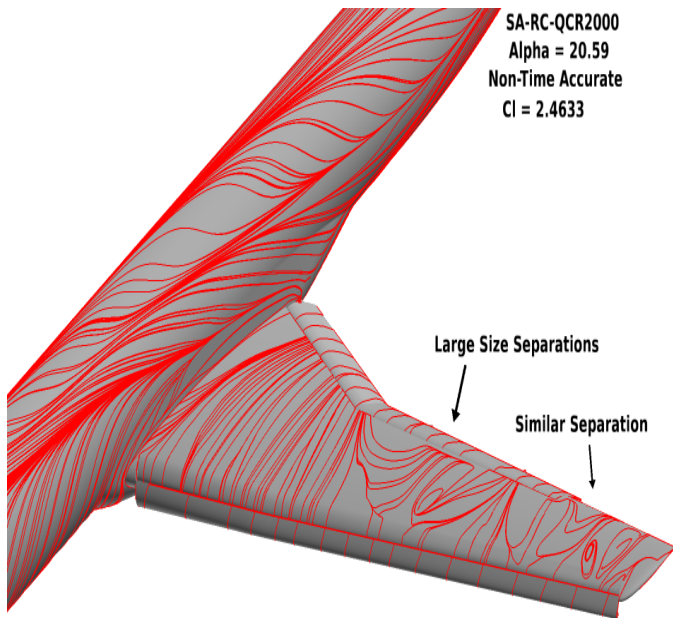
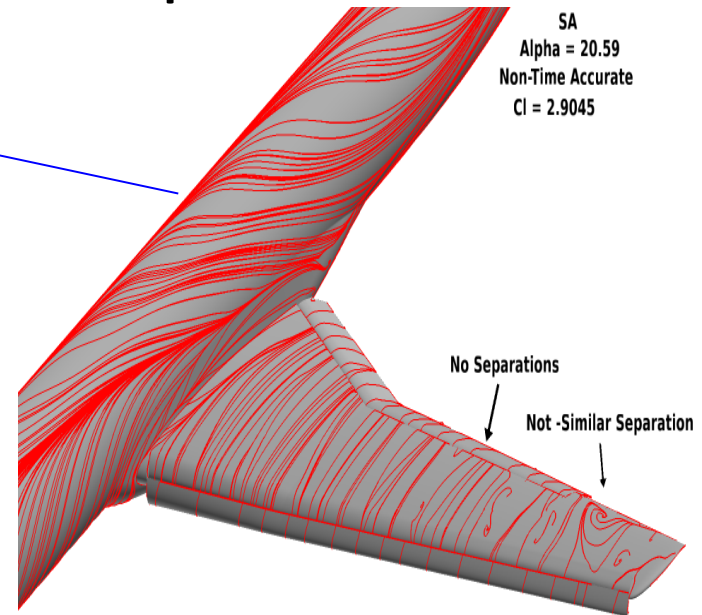
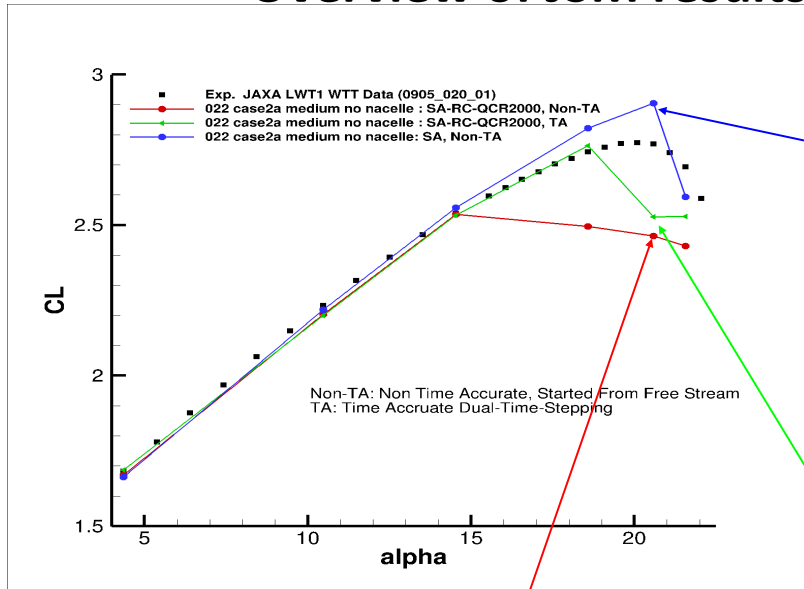
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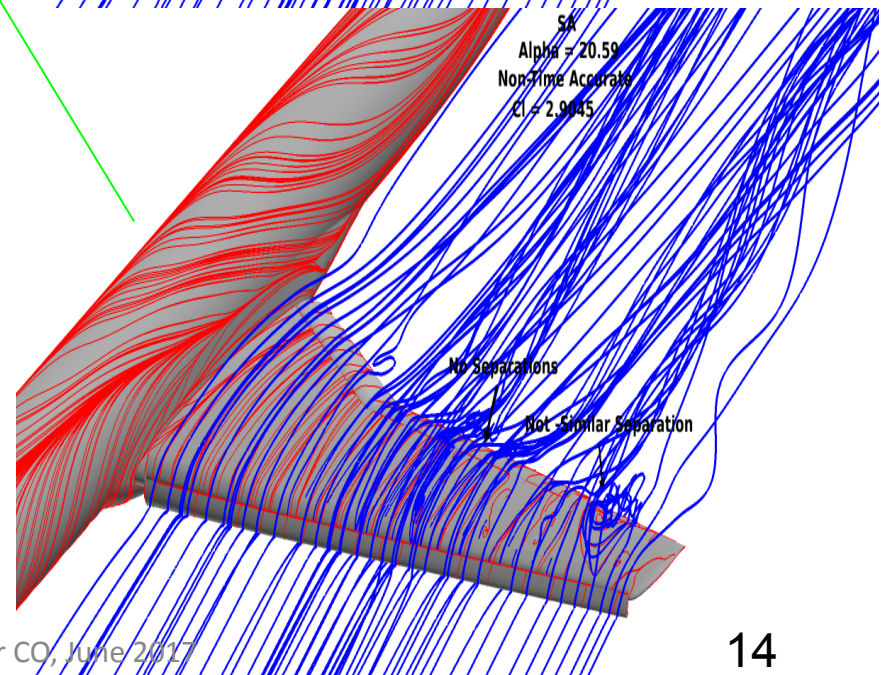
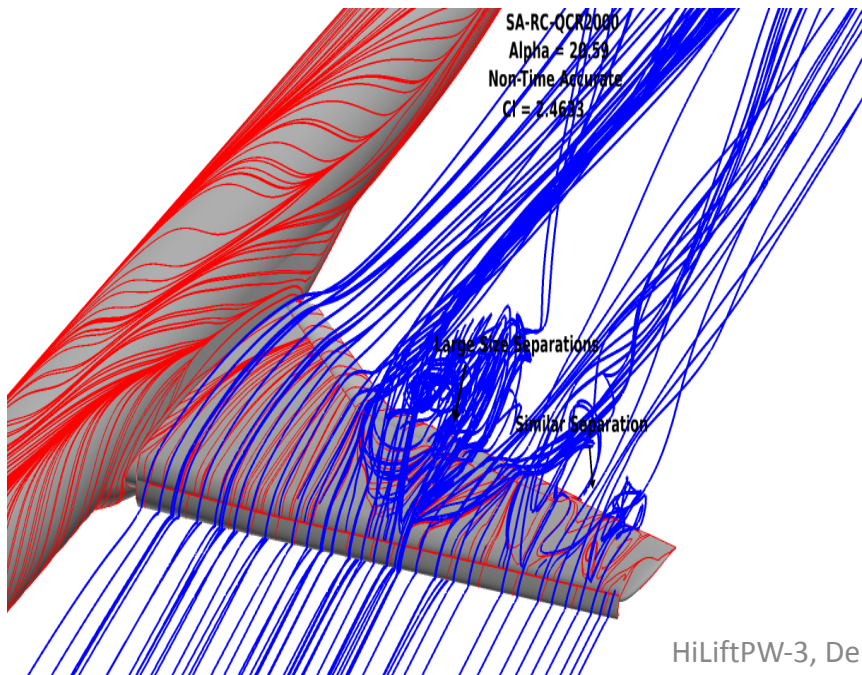
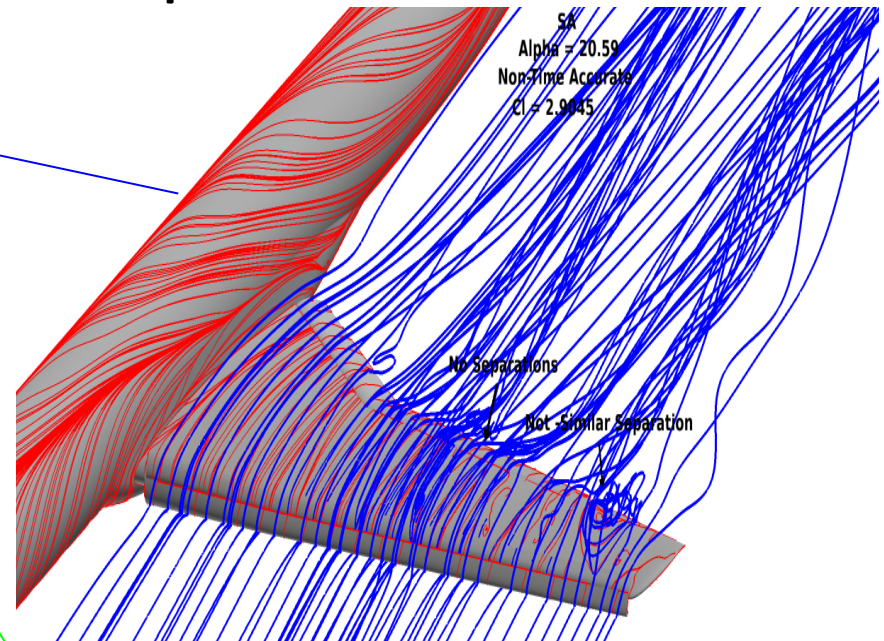
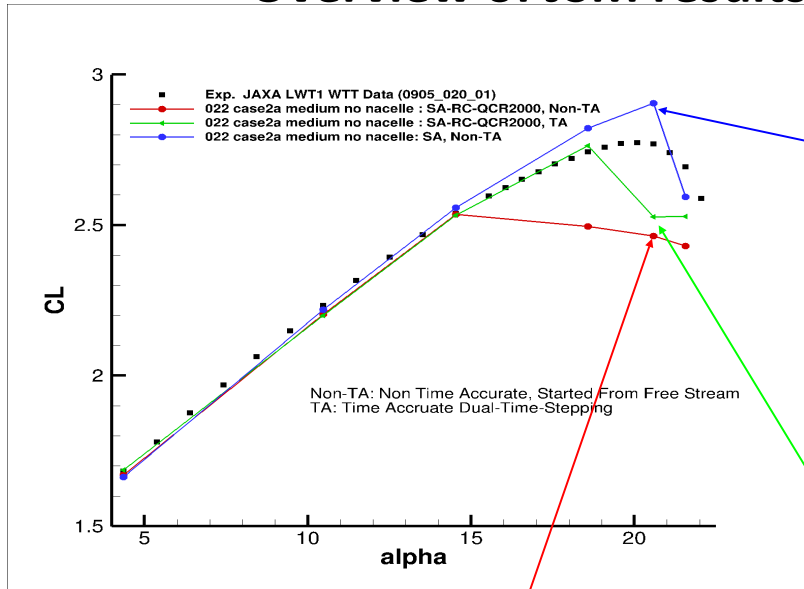
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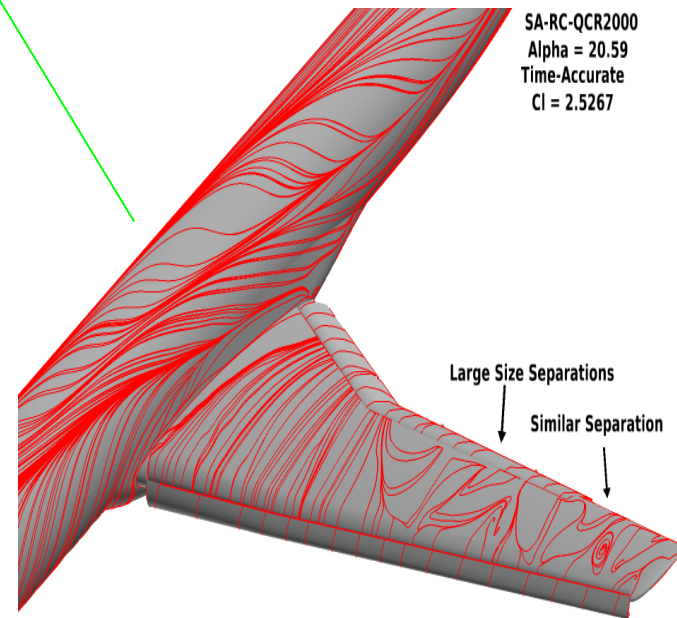
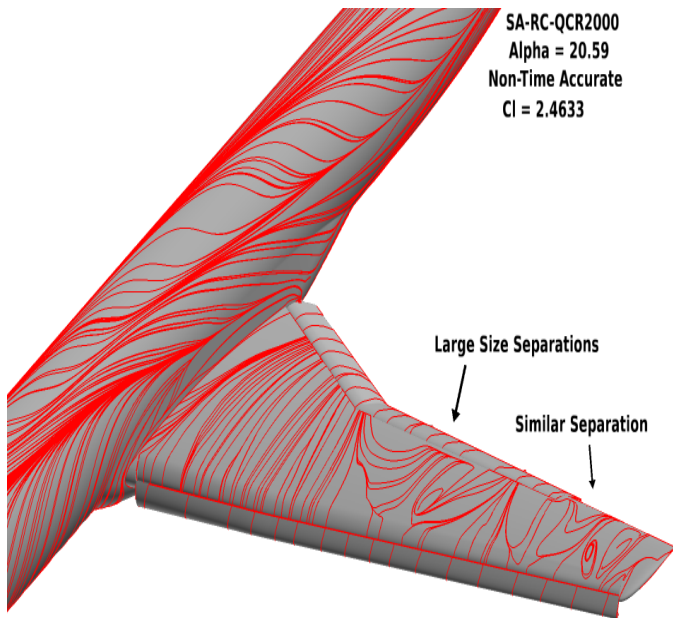
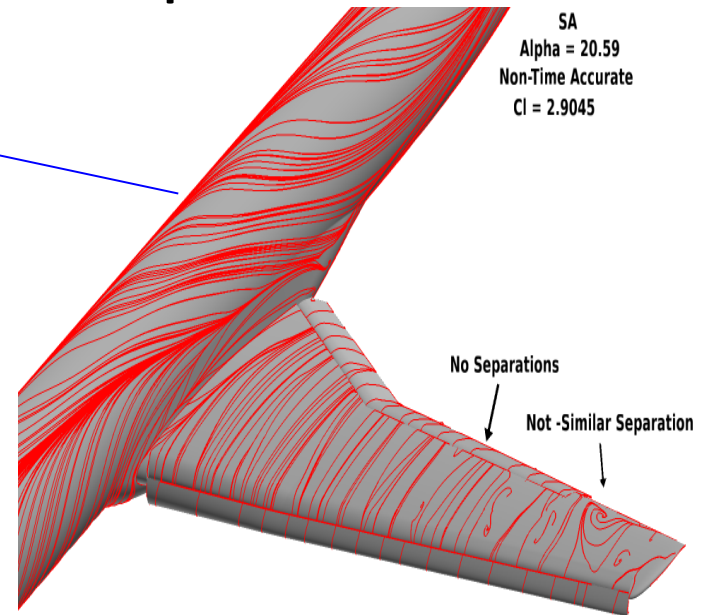
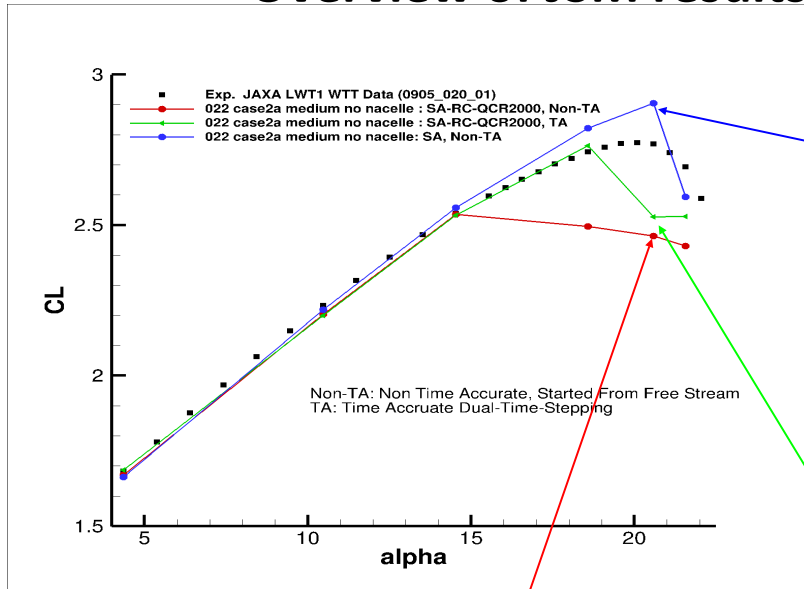
Overview of JSM results: Case2a: Alpha = 20.59



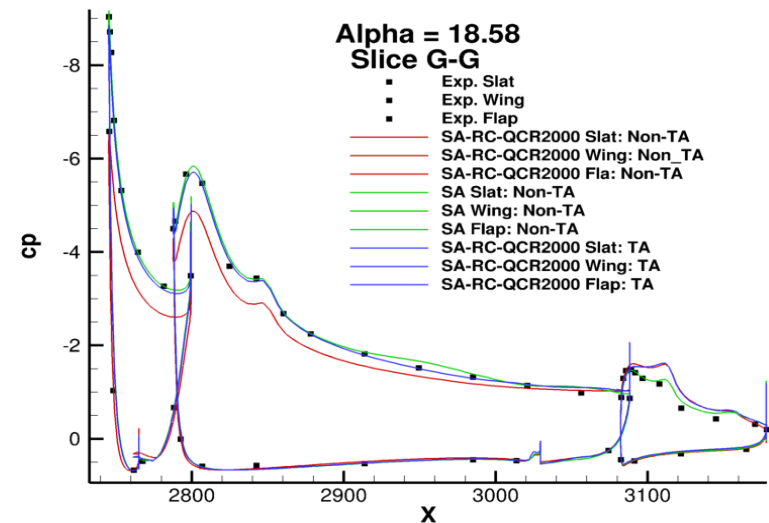
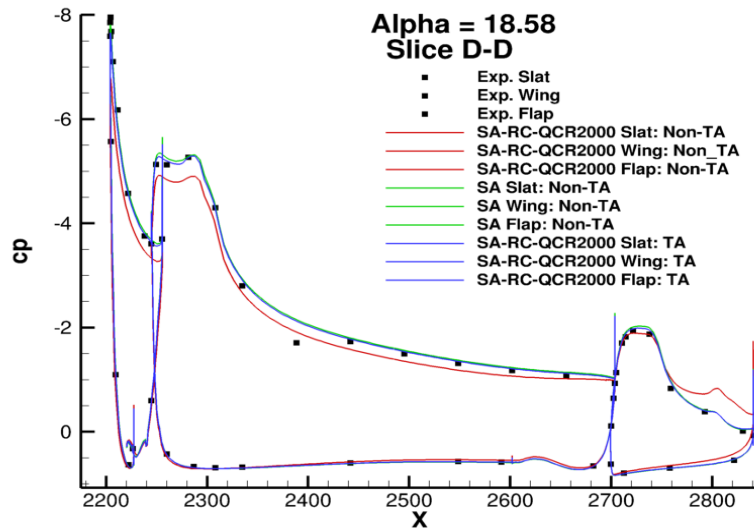
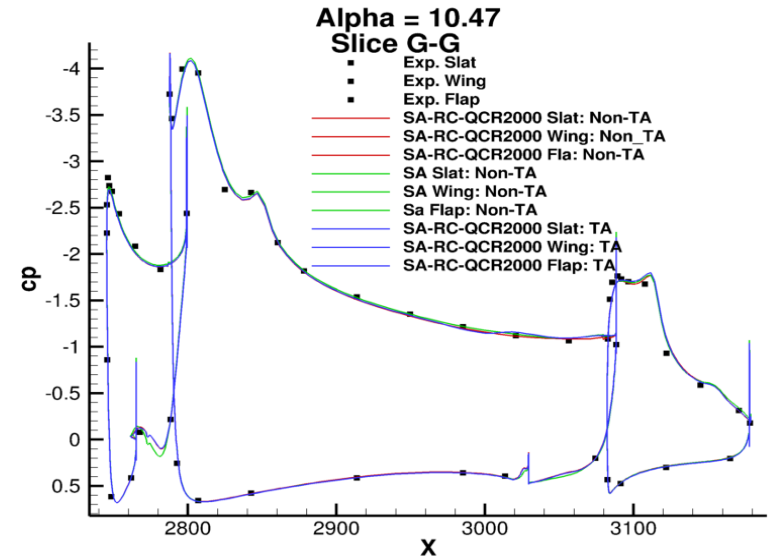
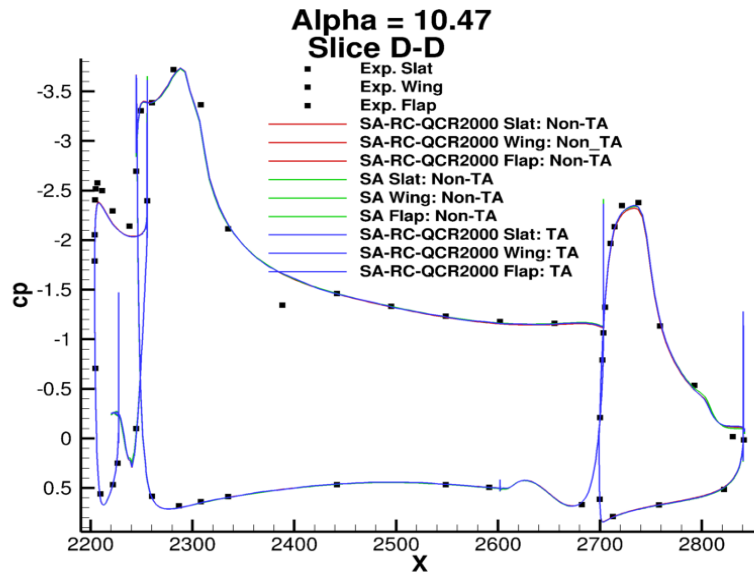
Overview of JSM results: Case2a: Alpha = 20.59



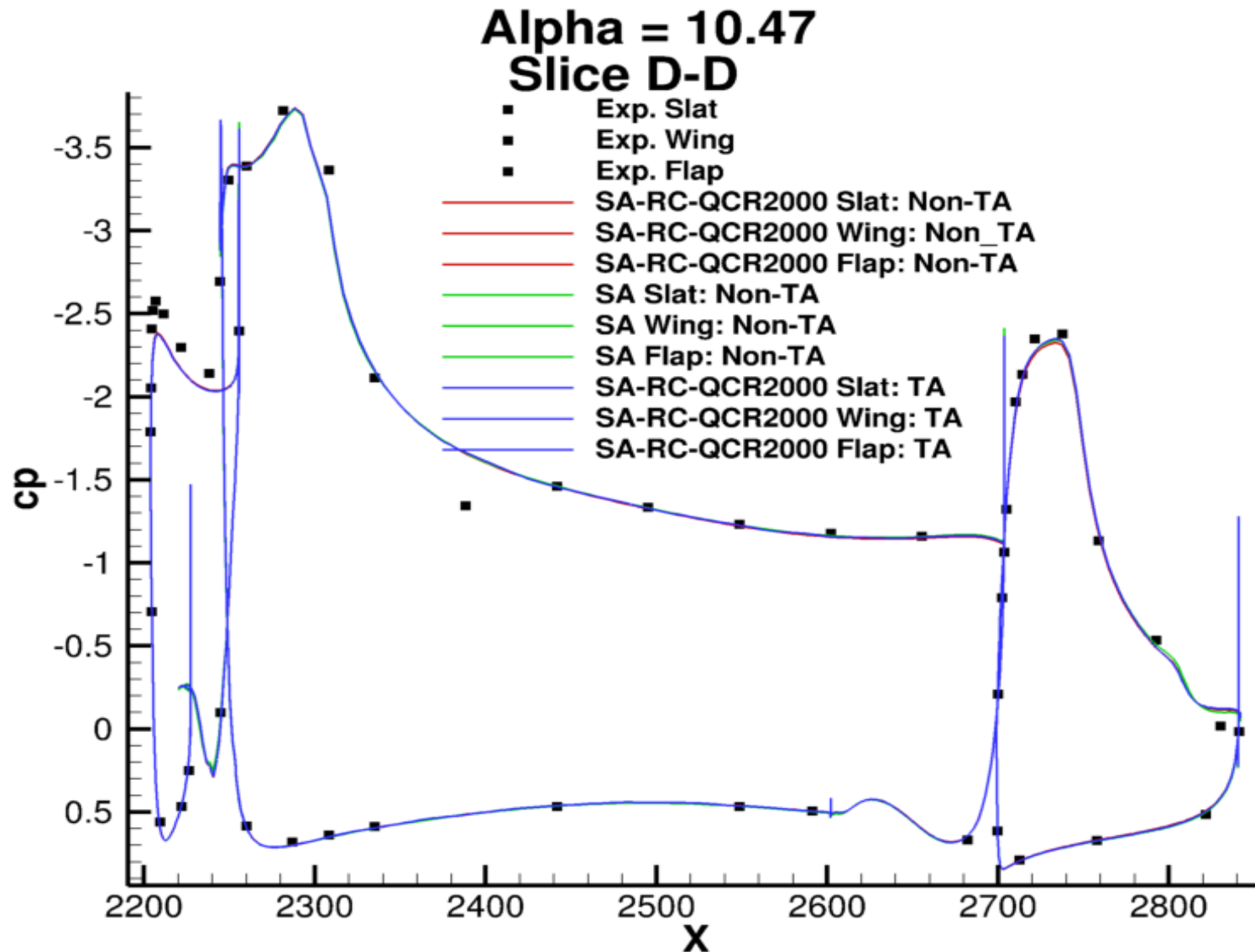
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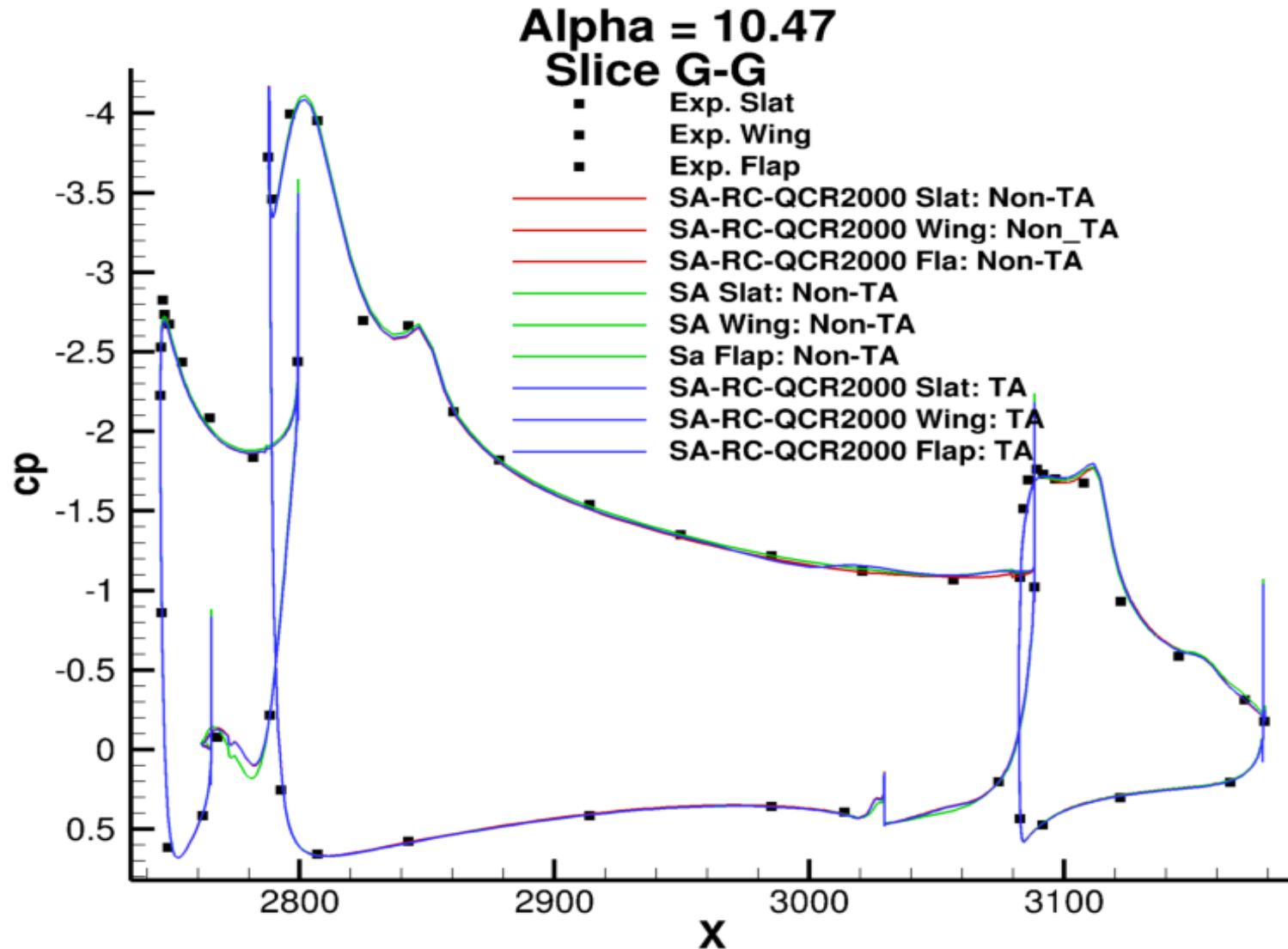
Overview of JSM results: Case2a



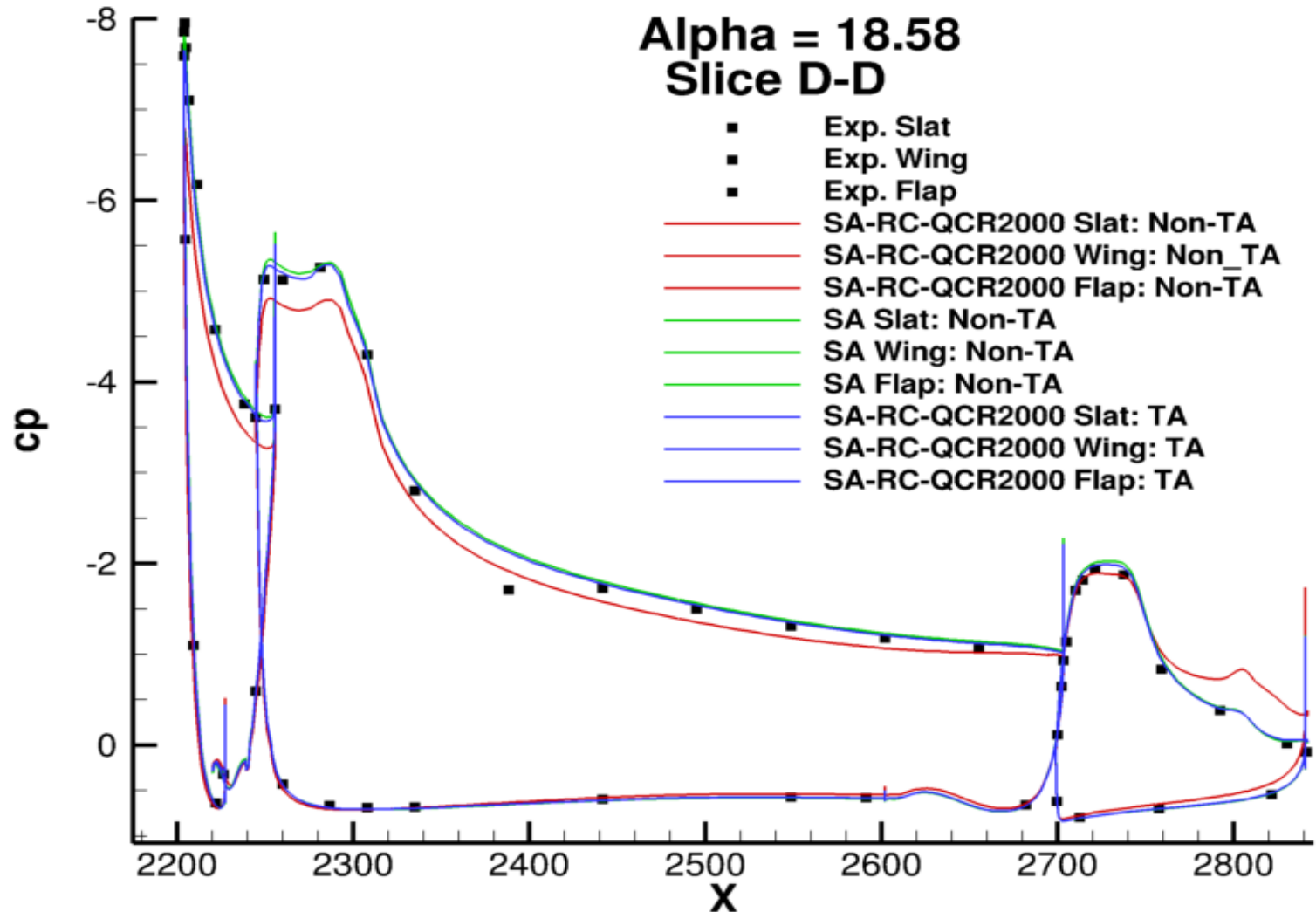
Overview of JSM results: Case2a



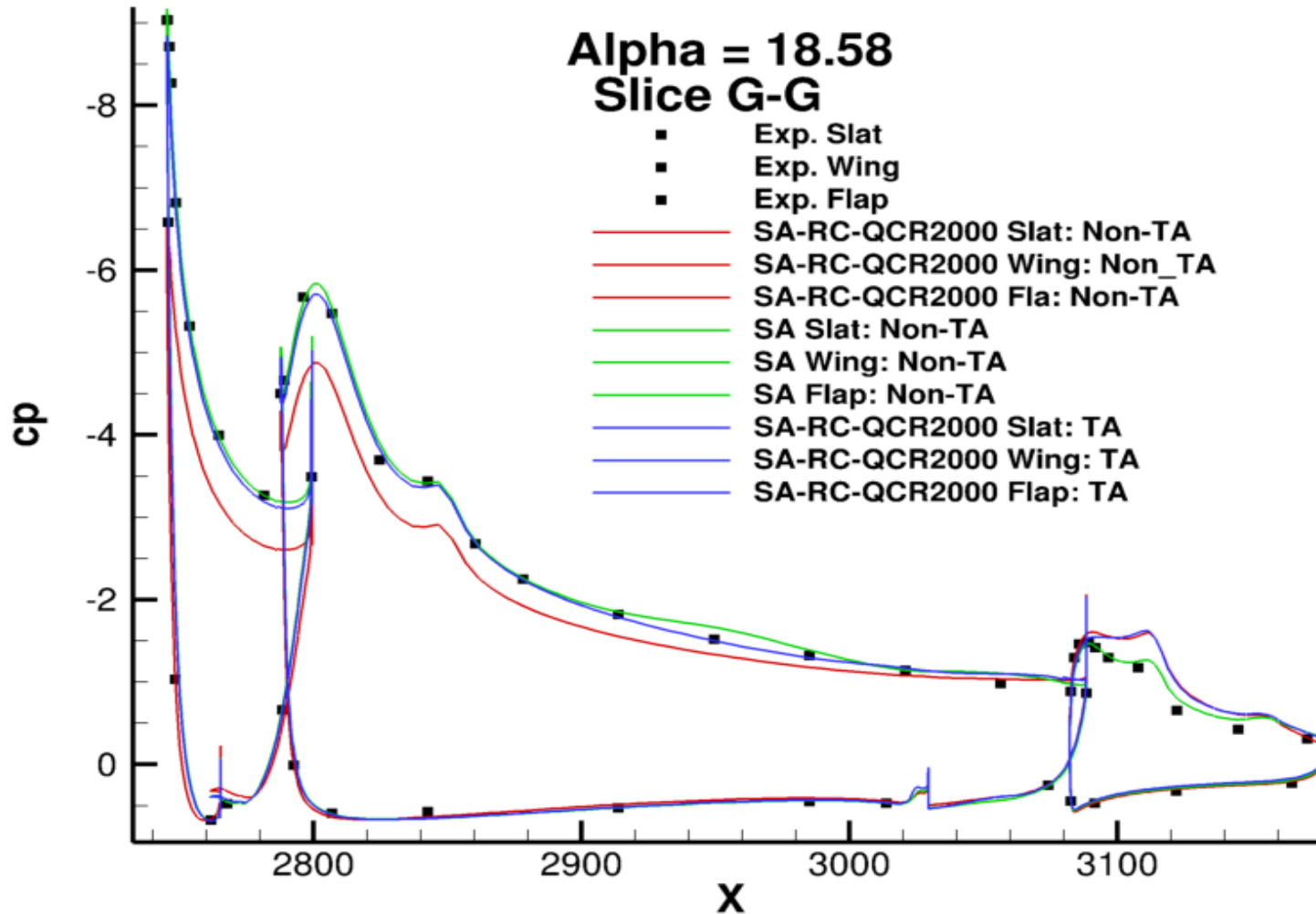
Overview of JSM results: Case2a



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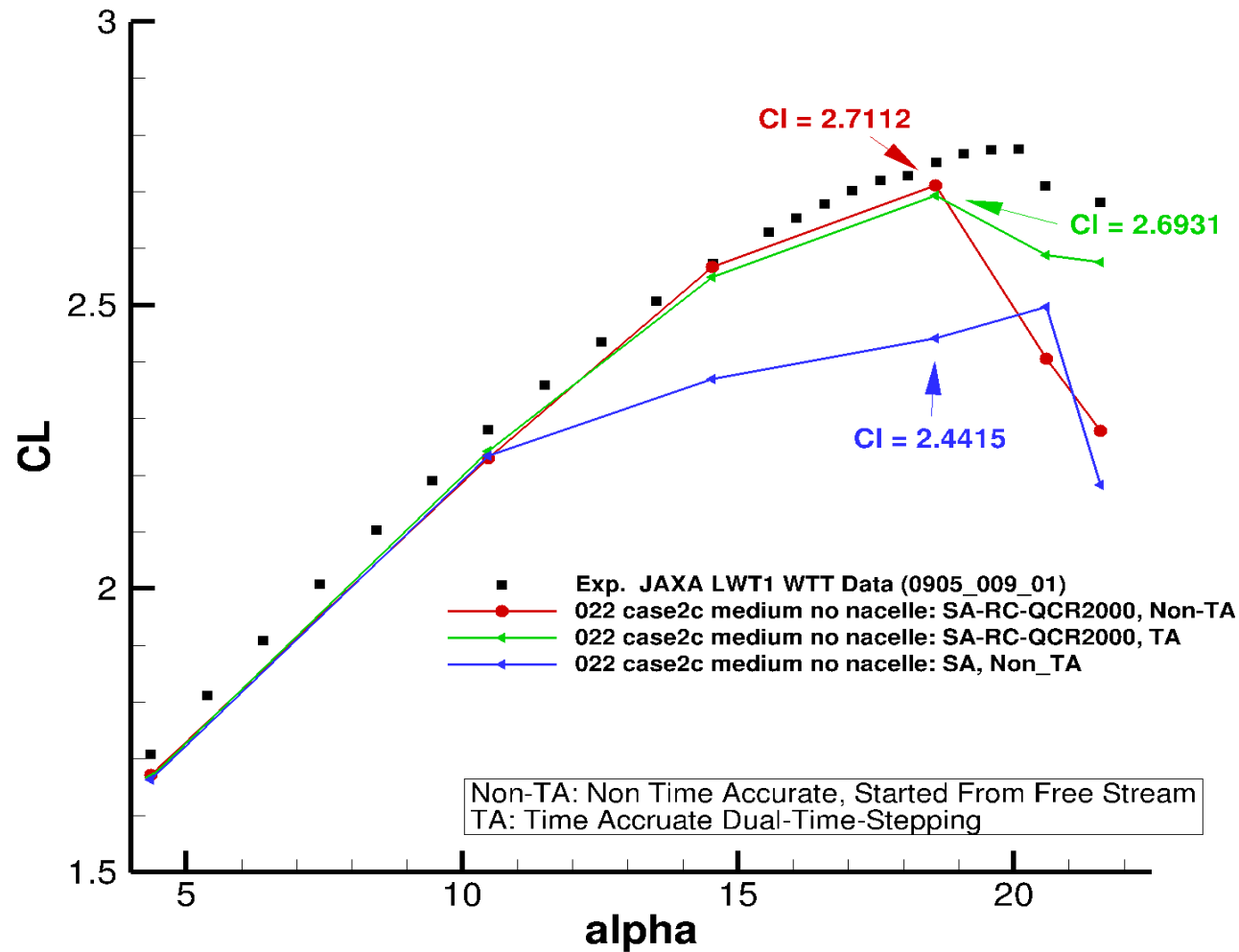


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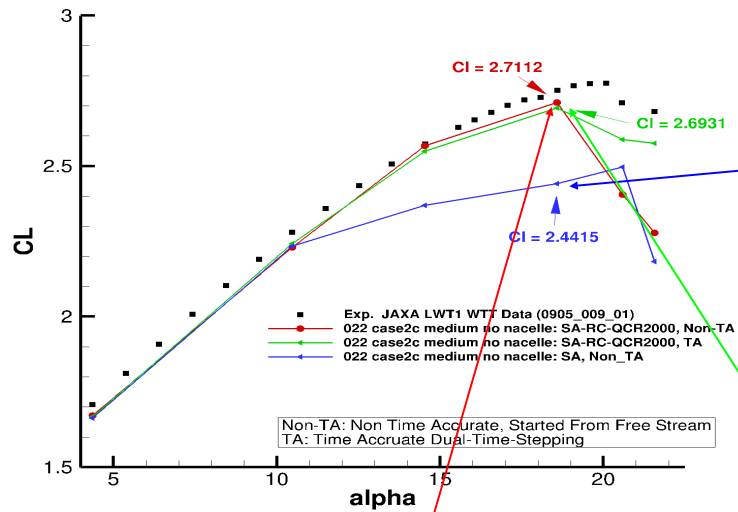


Overview of JSM results: Case2c

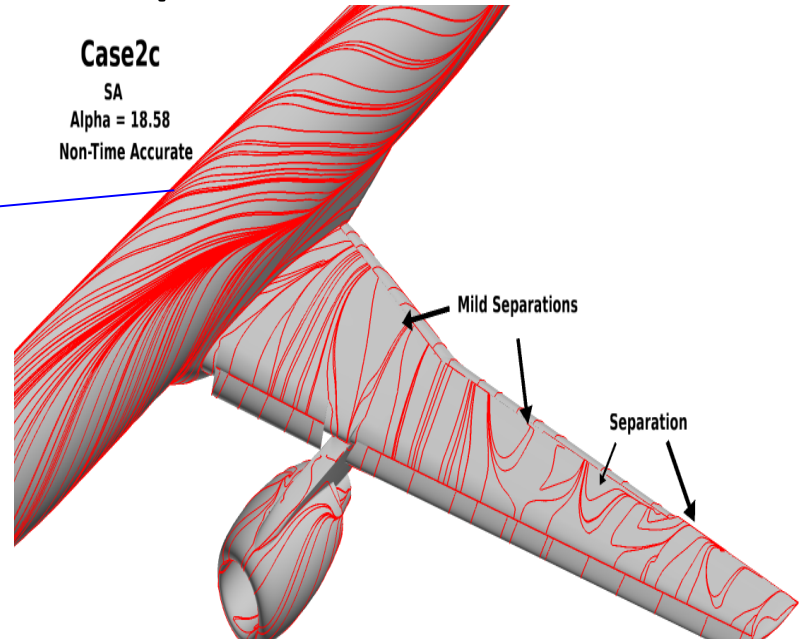
- Exp: Unstalled: Alpha 14.54-20.59
- SA-RC-QCR2000, Non-TA: Stalled Alpha > 18.58
- SA: Non-TA: Stalled: Alpha > 14.0



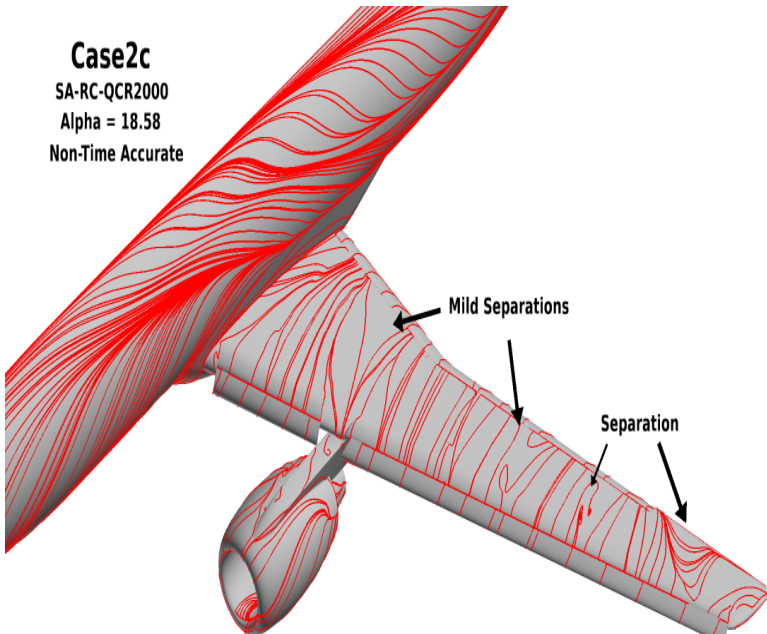
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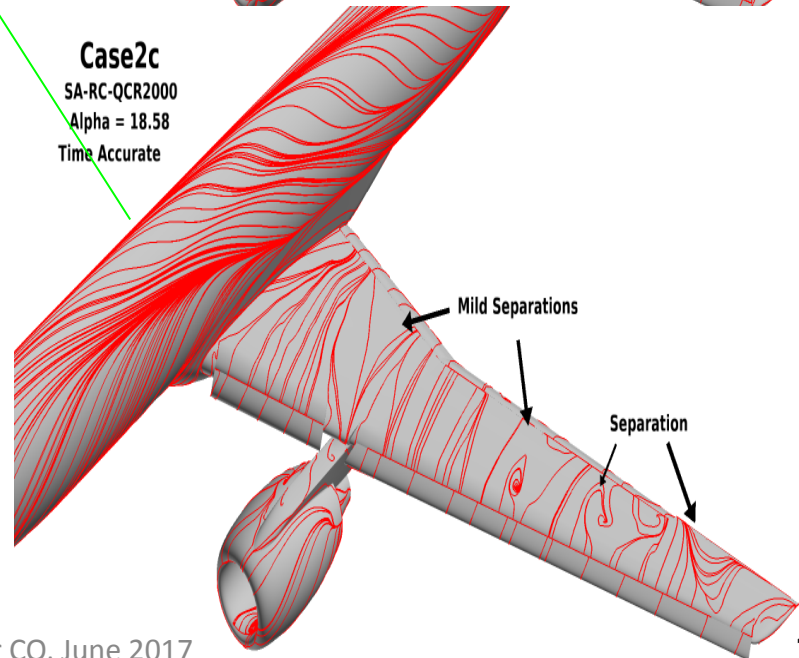
Case2c
SA
Alpha = 18.58
Non-Time Accurate



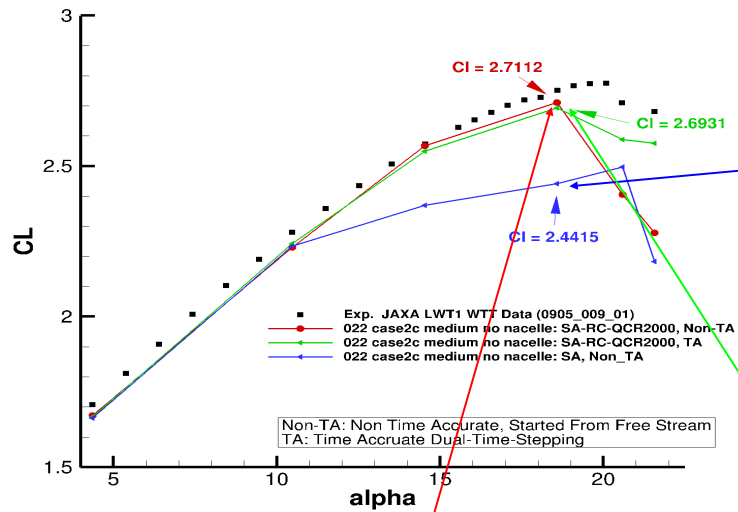
Case2c
SA-RC-QCR2000
Alpha = 18.58
Non-Time Accurate



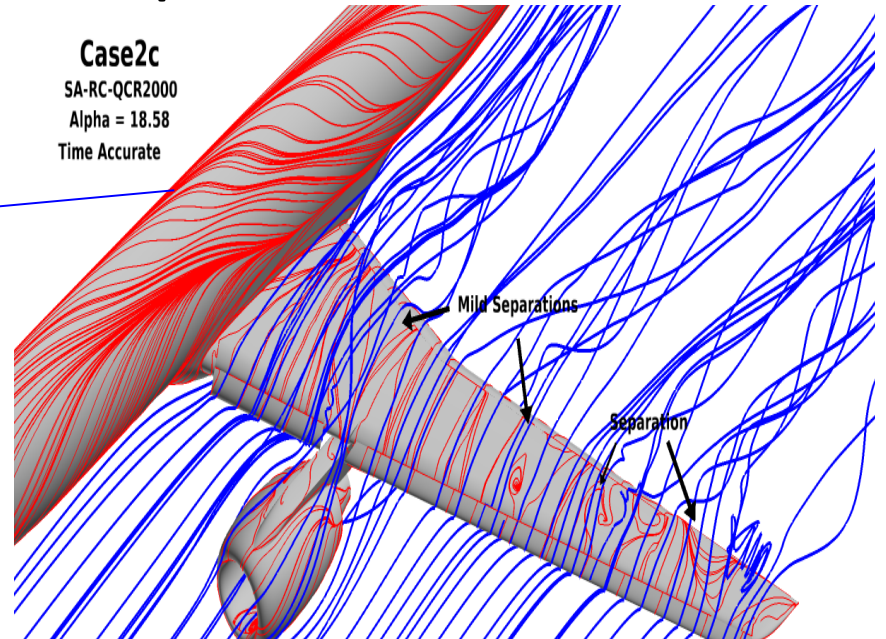
Case2c
SA-RC-QCR2000
Alpha = 18.58
Time Accurate



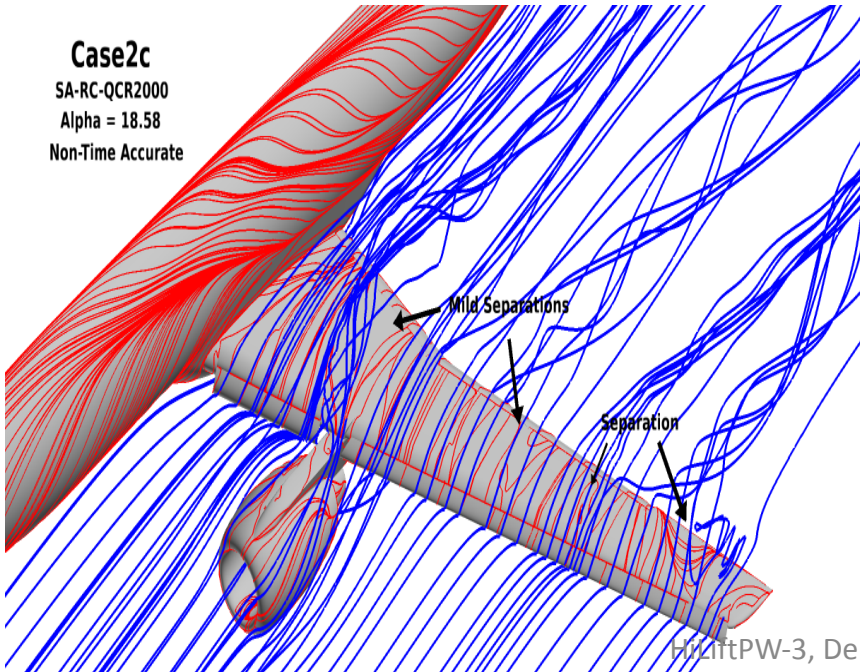
Overview of JSM results: Case2c: Alpha = 18.58



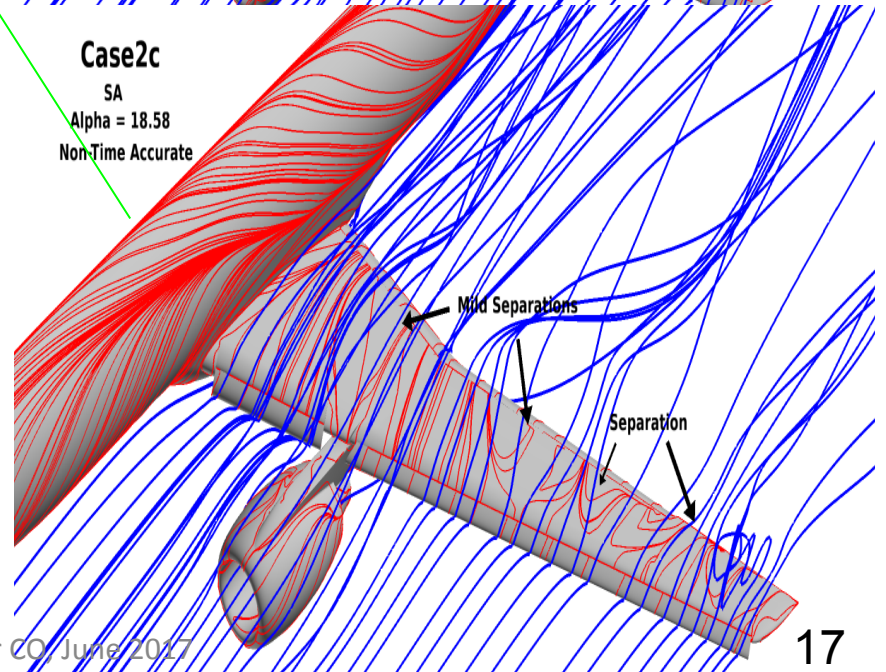
Case2c
SA-RC-QCR2000
Alpha = 18.58
Time Accurate



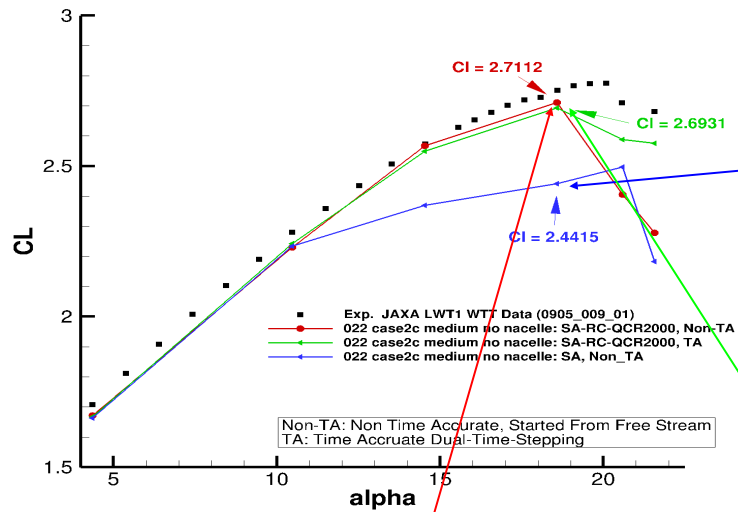
Case2c
SA-RC-QCR2000
Alpha = 18.58
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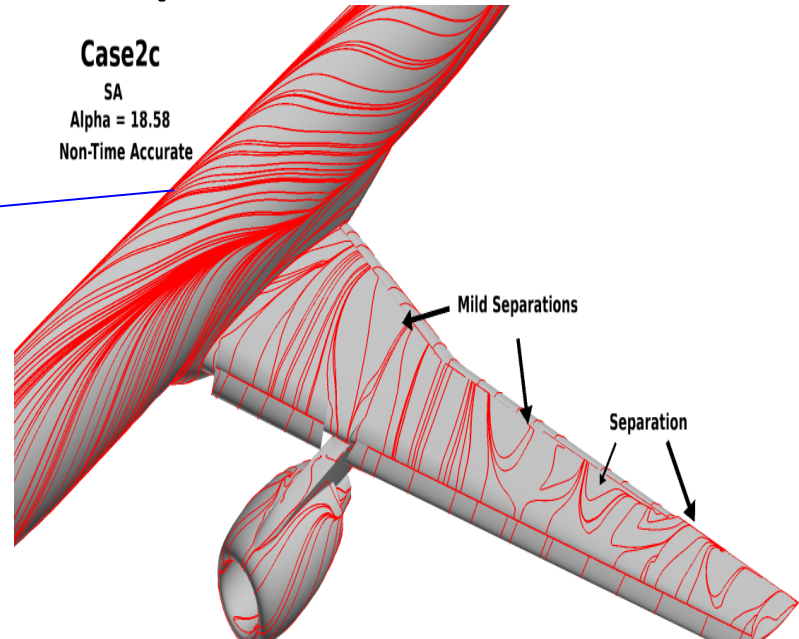
Case2c
SA
Alpha = 18.58
Non-Time Accurate



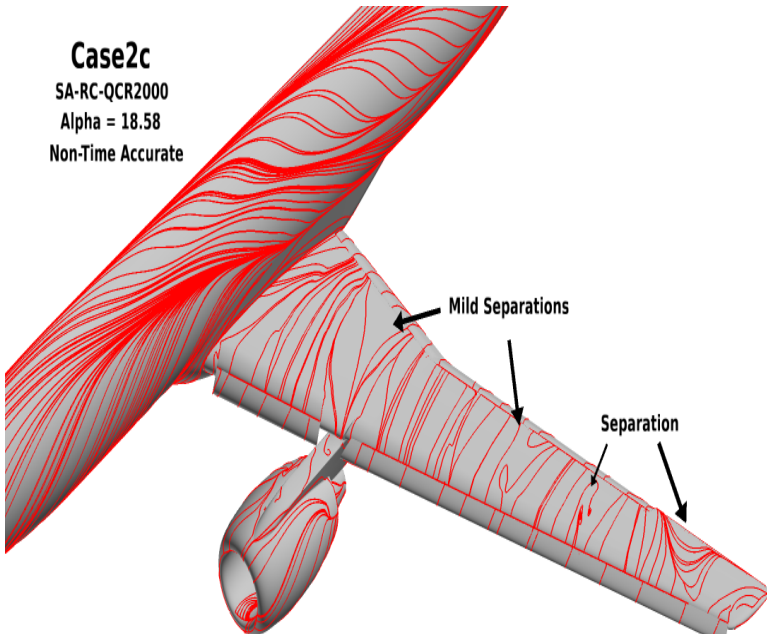
Overview of JSM results: Case2c: Alpha = 18.58



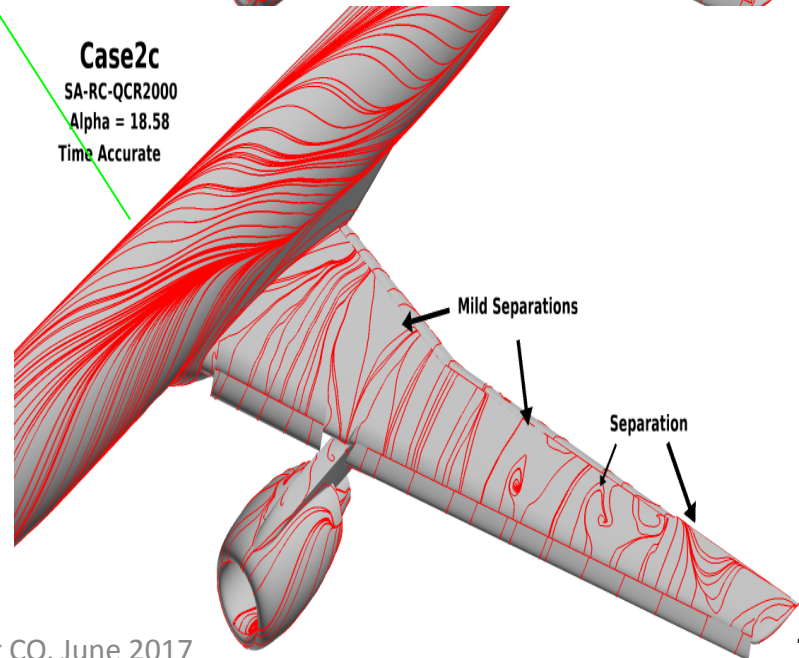
Case2c
SA
Alpha = 18.58
Non-Time Accurate



Case2c
SA-RC-QCR2000
Alpha = 18.58
Non-Time Accurate



Case2c
SA-RC-QCR2000
Alpha = 18.58
Time Accurate



Summary

- Geometry Makes A Difference!
 - Smoothness of Underlying CAD, Triangularizations is Critical to get Good CFD Grids and Results
- Turbulence Model + Turbulence Model Mods (RC, QCR2000)
 - Case3: Need to Include Verification of Turbulence Model Mods
 - Significant Affects On Separations, Loads And Stall
 - SA-RC-QCR2000 Seems to Be Most Reliable Form
- Stall Boundaries are Still Difficult
 - Some Cases Needed to Be Restarted From Lower Alpha's
 - Time-Accurate Integration May be Required to Eliminate Startup Issues, especially at stall.
 - Transition Modeling Still an Unknown.

Thank You

NASA's Transformational Tools and Technologies
(T³)

NASA Pleiades Supercomputer for the CPU's



Questions?