HOKKAIDO UNIVERSITY

Aerodynamics Prediction challenge（APC-III）

FaSTAR/RG-FaSTARによる空力予測：RANS, LES/RANS hybridを用いた解析結果

Aerodynamics prediction using RANS and LES/RANS hybrid in RG-FaSTAR

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Summary for our simulation

- RG-FaSTAR
- HexaGrid provided by JAXA
- Turbulence models: SST-2003 and SS/SST-2003 Hybrid

- Case 1
- AoA for SST-2003: -1.79, -0.62, 0.32, 1.39, 2.47, 2.94, 3.55, 4.65, 5.72
- AoA for Hybrid: -1.79, -0.62, 0.32, 1.39, 2.47, 2.94, 3.55, 4.65, 5.72

Numerical Methods

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Code	RG-FaSTAR (version2.1.0)
Governing Equations	The compressible Navier-Stokes equations Calorically perfect gas
Discretization	Cell-centered finite volume method
Numerical flux	Convection term: SLAU Slope limiter for MUSCL: minmod Viscous term: 2nd order central difference scheme
Time integration	LU-SGS (inner loop: 5 times) Global (delta t fixed)/Local time stepping
Turbulence model	RANS (SST-2003) LES/RANS Hybrid (SS and SST-2003)

Conditions

Reference length (MAC length) : 1.0 m
Reference area : 3.90926 m^2

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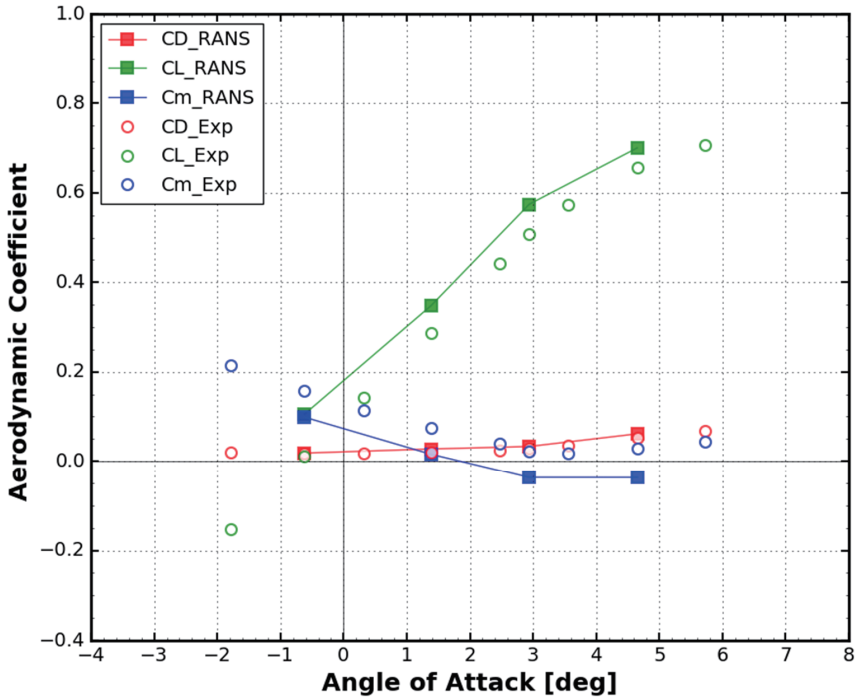
Inflow conditions							
Mach number	**0.847**						
Reynolds number	**2.26E+06**						
Velocity, m/s	2.86963E+02						
Density, kg/m3	1.39334E-01						
Temperature, K	2.840E+02						
Viscosity, Pa･s	1.76920E-05						
Pressure, Pa	1.14240E+04						
Angle of Attack (AoA)	**-0.62**		**1.39**	**2.49**		**4.56**	
Delta t, sec	**5E-5**	**5E-6**	**5E-5**	**5E-5**	**5E-6**	**5E-6**	**5E-6**
Turbulence model	**SST**	**Hybrid**	**SST**	**SST**	**Hybrid**	**SST**	**Hybrid**
Grid	medium	medium	medium	medium	medium	medium	medium

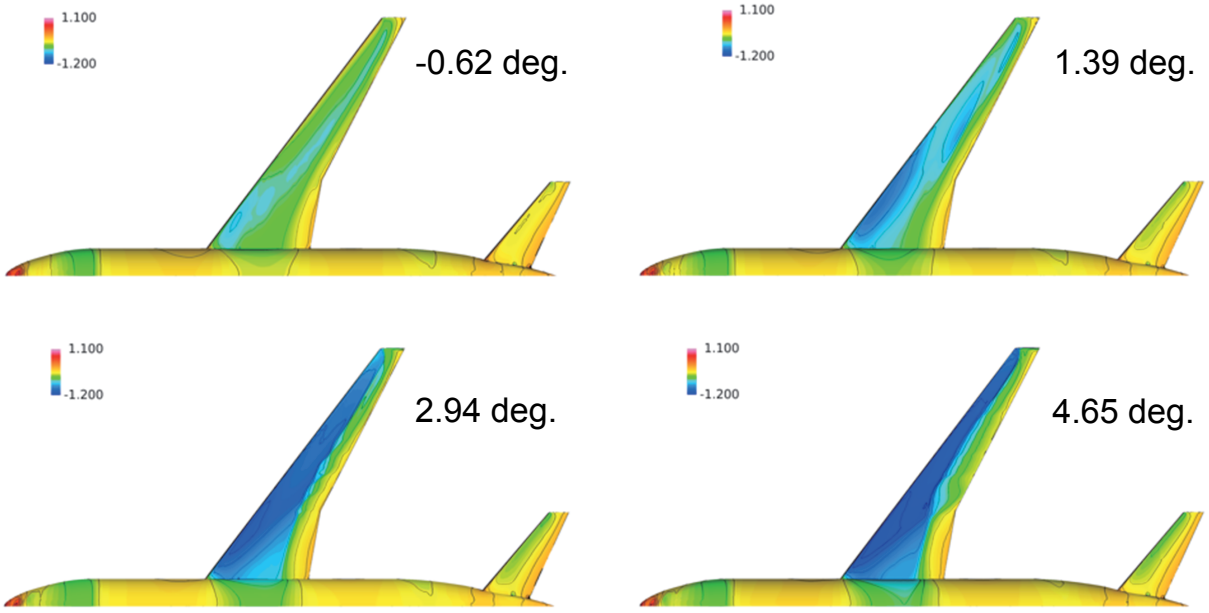
No-slip, no-pressure gradient, adiabatic wall condition

5 Comparison between SST and Experimental data



6 Effects of AoA on pressure coefficient distributions

SST-2003; Upper surface



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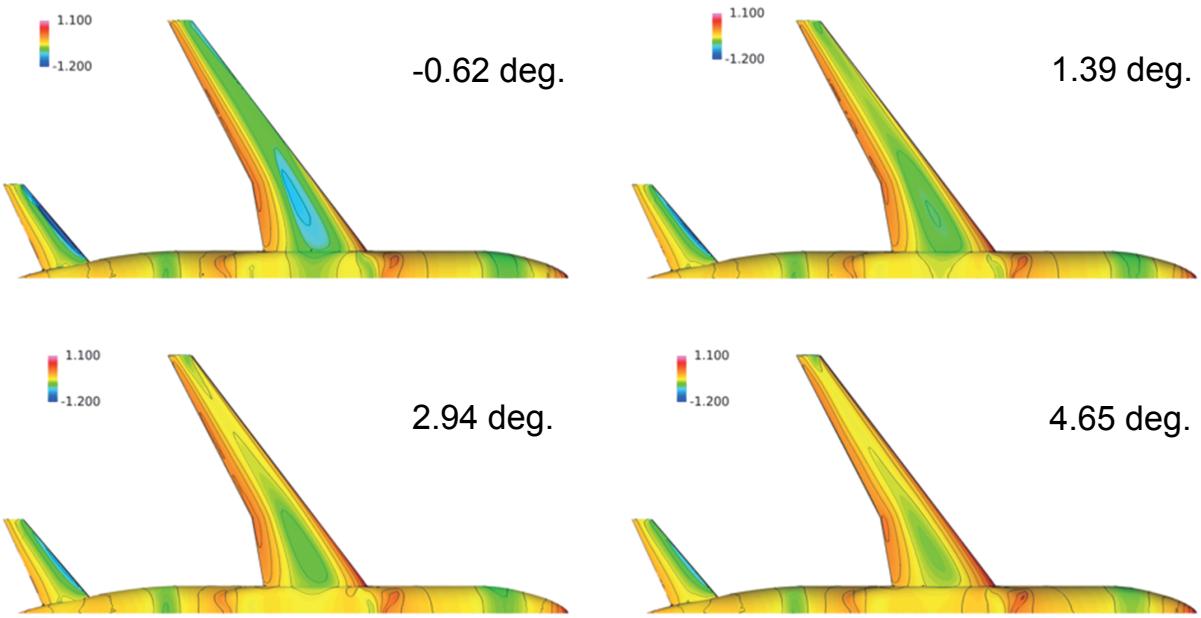
Effects of AoA on pressure coefficient distributions

SST-2003; Lower surface



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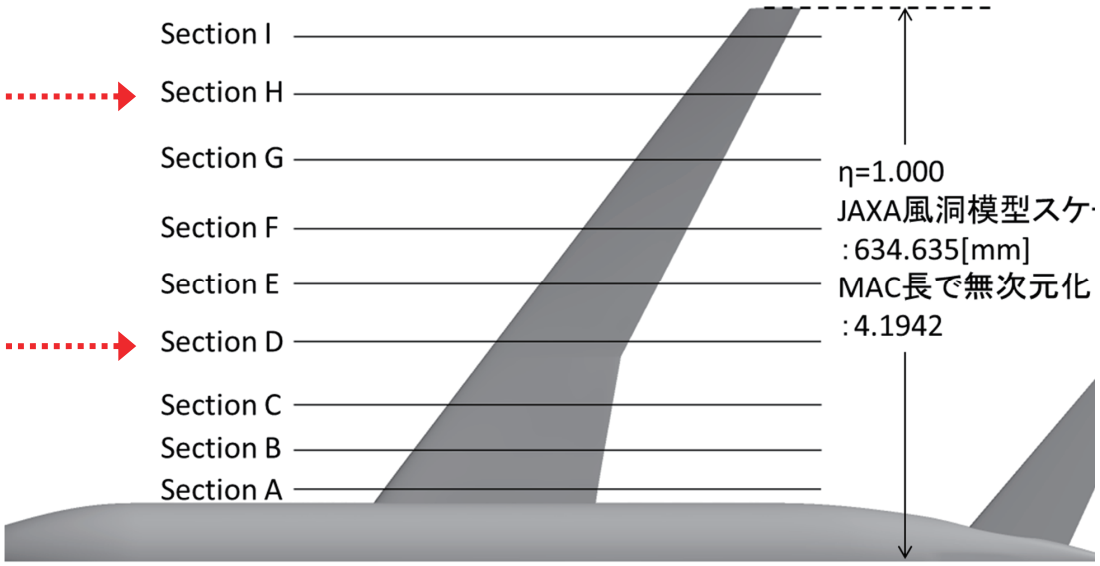

Effects of AoA on flow fields

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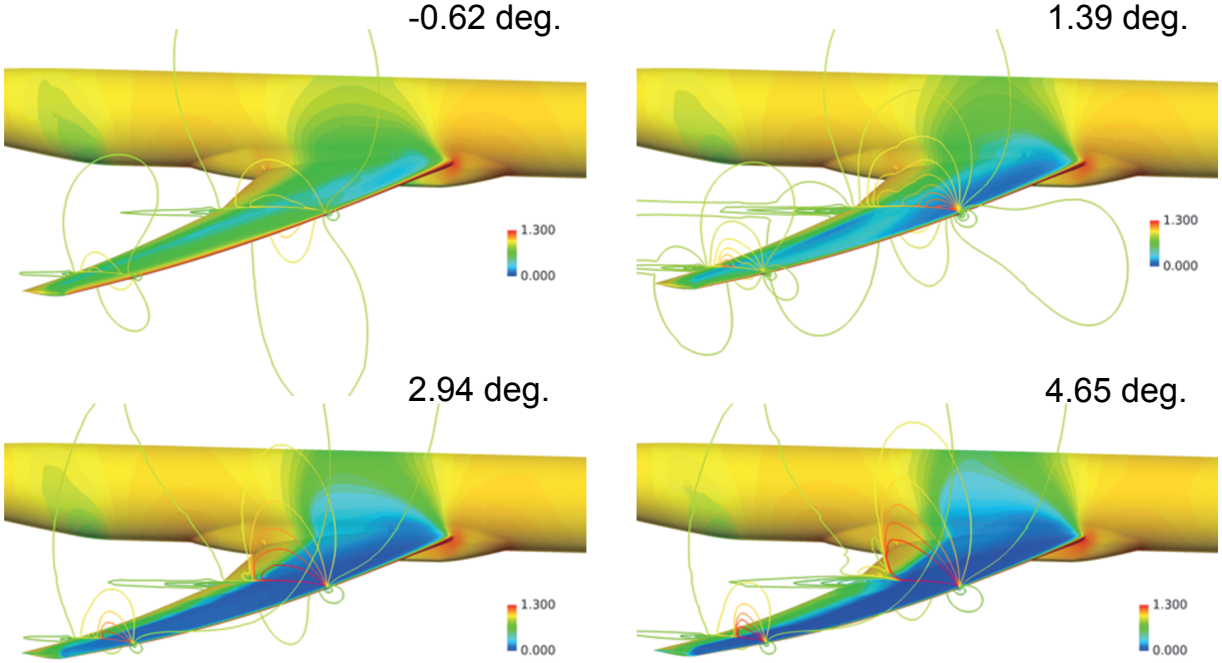
Pressure on the surface
Mach number for two sections

SST-2003



Comparison between SST and Experimental data

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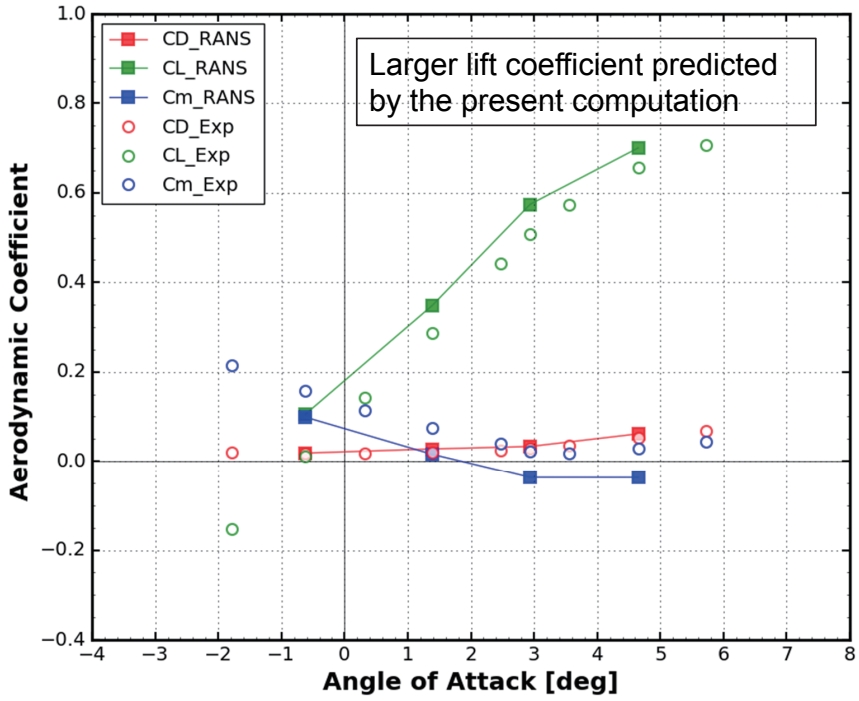

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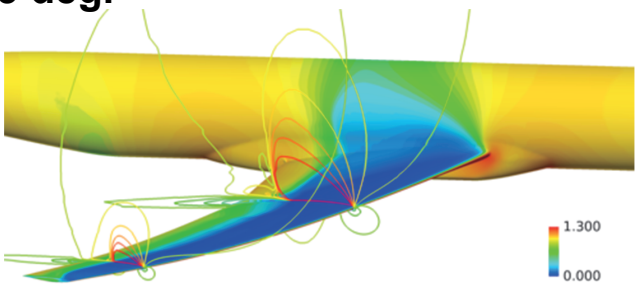
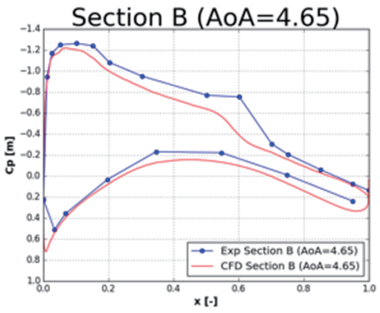
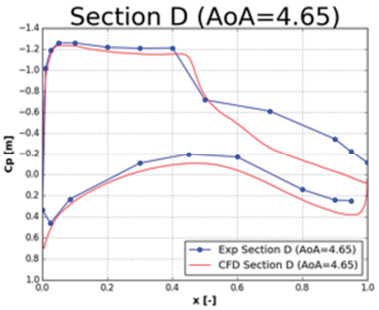
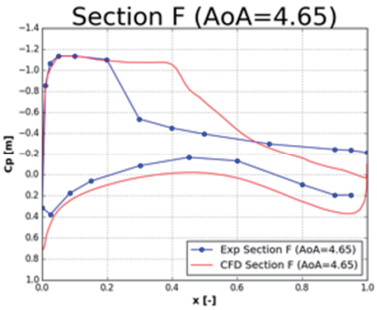
Pressure coefficients (A-F), SST-2003

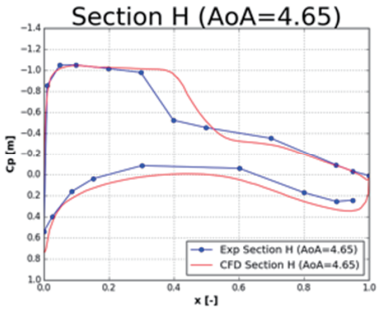
4.65 deg.











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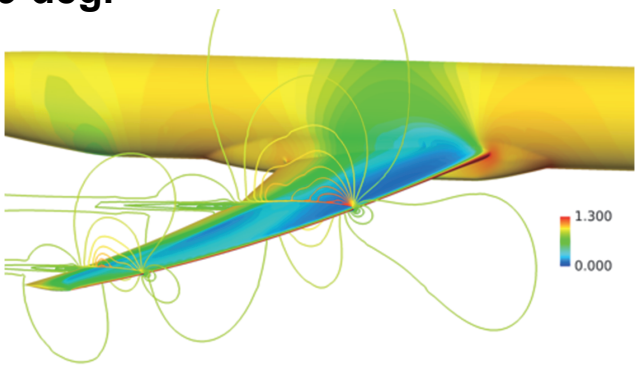
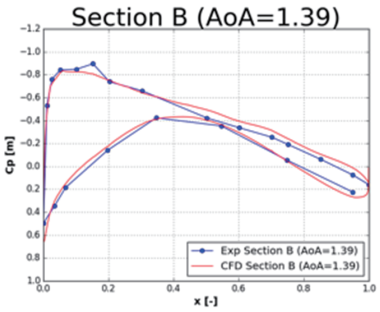
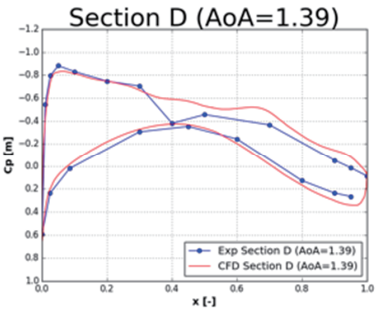
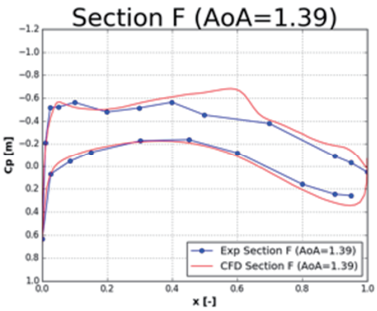
Pressure coefficients (A-F), SST-2003

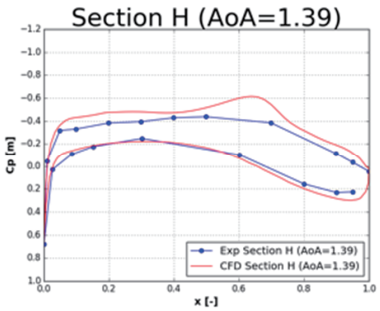
1.39 deg.



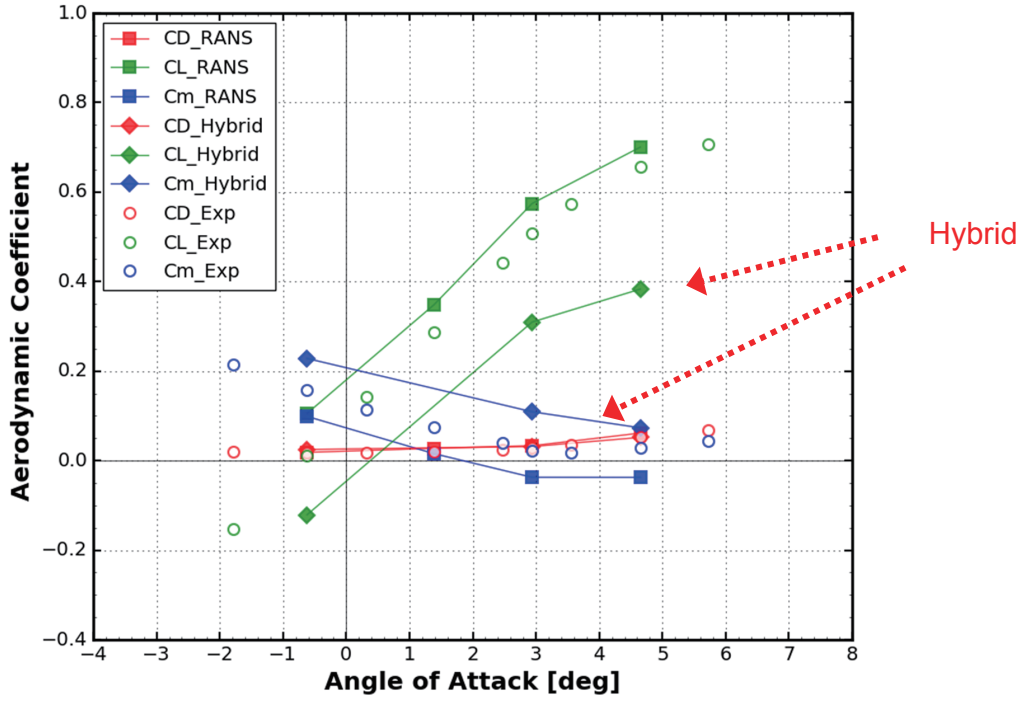








13 Comparison among SST, Hybrid, Experimental data

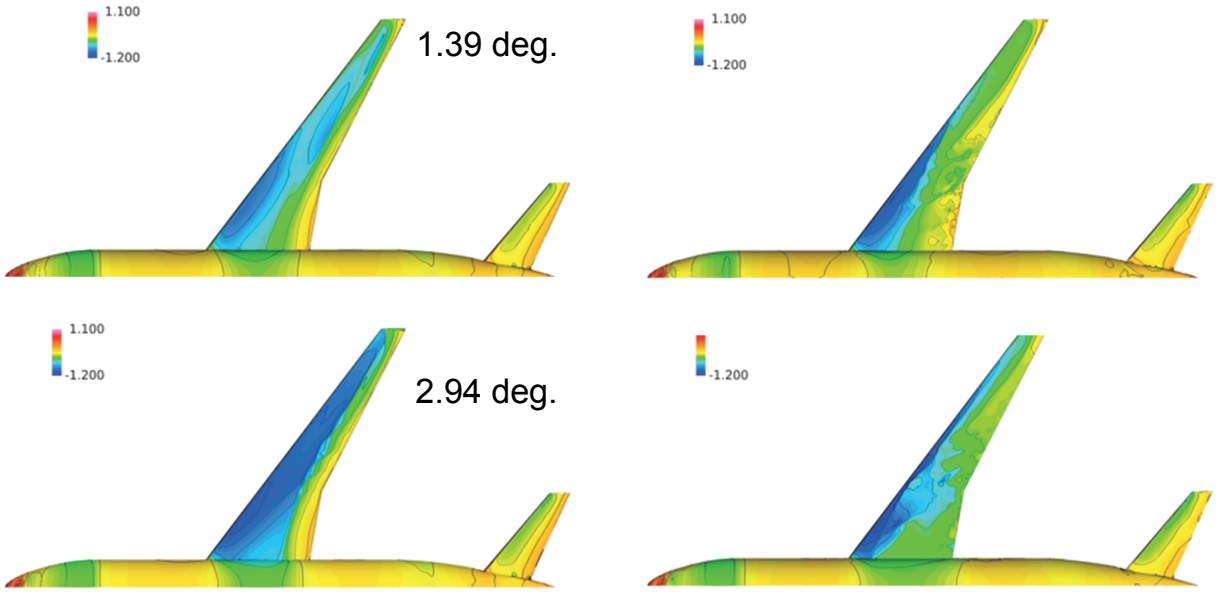


14 Comparison between SST and SS/SST Hybrid

Upper surface

SST-2003

Hybrid



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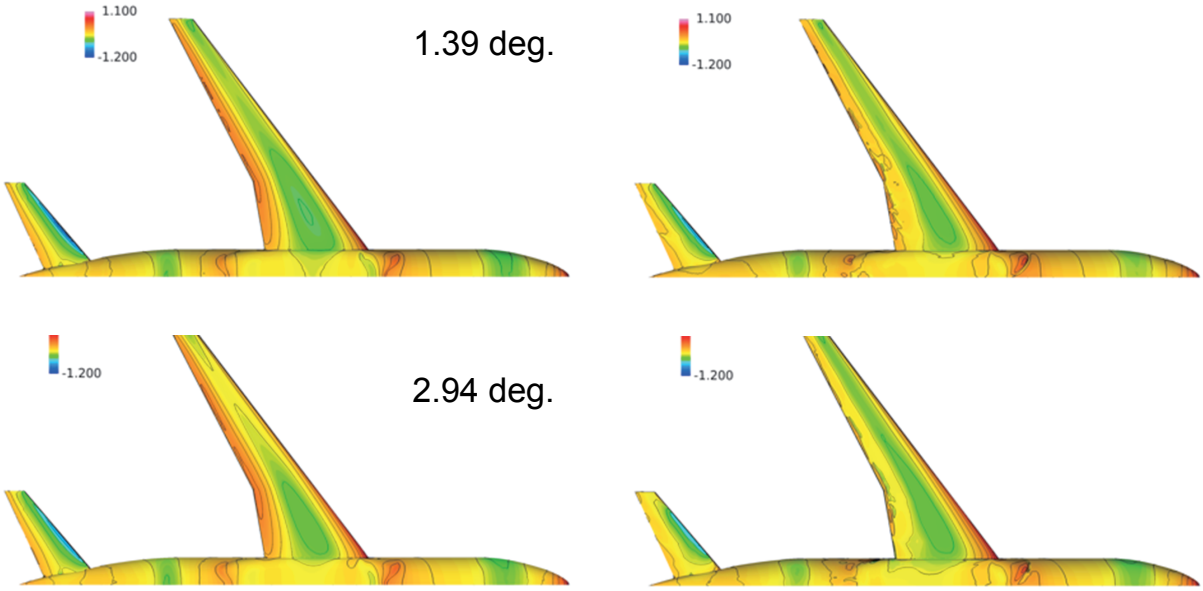
Comparison between SST and SS/SST Hybrid

Lower surface

SST-2003

Hybrid



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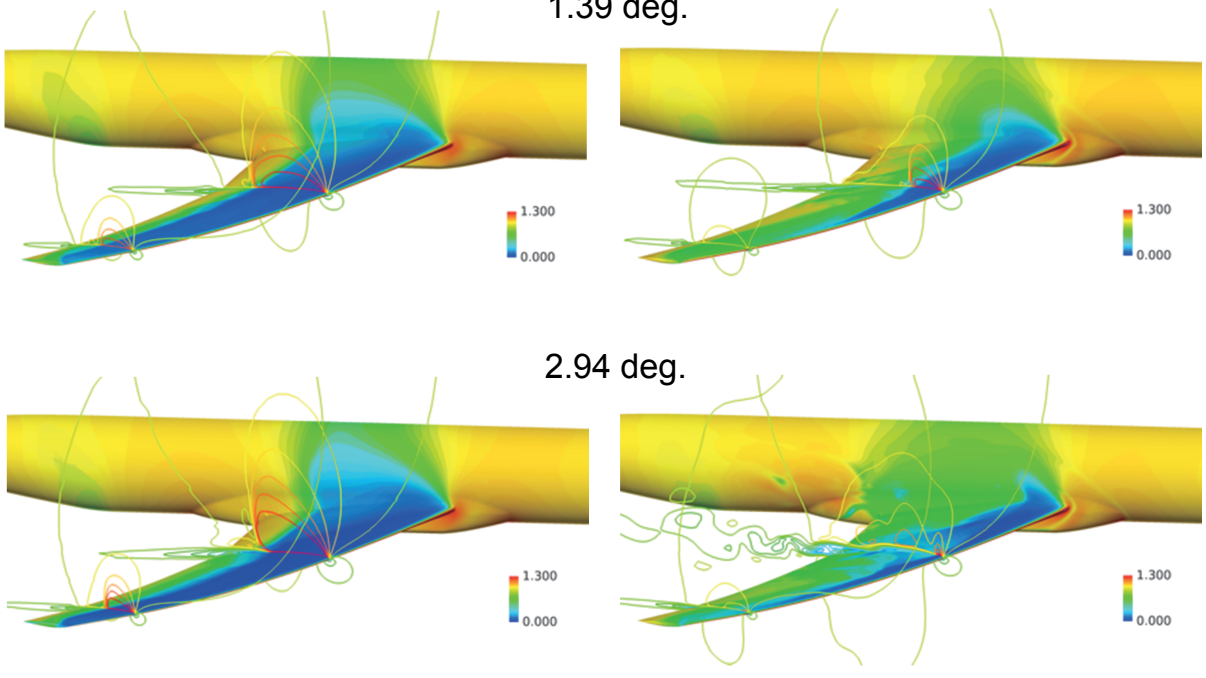
Comparison between SST and SS/SST Hybrid

SST-2003

1.39 deg.

Hybrid



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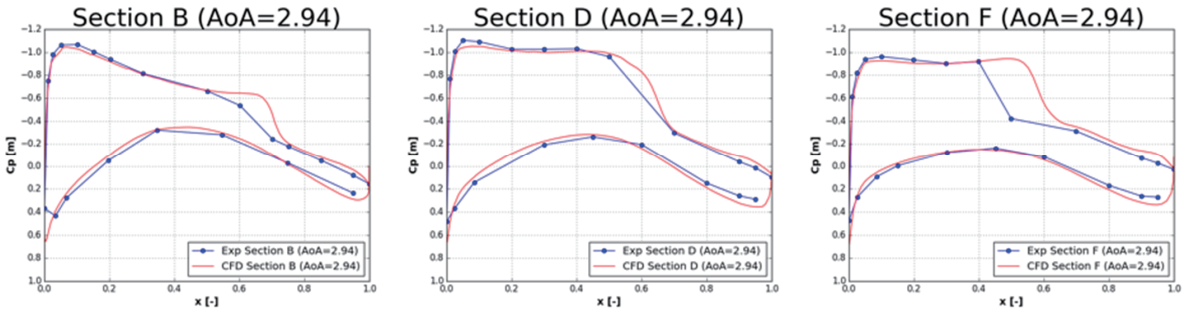
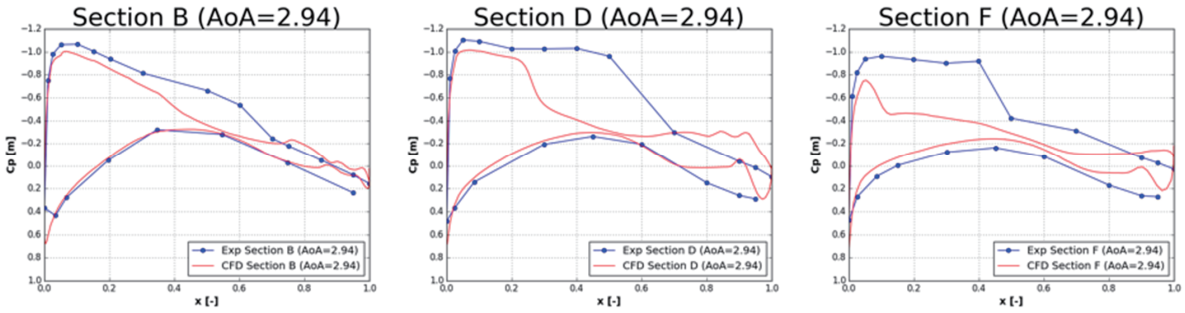
Comparison between SST and SS/SST Hybrid

SST-2003

Pressure coefficient profiles at **2.94 deg.**



Hybrid



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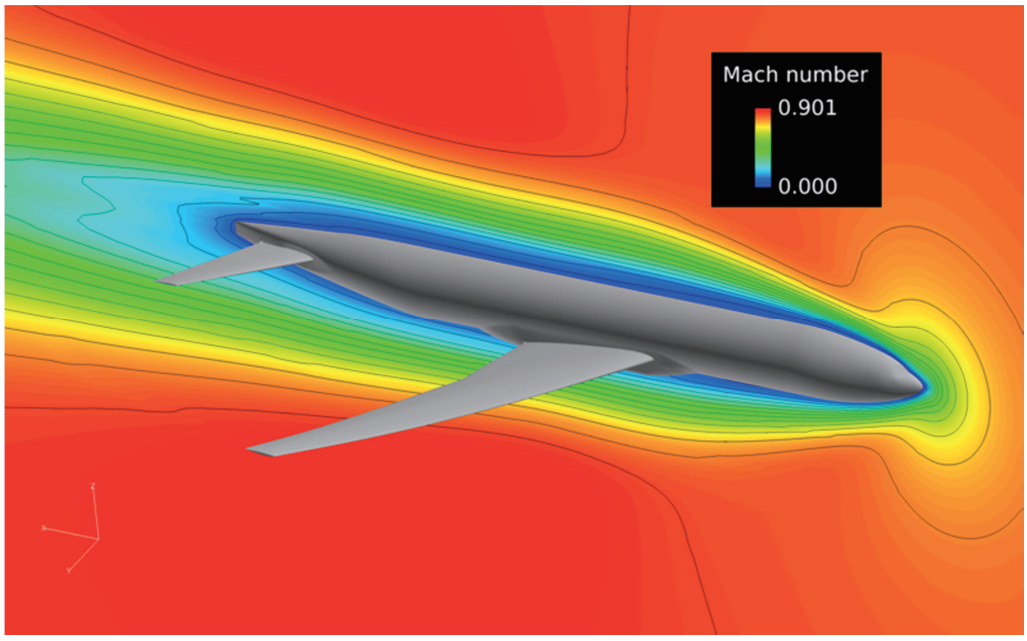
Local time step



Conclusions

- SST-2003 can predict well the aerodynamic forces of NASA-CRM configuration
- The position of the shock wave on the upper surface is different from that in the experimental data at high angle of attack, resulting in larger lift coefficients, thus moment coefficients (stronger pitch-down)
- The local time stepping in RG-FaSTAR did not work
- The present SS/SST-2003 hybrid provides poor results, maybe due to the insufficient grid resolution used in the present computation