SIEMENS
Ingenuity for life

Contribution to HiLiftPW-3

Marian Zastawny, Sylvain Lardeau,
Steve Evans, Oisin Tong
Siemens PLM Software Inc. (003)

Summary of cases completed:
STAR-CCM+, committee grids, k-ω SST (a1 = 1)

SIEMENS
Ingenuity for life

Case	α = 8 Fully turbulent grid study	α = 16 Fully turbulent grid study
1a (full gap)	YES	YES
1b (full gap w adaptation)	NO	NO
1c (partial seal)	YES	YES
1d (partial seal w adaptation)	NO	NO

Case	Polar Fully turbulent	Polar Specified transition	Polar W transition prediction
2a (no nacelle)	YES	NO	YES
2b (no nacelle w adaptation)	NO	NO	NO
2c (with nacelle)	YES	NO	NO
2d (with nacelle w adaptation)	NO	NO	NO

Case	2D verification study
3 (aerofoil wake)	YES

Summary of cases completed:
STAR-CCM+, committee grids, SA

SIEMENS
Ingenuity for life

Case	α = 8 Fully turbulent grid study	α = 16 Fully turbulent grid study
1a (full gap)	YES	YES
1b (full gap w adaptation)	NO	NO
1c (partial seal)	NO	NO
1d (partial seal w adaptation)	NO	NO

Case	Polar Fully turbulent	Polar Specified transition	Polar W transition prediction
2a (no nacelle)	NO	NO	NO
2b (no nacelle w adaptation)	NO	NO	NO
2c (with nacelle)	NO	NO	NO
2d (with nacelle w adaptation)	NO	NO	NO

Case	2D verification study
3 (aerofoil wake)	YES

Summary of cases completed:
STAR-CCM+, committee grids, k-ε Lag Elliptic Blending

SIEMENS
Ingenuity for life

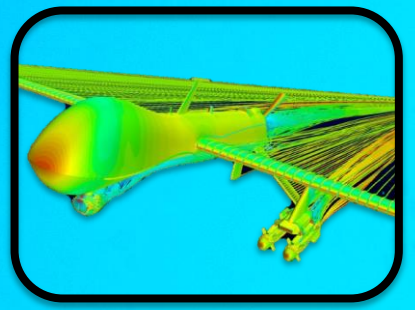
Case	α = 8 Fully turbulent grid study	α = 16 Fully turbulent grid study
1a (full gap)	YES	YES
1b (full gap w adaptation)	NO	NO
1c (partial seal)	NO	NO
1d (partial seal w adaptation)	NO	NO

Case	Polar Fully turbulent	Polar Specified transition	Polar W transition prediction
2a (no nacelle)	NO	NO	YES
2b (no nacelle w adaptation)	NO	NO	NO
2c (with nacelle)	NO	NO	NO
2d (with nacelle w adaptation)	NO	NO	NO

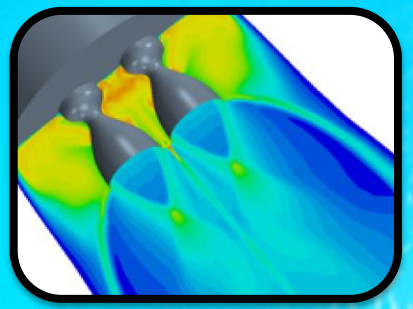
Case	2D verification study
3 (aerofoil wake)	YES

Aerospace and Defense applications of STAR-CCM+

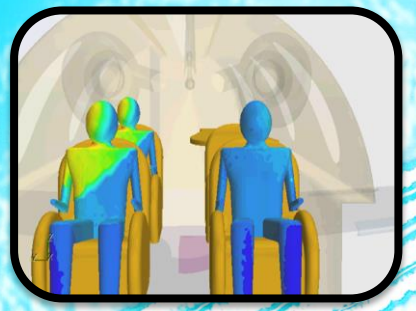
SIEMENS
Ingenuity for life



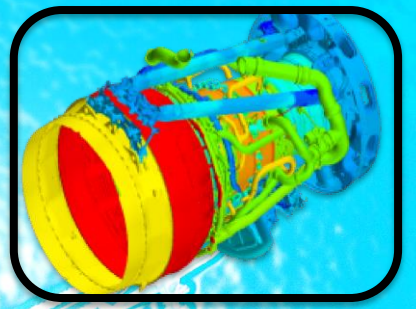
External Aerodynamics



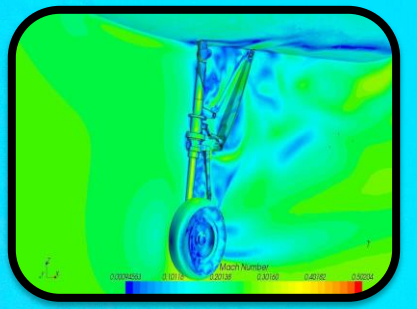
Rocket Propulsion



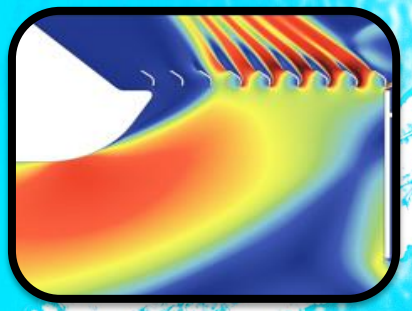
Environmental Control Systems



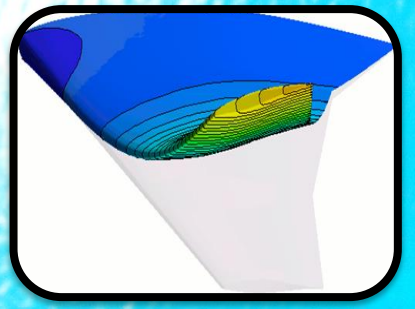
Thermal Management



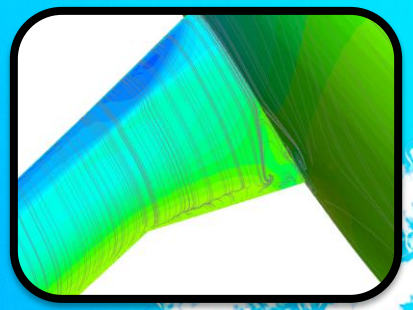
Aeroacoustics



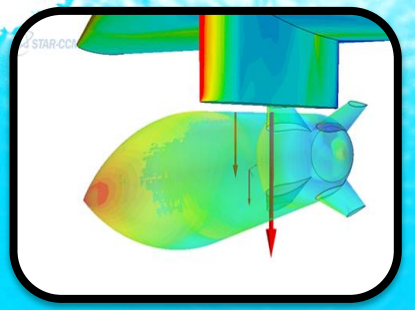
Design Exploration



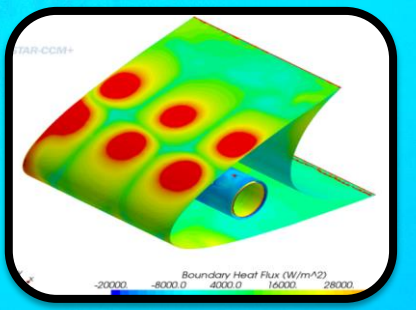
Fluid Structure interactions



Validation



Store Separation



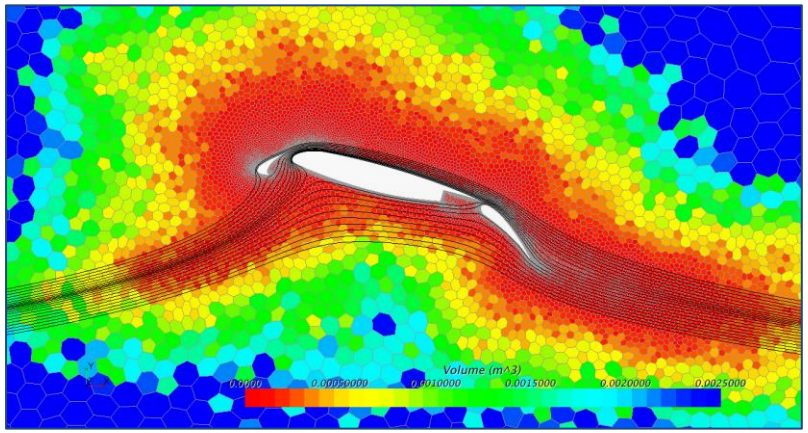
Ice Accretion and Protection

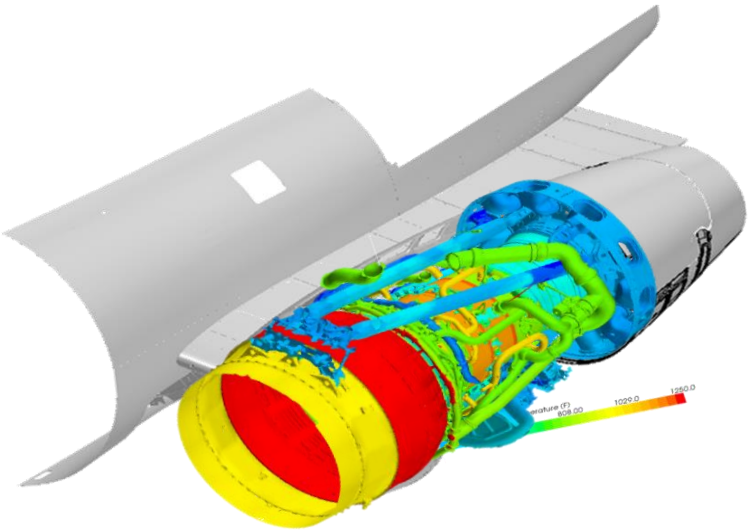
SIEMENS
Ingenuity for life

Summary of the code and numerics used

Modelling

- Density-based coupled-flow solver, with an automated convergence control tool (expert driver) to accelerate convergence rate.
- Various turbulence models: SA, SST k-ω, Lag EB k-ε
- Additional transition modelling for SST k-ω: γ-model





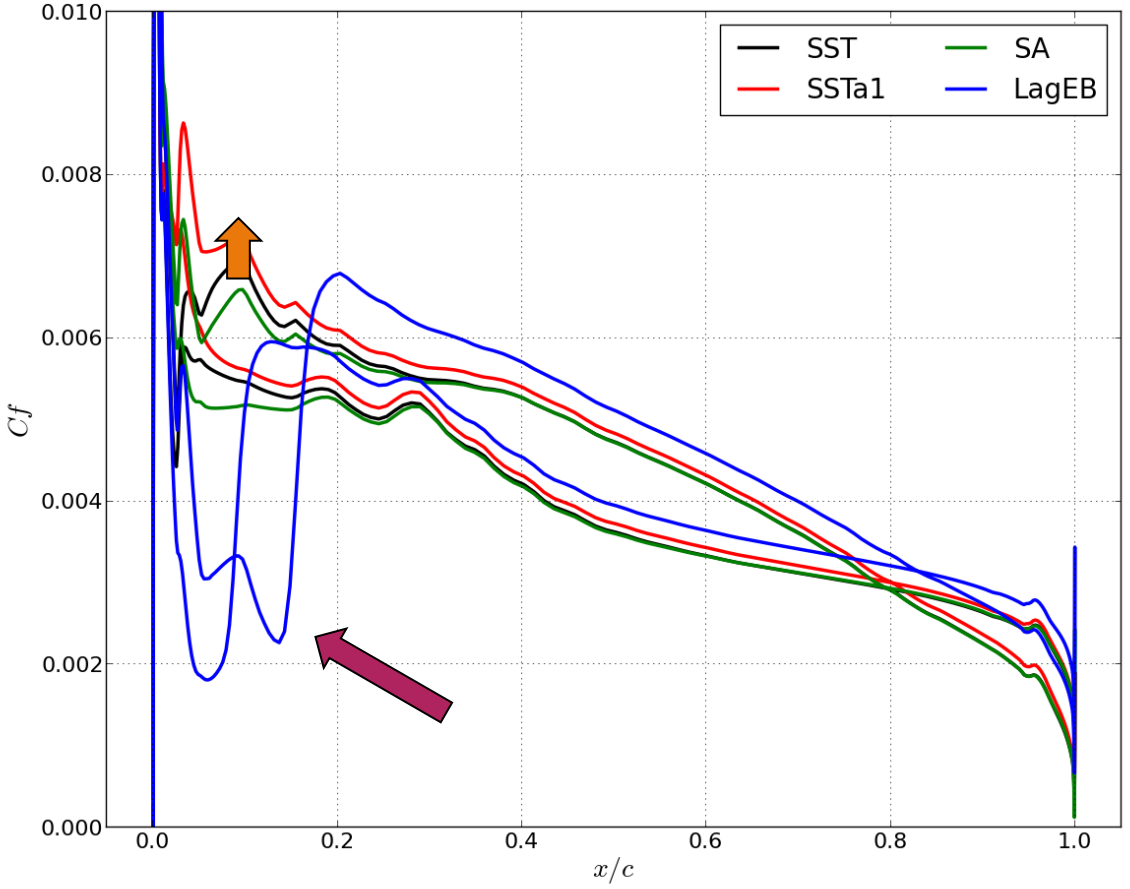
References

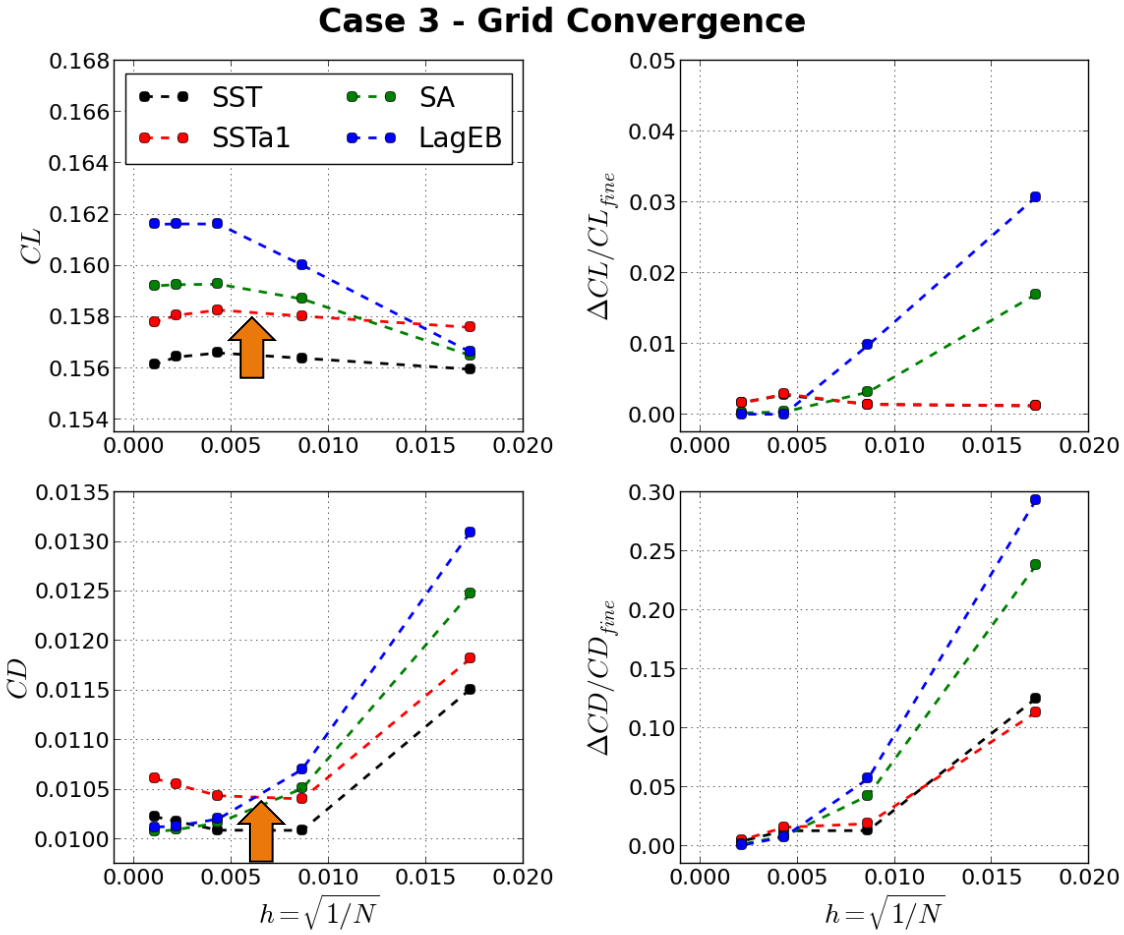
- Evans, S., and Lardeau, S., "Validation of a turbulence methodology using the SST k-ω model for adjoint calculation," *54th AIAA Aerospace Sciences Meeting,* 2016.
- Lardeau, S., and Billard F., “Development of an elliptic-blending lag model for industrial applications," *54th AIAA Aerospace Sciences Meeting*, 2016.
- Menter, F., et al., "A one-equation local correlation-based transition model," *Flow, Turbulence and Combustion 95.4* (2015): 583-619.
- Weiss, J.M., and Smith, W.A.,. “Preconditioning applied to variable and constant density flows,” *AIAA Journal*, 33(11), pp. 2050-2057.1995

Verification study results

2D Airfoil Near-Wake

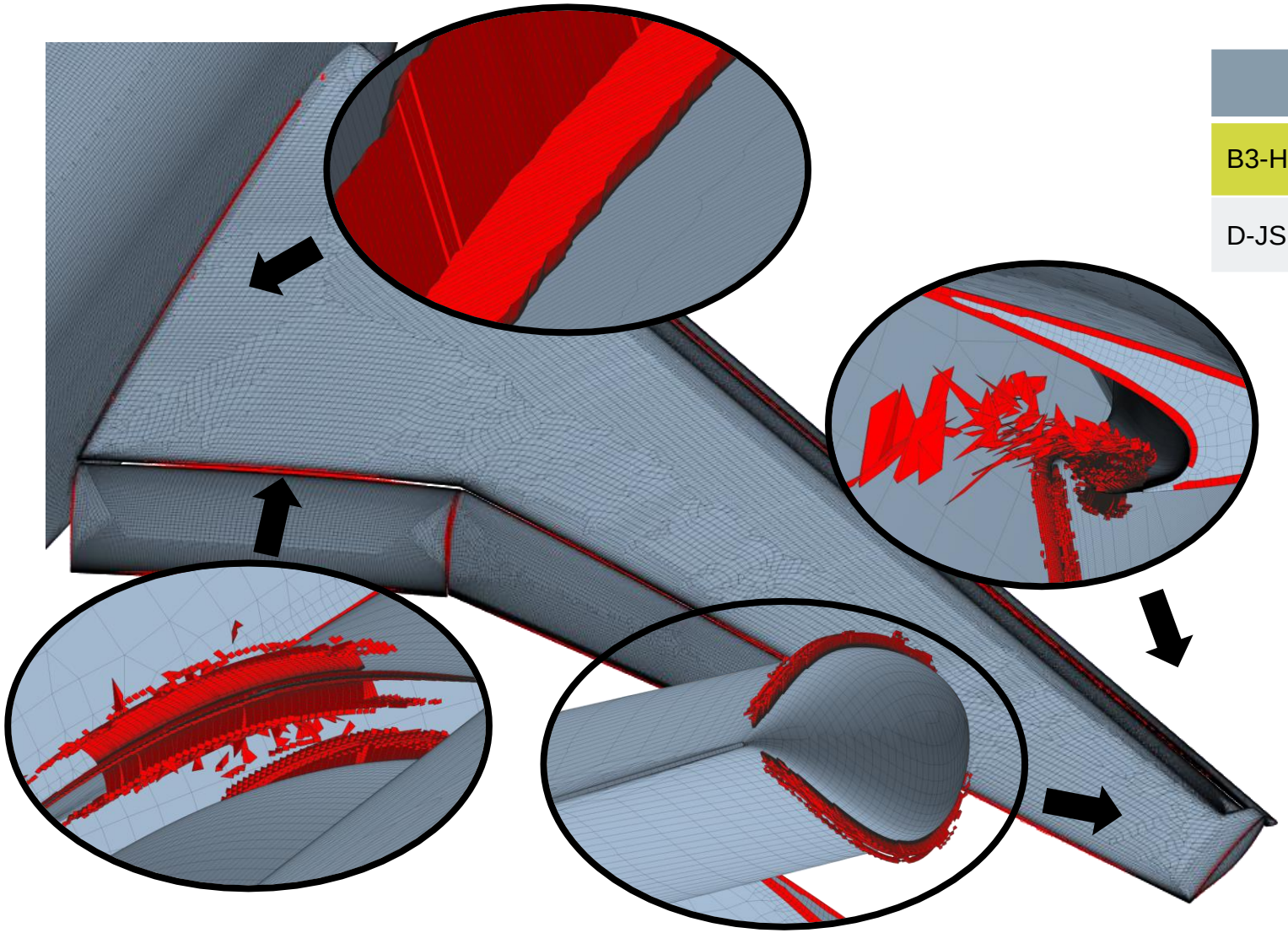
SIEMENS
Ingenuity for life



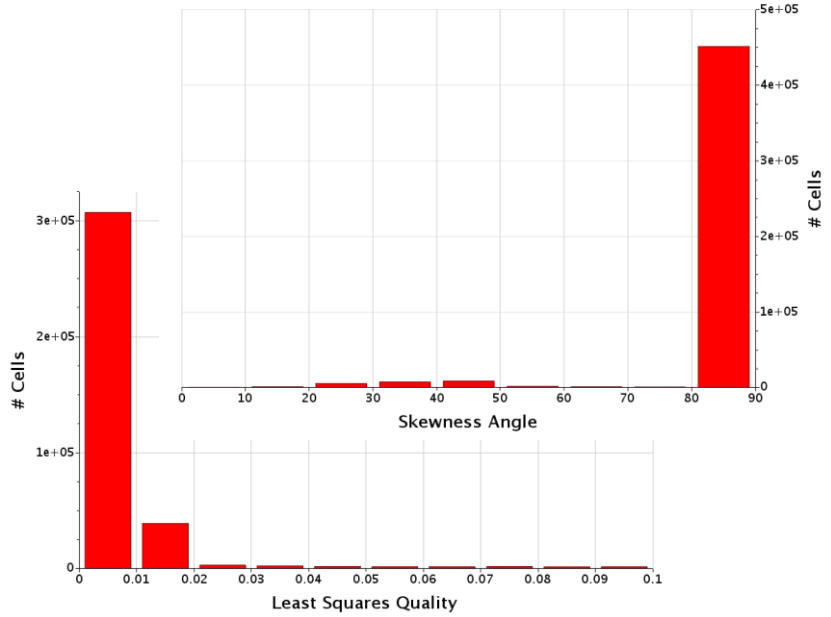


Overview of grid systems – HL-CRM

SIEMENS
Ingenuity for life



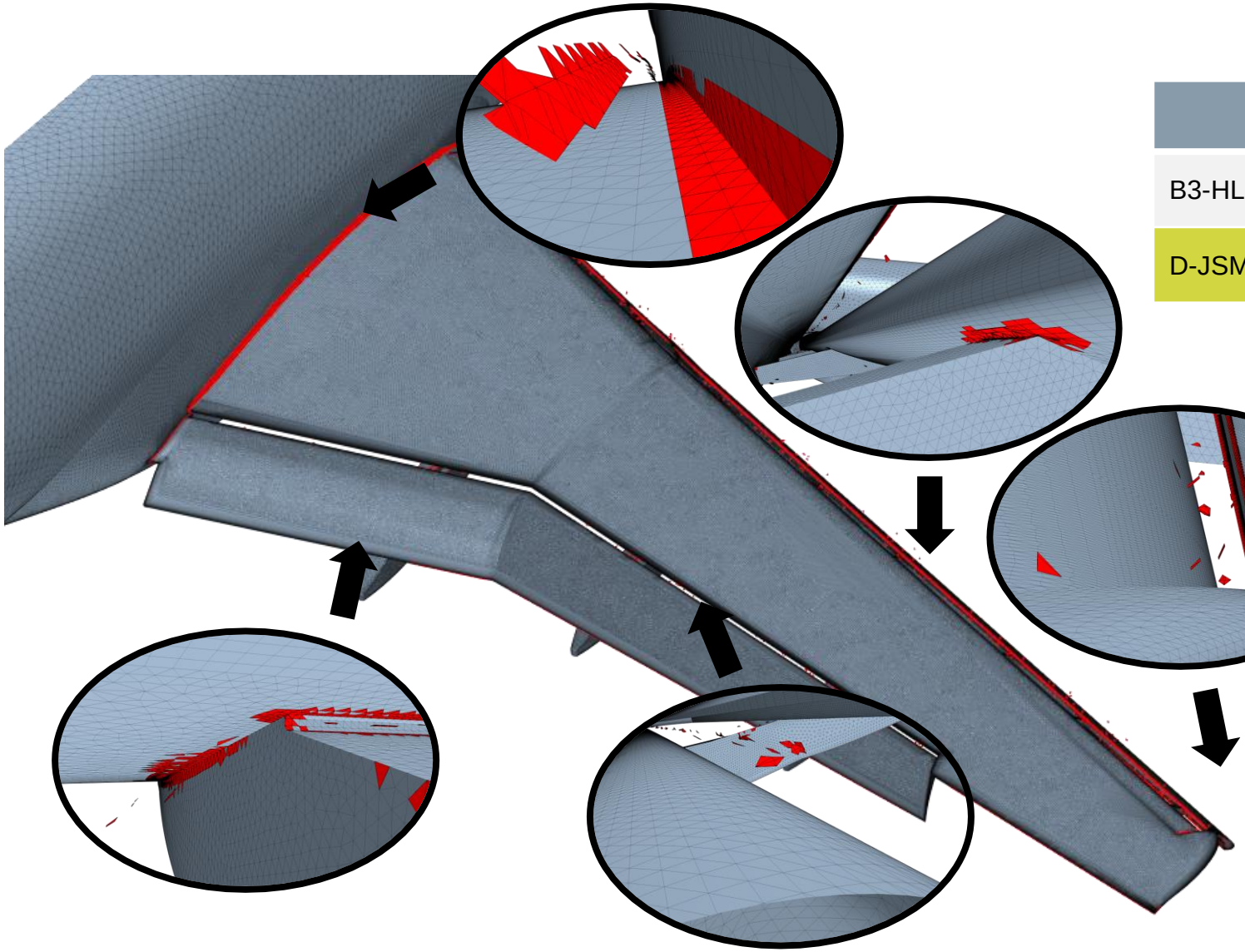
Grid System	Cases
B3-HLCRM_UnstrHexPrismPyrTet_PW	1a, 1c
D-JSM_UnstrMixed_JAXA	2a, 2c

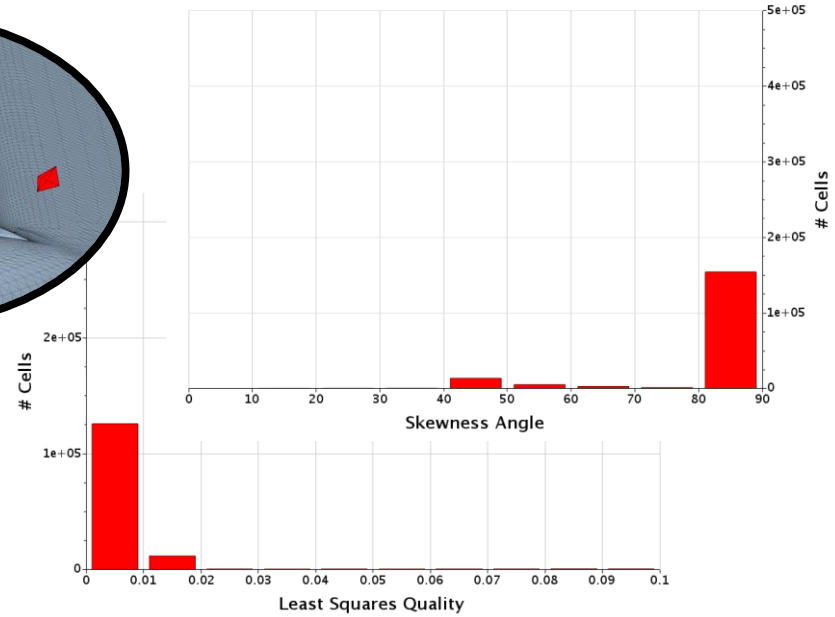


Overview of grid systems - JSM

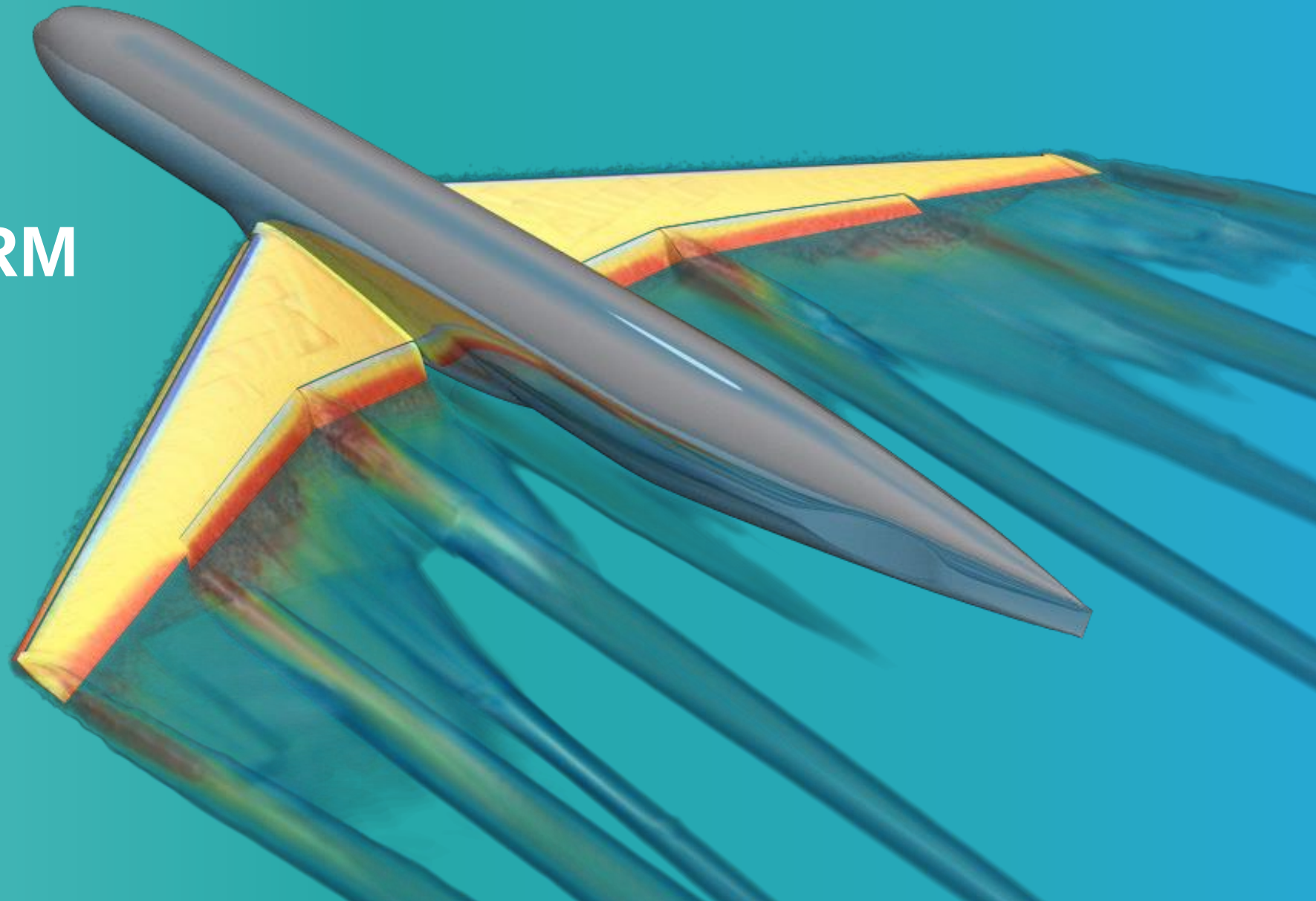
SIEMENS
Ingenuity for life

Grid System	Cases
B3-HLCRM_UnstrHexPrismPyrTet_PW	1a, 1c
D-JSM_UnstrMixed_JAXA	2a, 2c





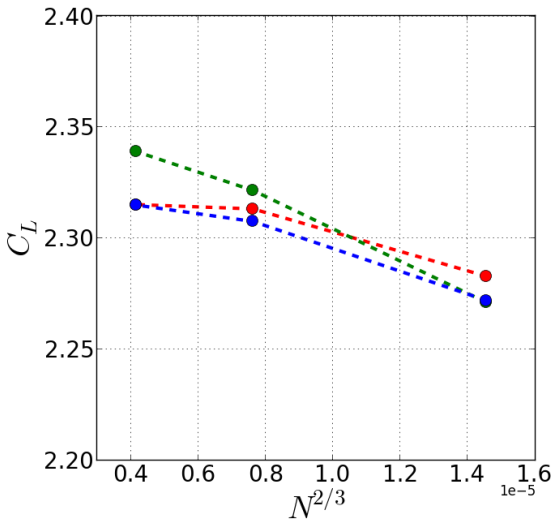
Case 1: HL - CRM

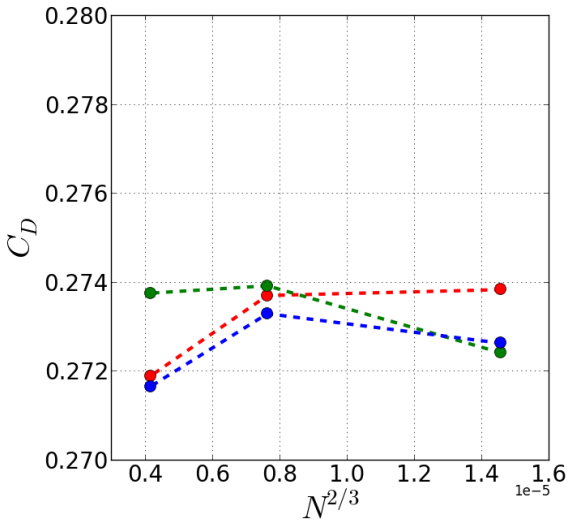


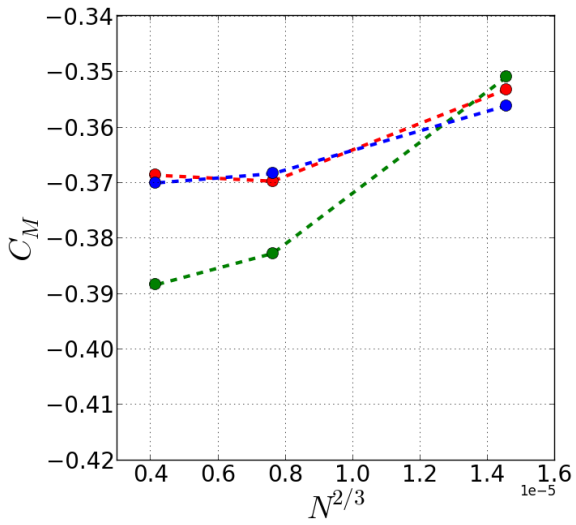
Overview of HL-CRM results

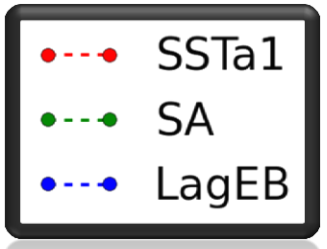
SIEMENS
Ingenuity for life

16°

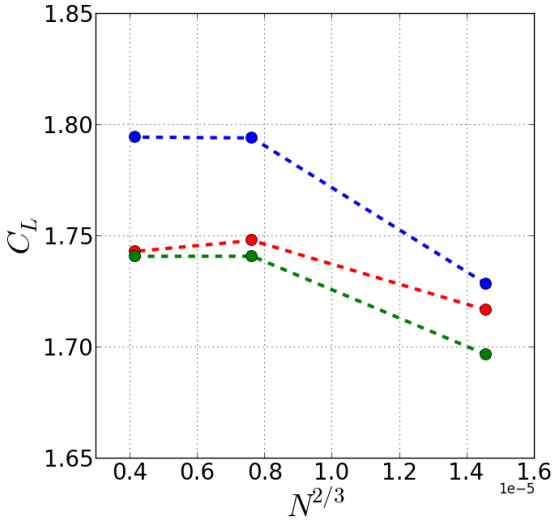


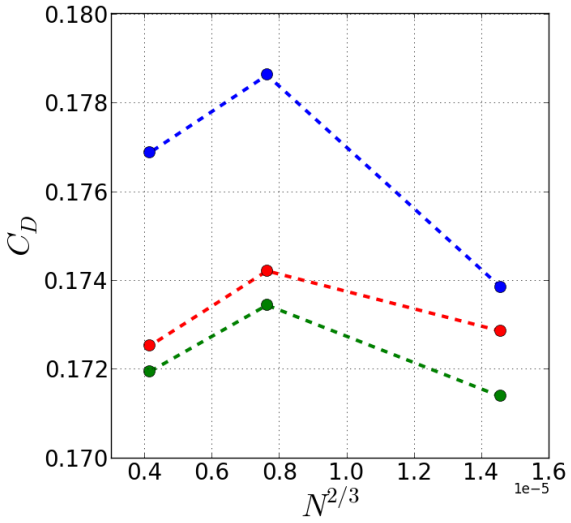


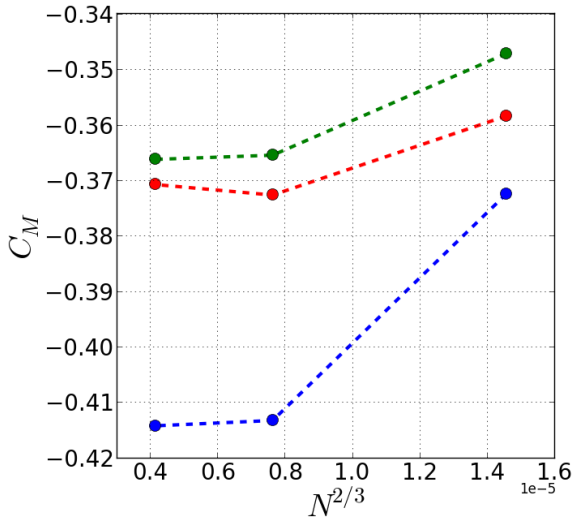




8°

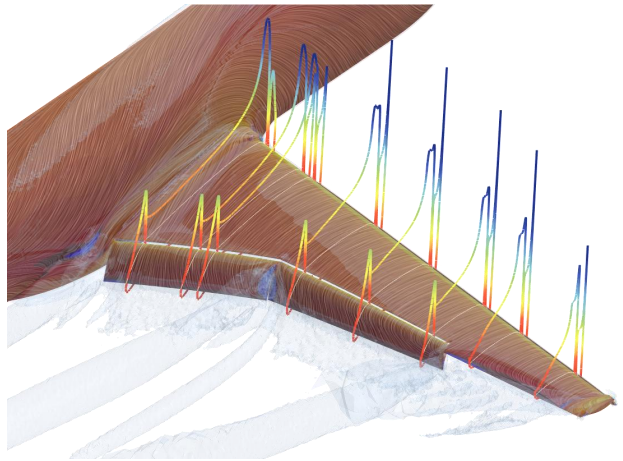
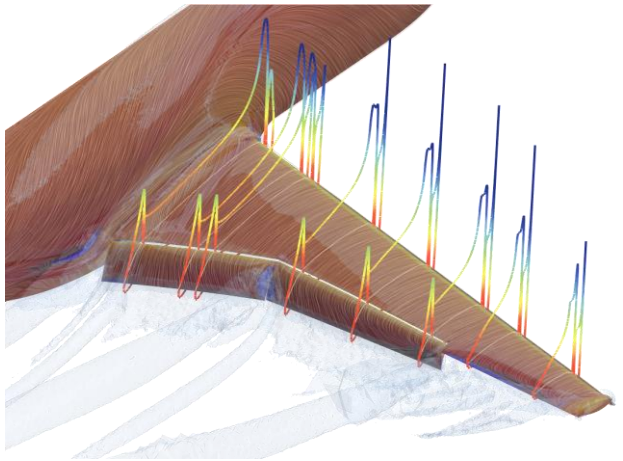
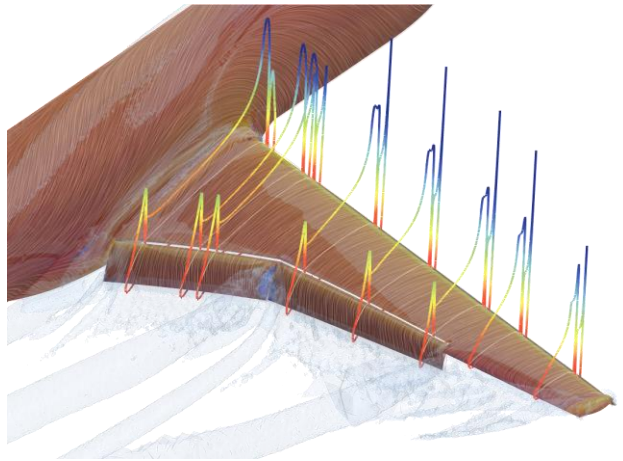
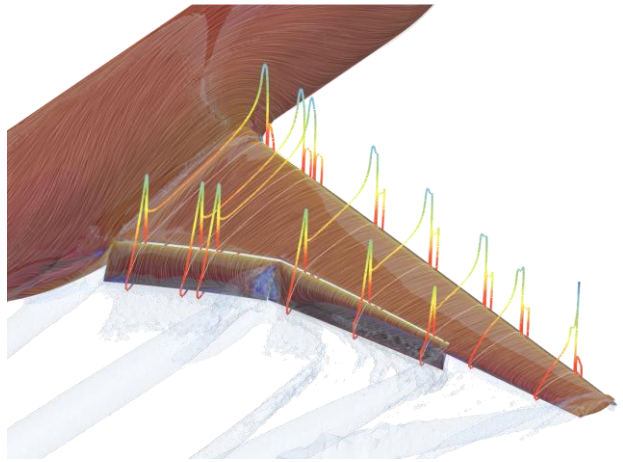
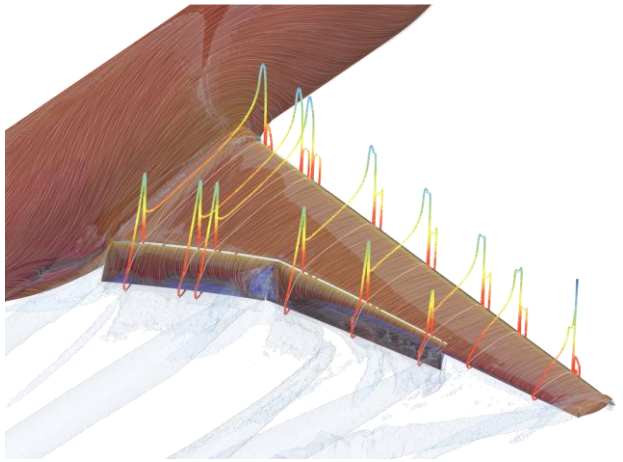
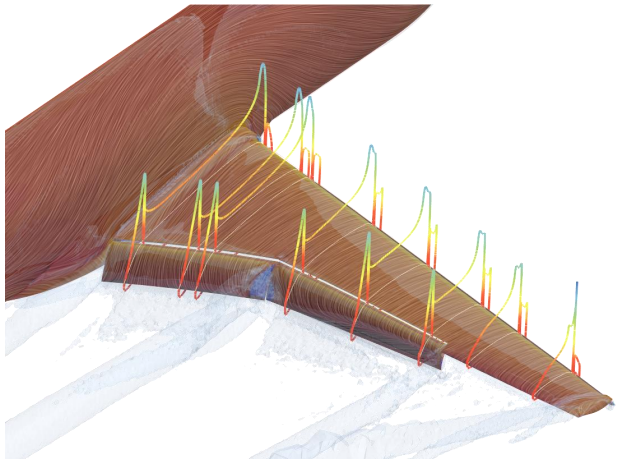


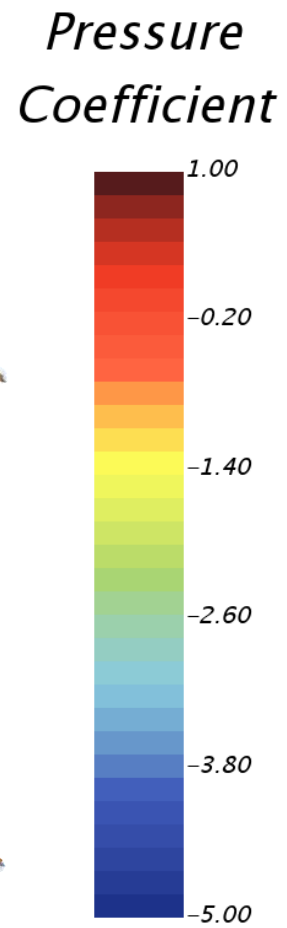




HL-CRM – Comparison of turbulence models

SIEMENS
Ingenuity for life

	SSTa1	SA	LagEB
16°			
8°			



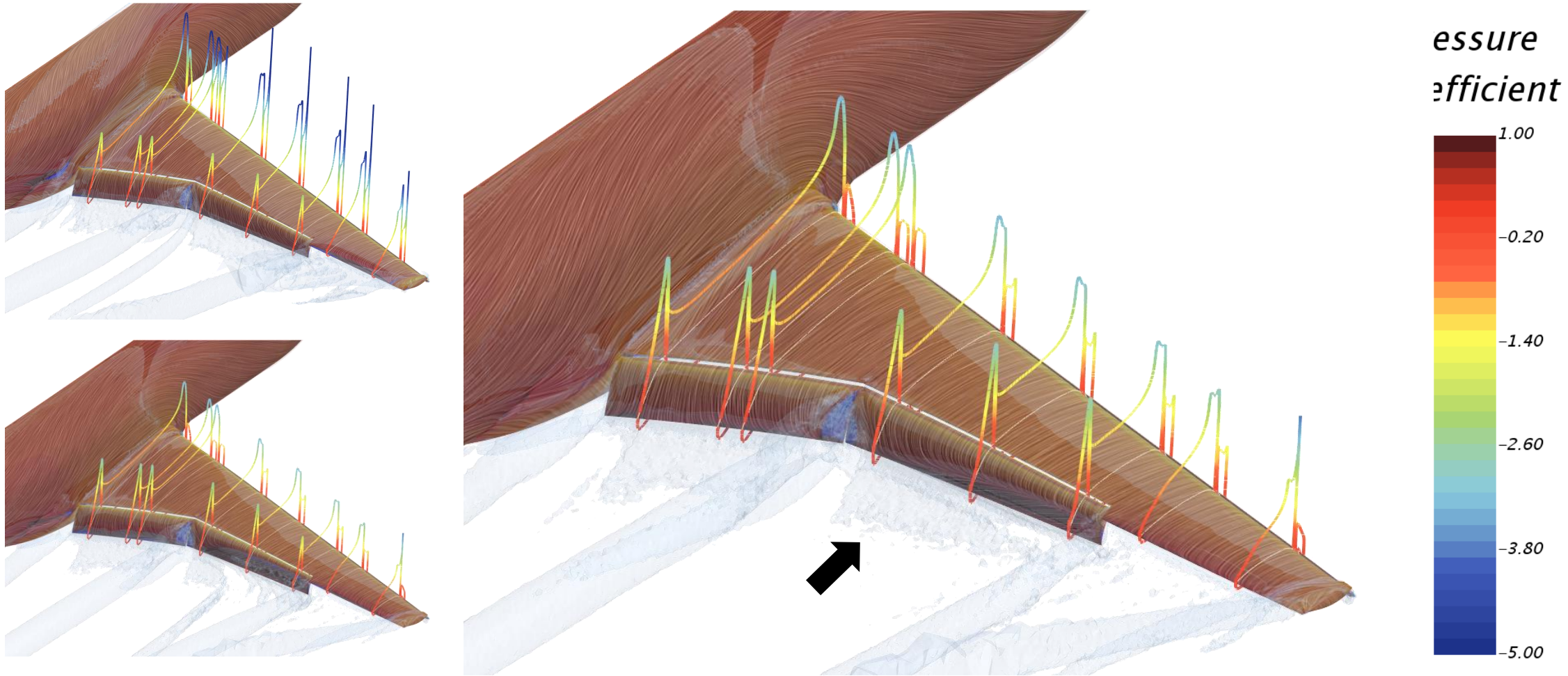
HL-CRM – Comparison of turbulence models

SIEMENS
Ingenuity for life

SSTa1 **SA** **LagEB**

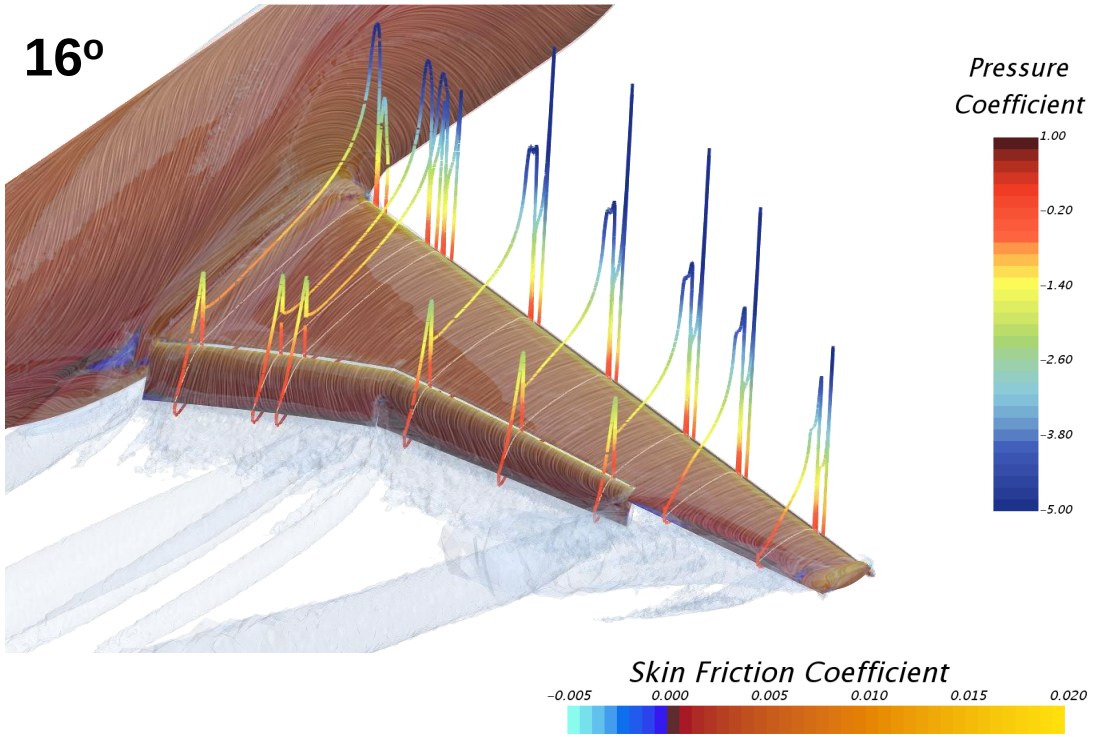
16°

8°

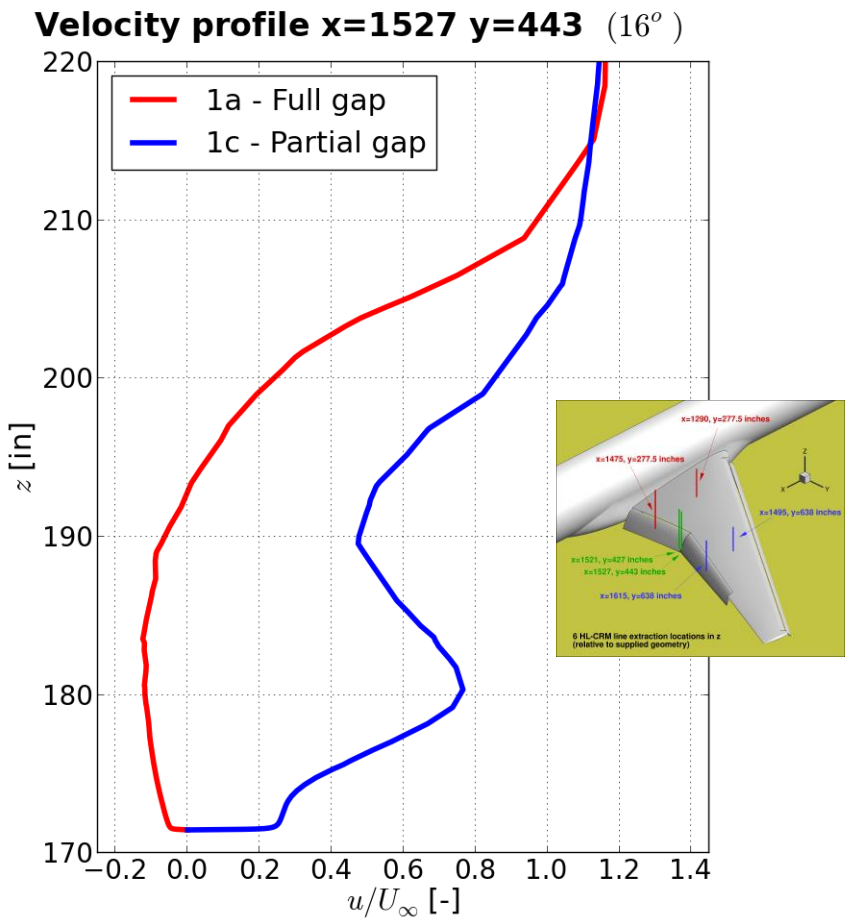


HL-CRM – Impact of the flap gap (SSTa1)

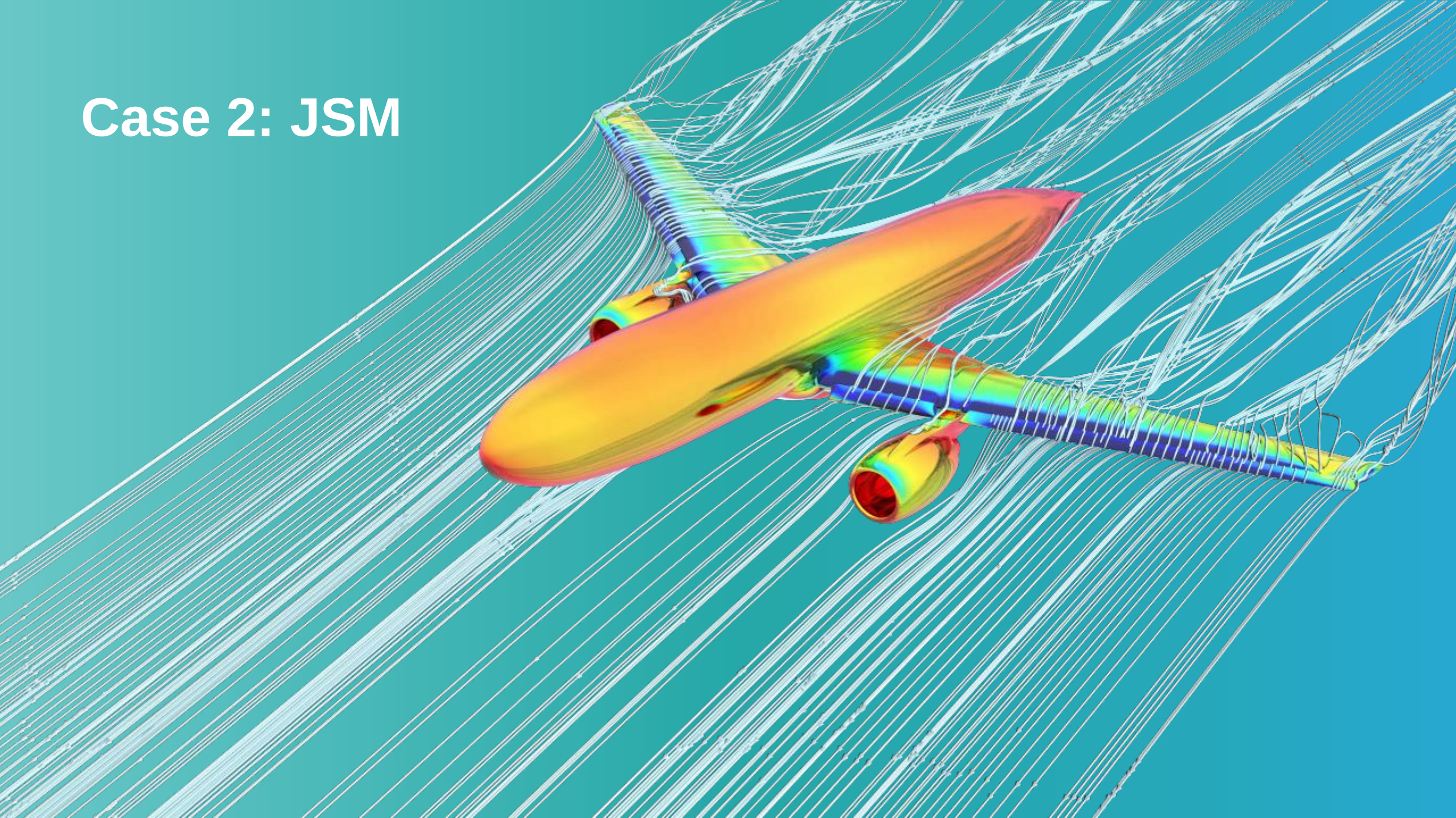
SIEMENS
Ingenuity for life



Alpha	ΔCL	ΔCD	ΔCM
8	+2.26%	+0.36%	-0.98%
16	+2.16%	+1.57%	-4.19%



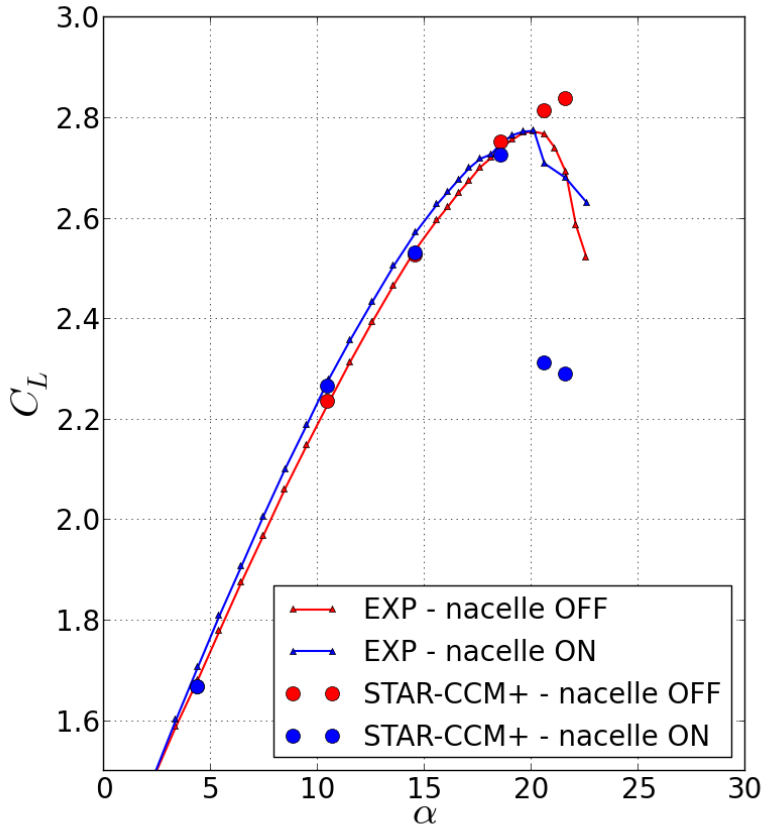
Case 2: JSM

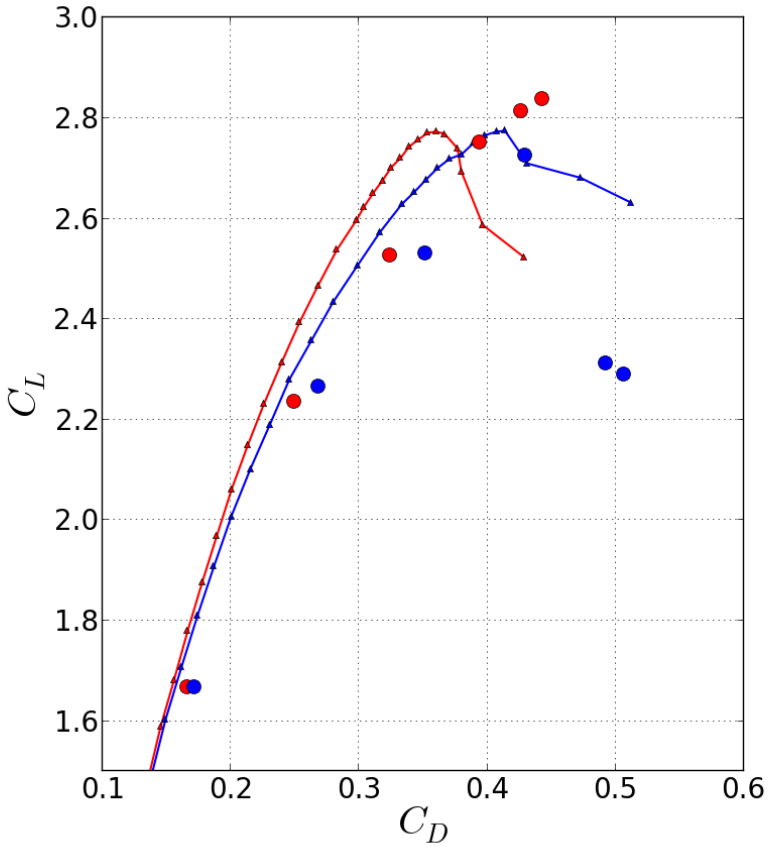


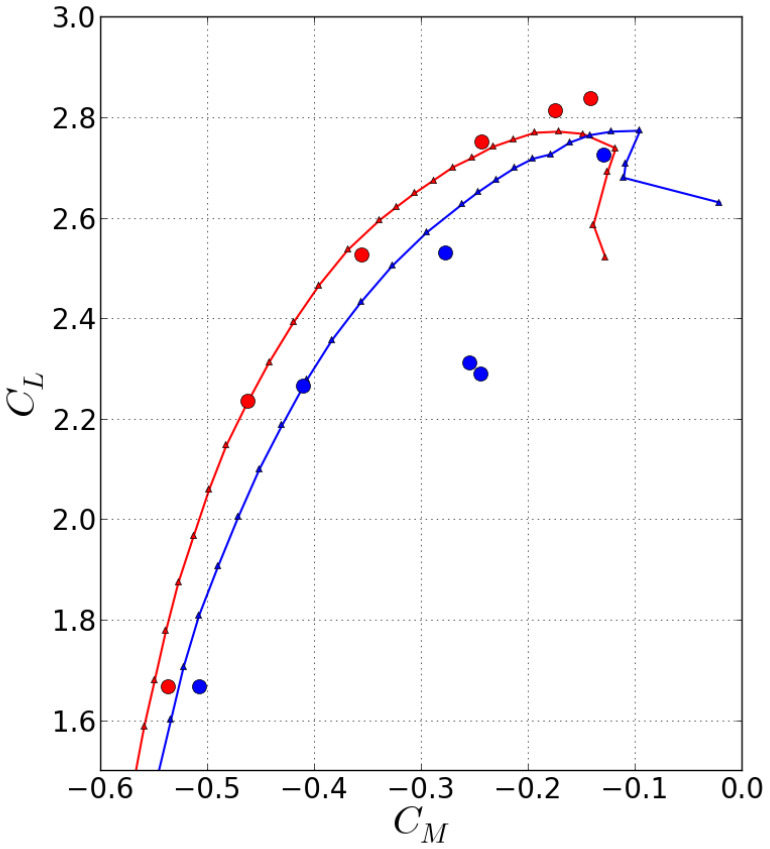
Overview of JSM results

Nacelle installation study (SSTa1)

SIEMENS
Ingenuity for life

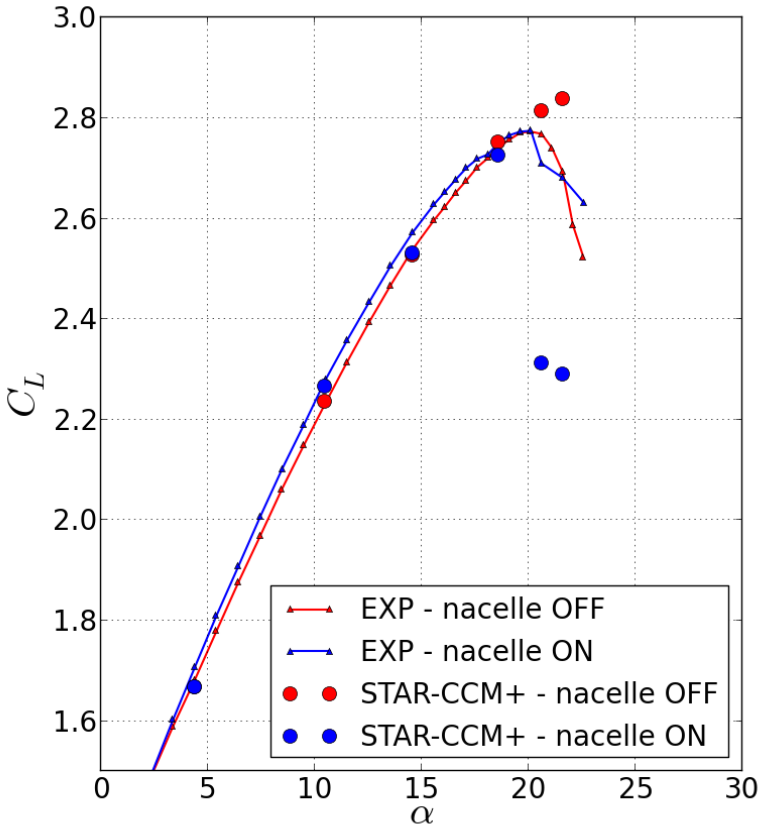


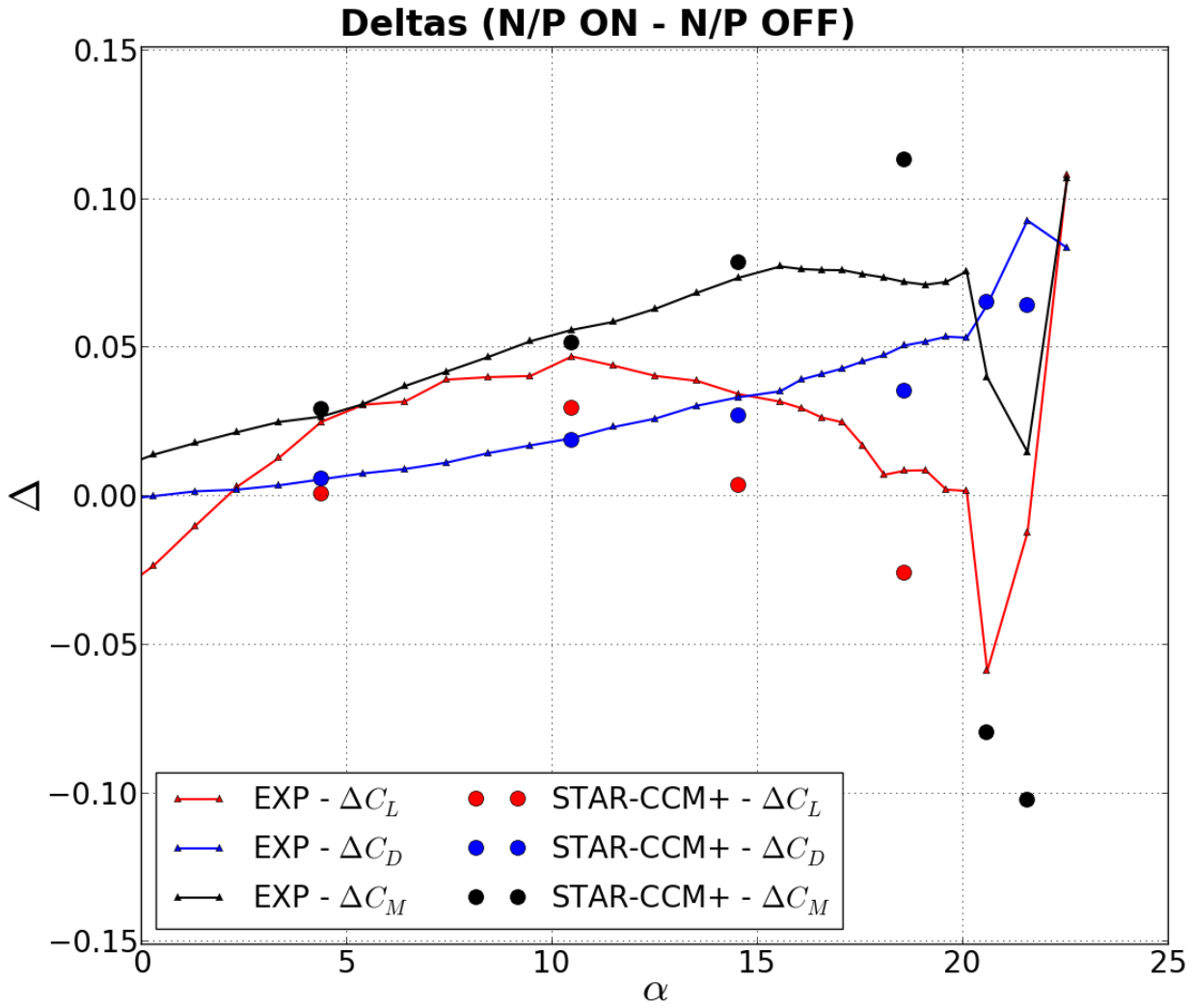




Overview of JSM results

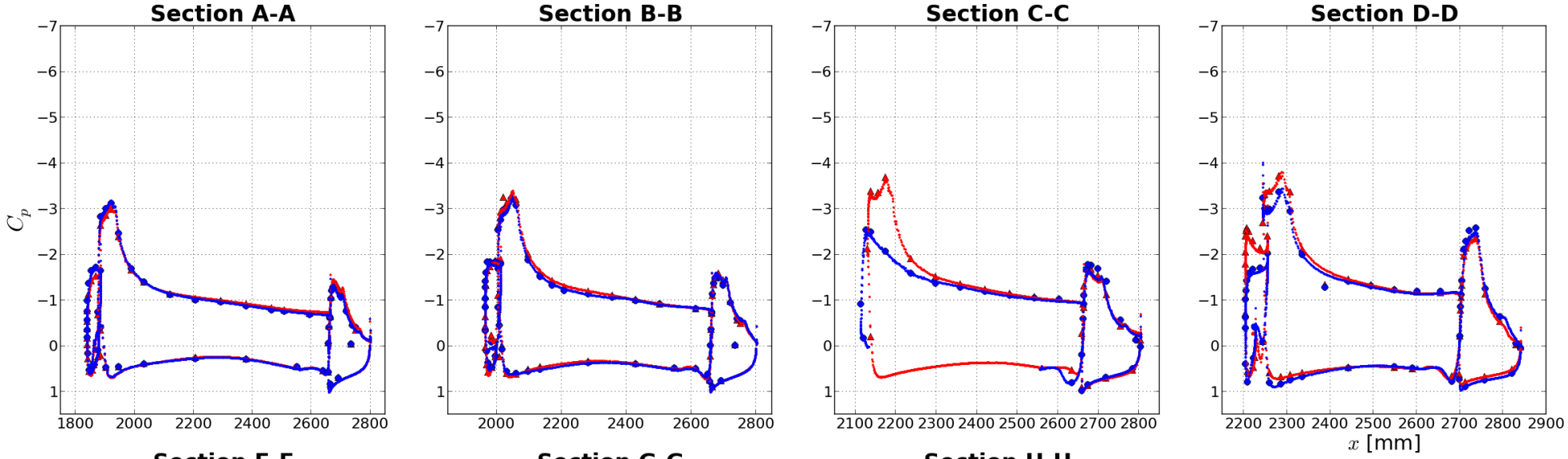
Nacelle installation study (SSTa1)

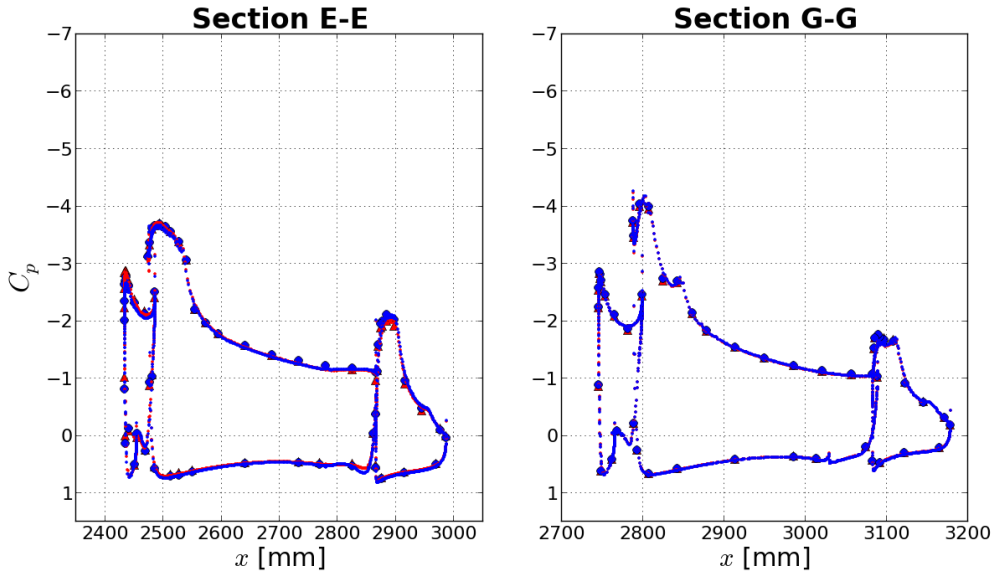


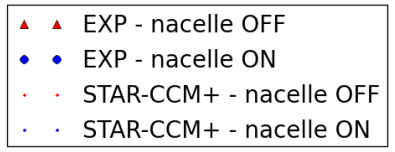


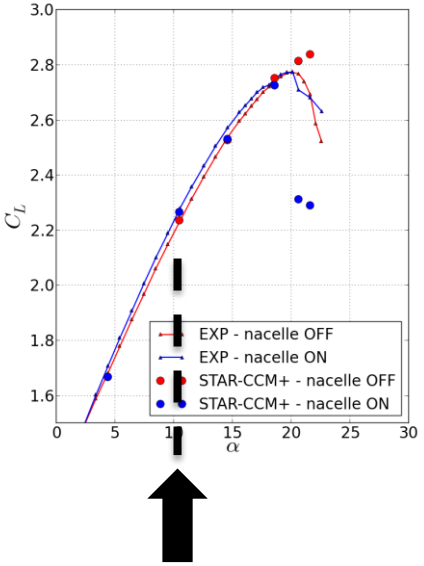
Pressure Coefficient - α = 10.47 deg

SIEMENS
Ingenuity for life



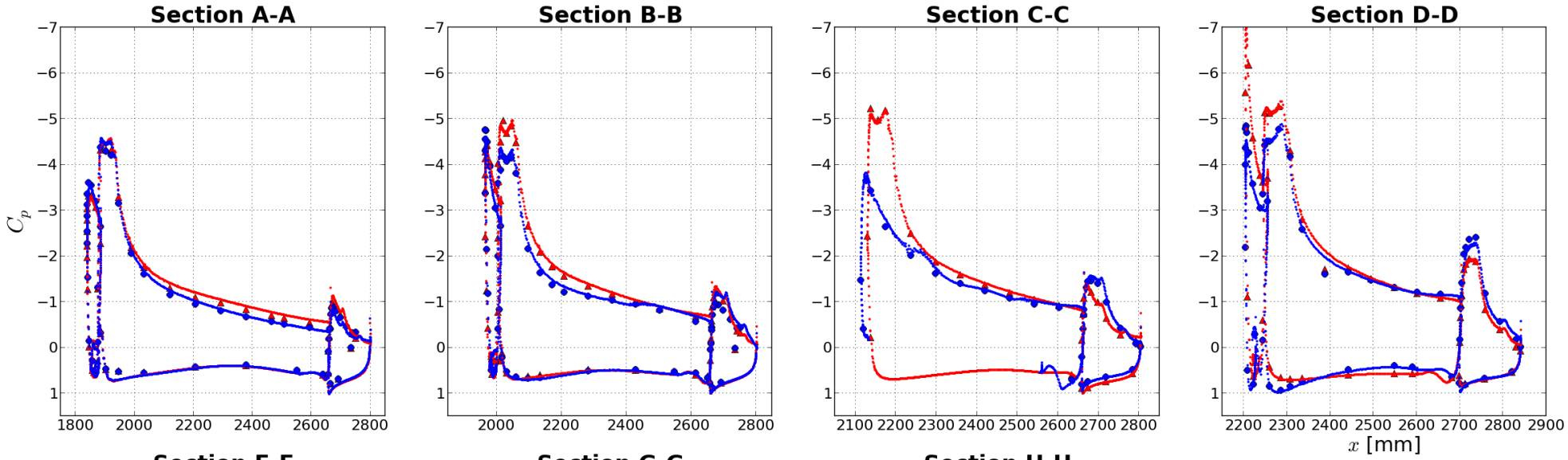


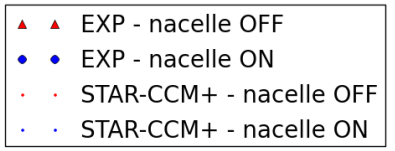


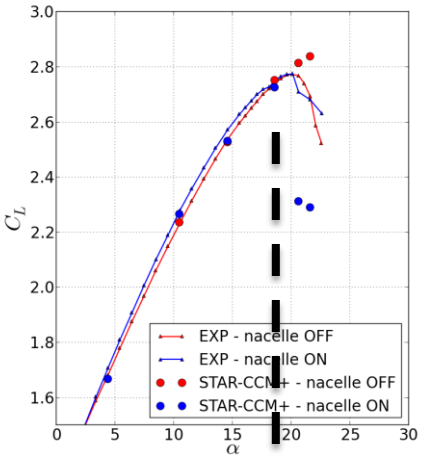


Pressure Coefficient - α = 18.58 deg

SIEMENS
Ingenuity for life

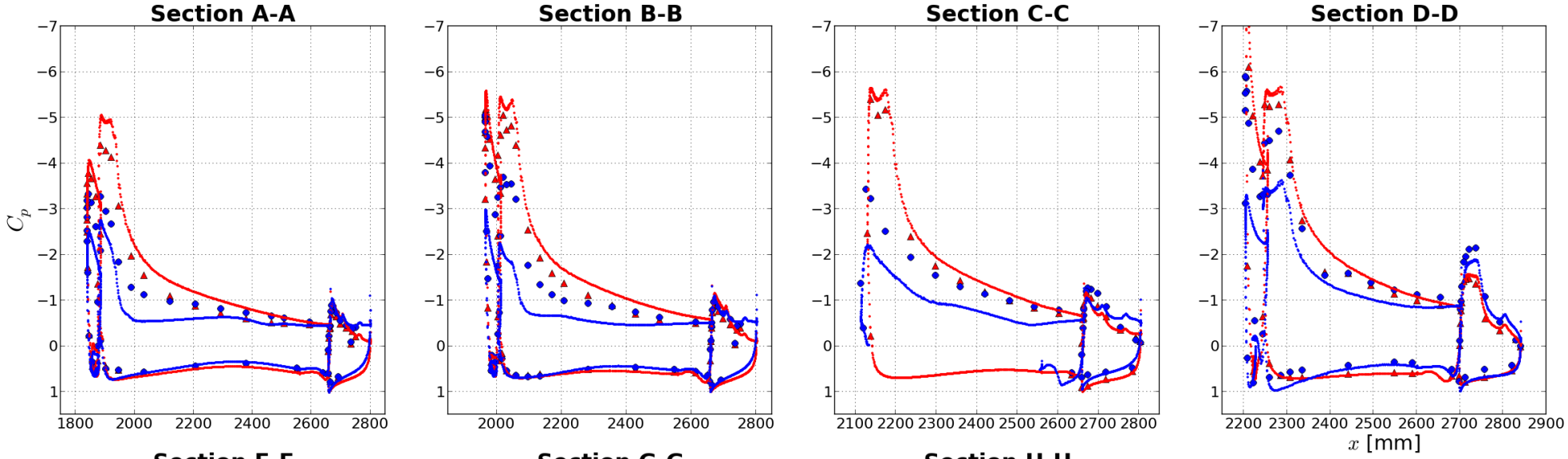


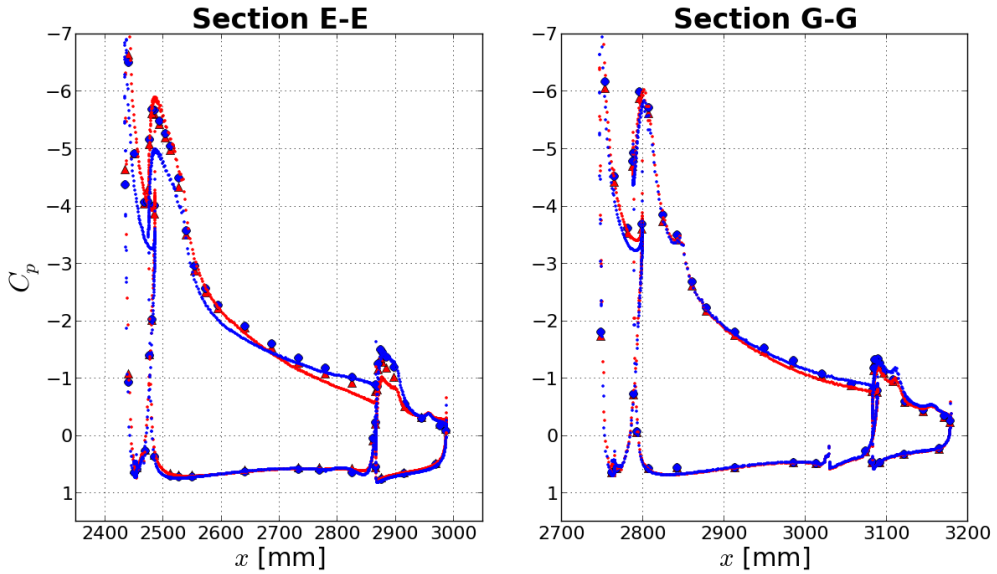


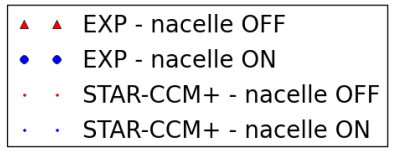


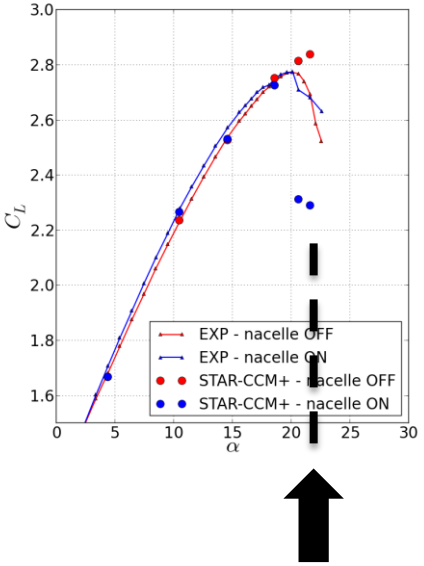
Pressure Coefficient - α = 21.57 deg

SIEMENS
Ingenuity for life







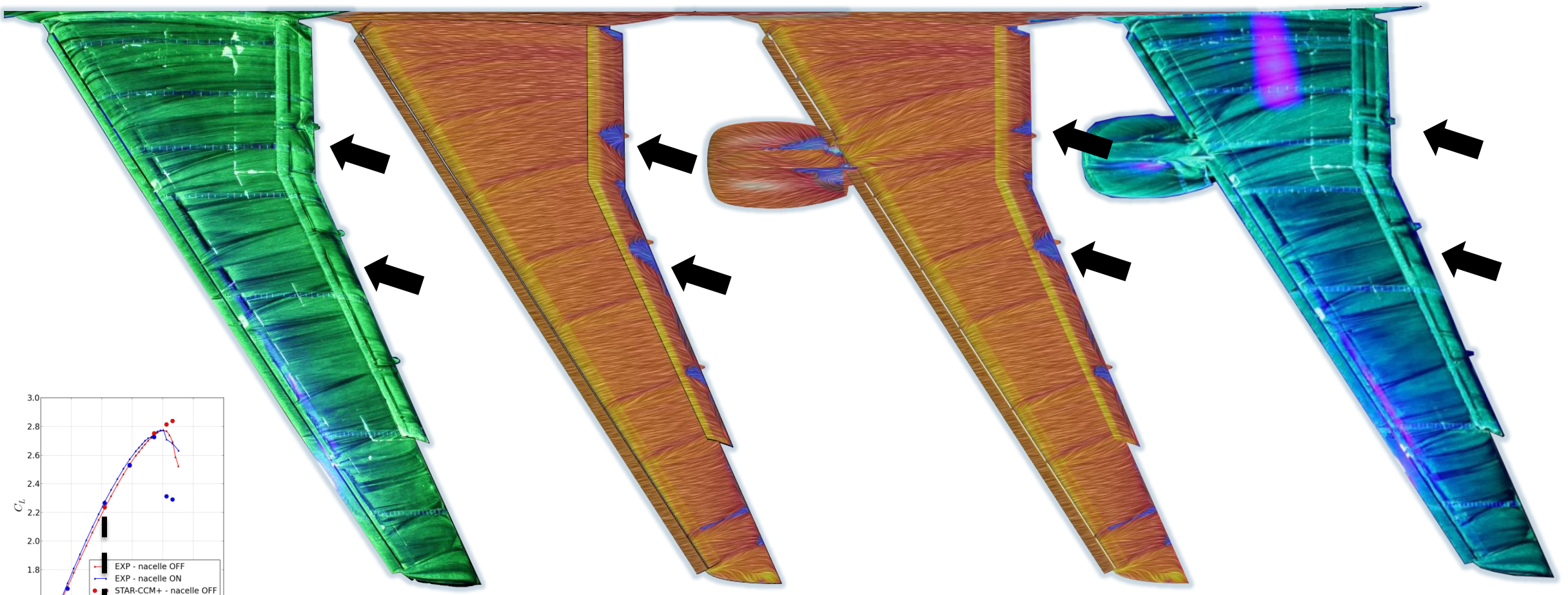


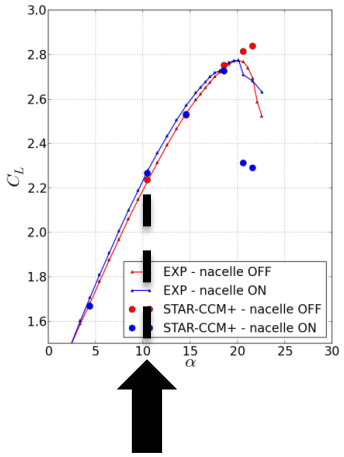
Flow visualisation on the upper wing surface

α = 10.47 deg

SIEMENS

Ingenuity for life



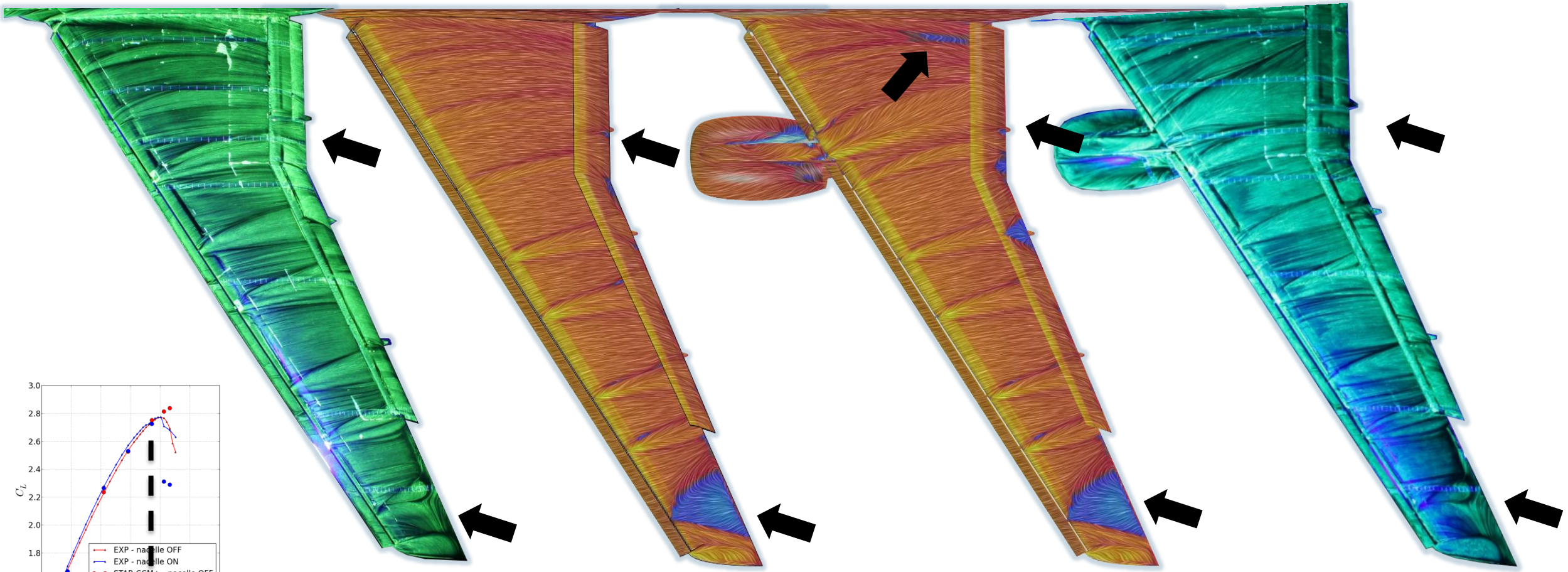


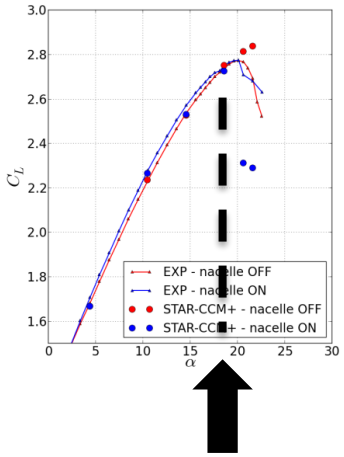
Flow visualisation on the upper wing surface

α = 18.58 deg

SIEMENS

Ingenuity for life



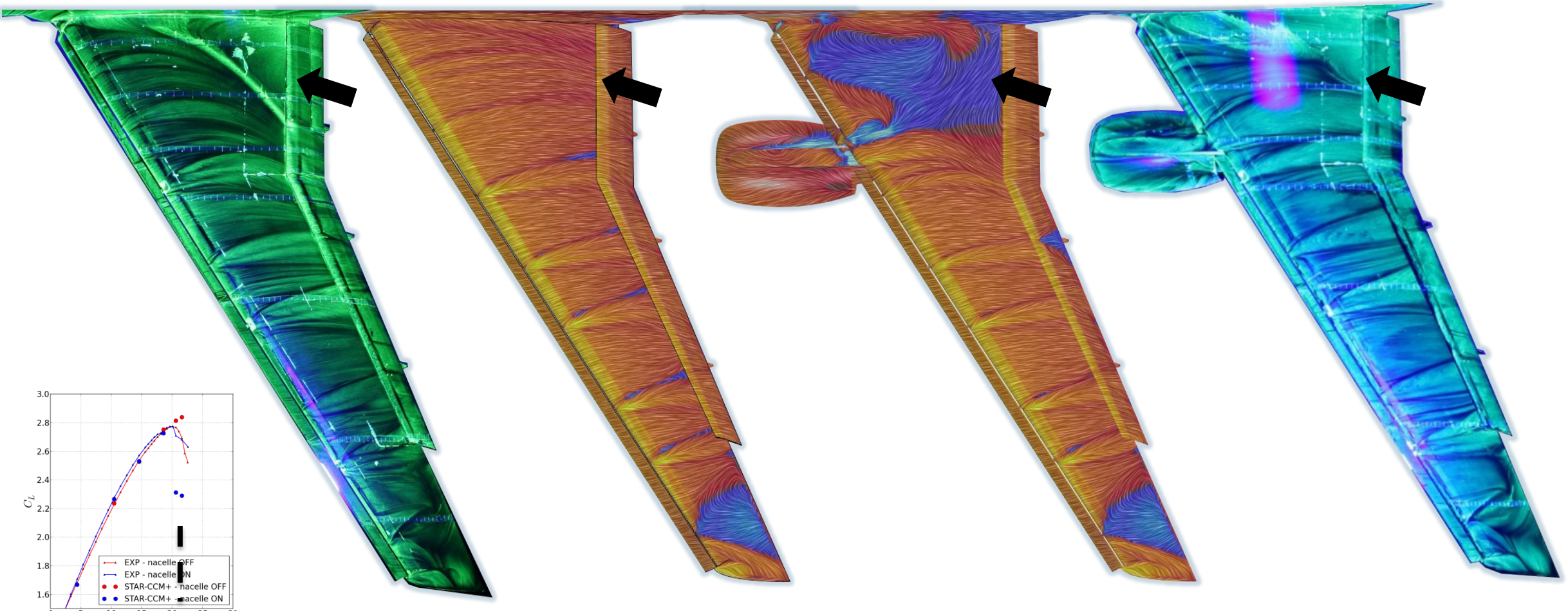


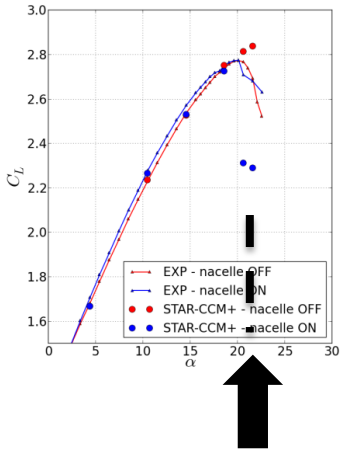
Flow visualisation on the upper wing surface

α = 21.57 deg

SIEMENS

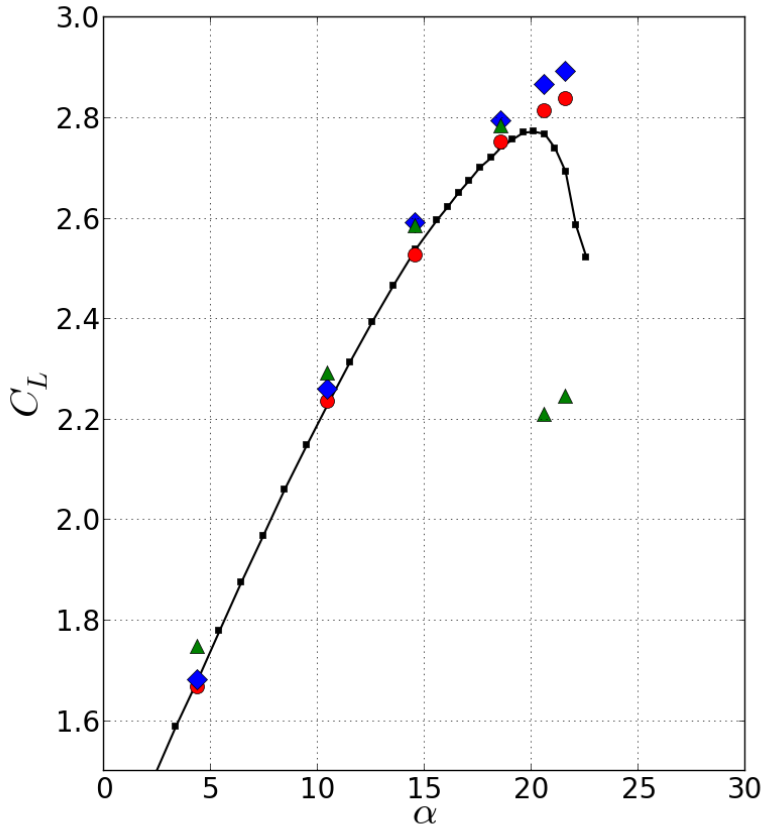
Ingenuity for life

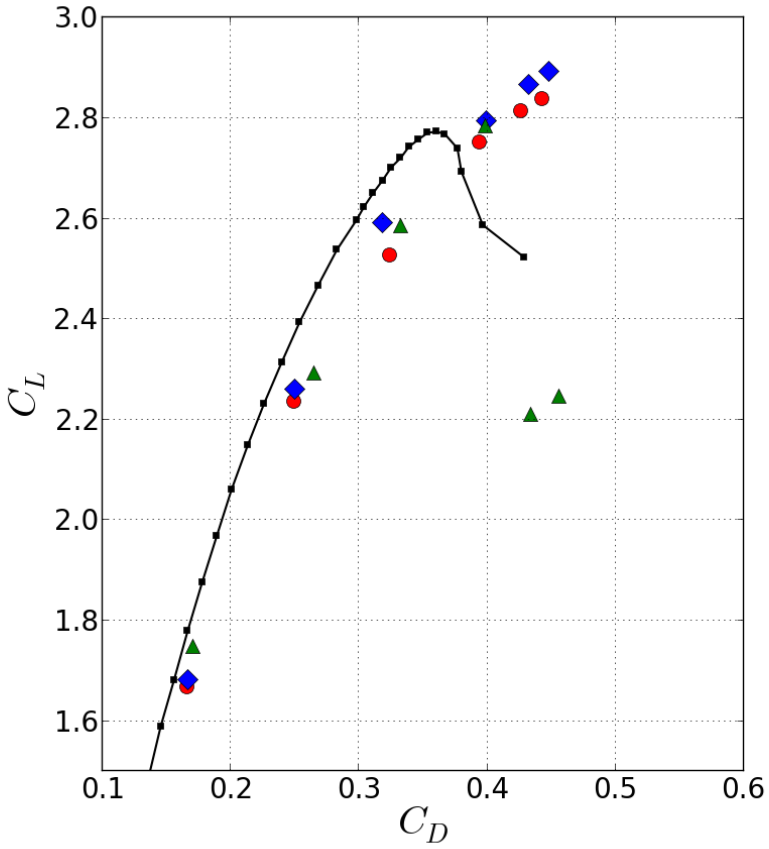


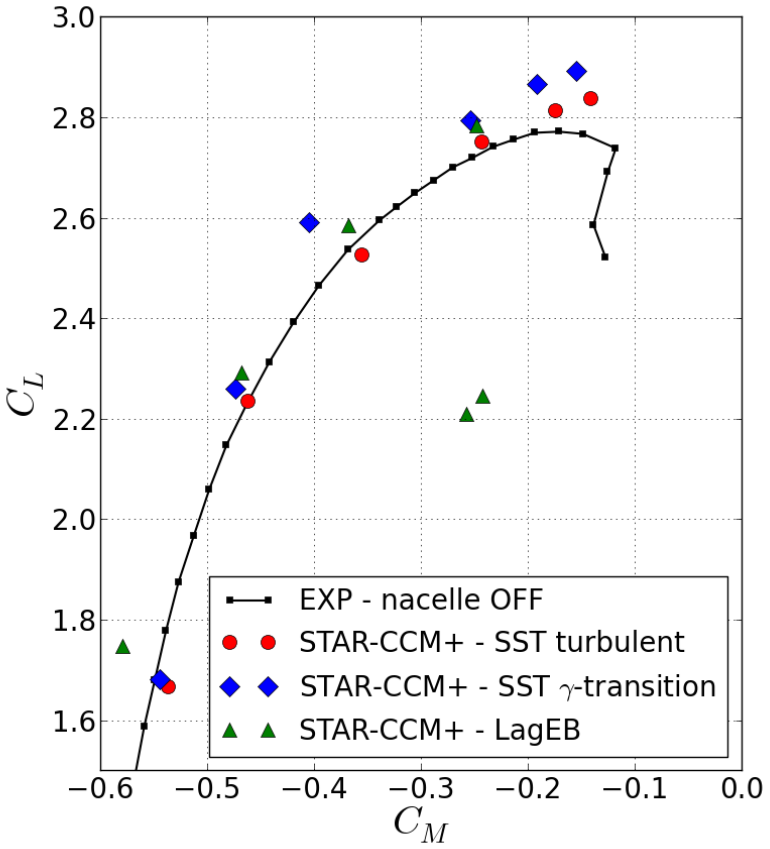


Overview of JSM results

Transition model study







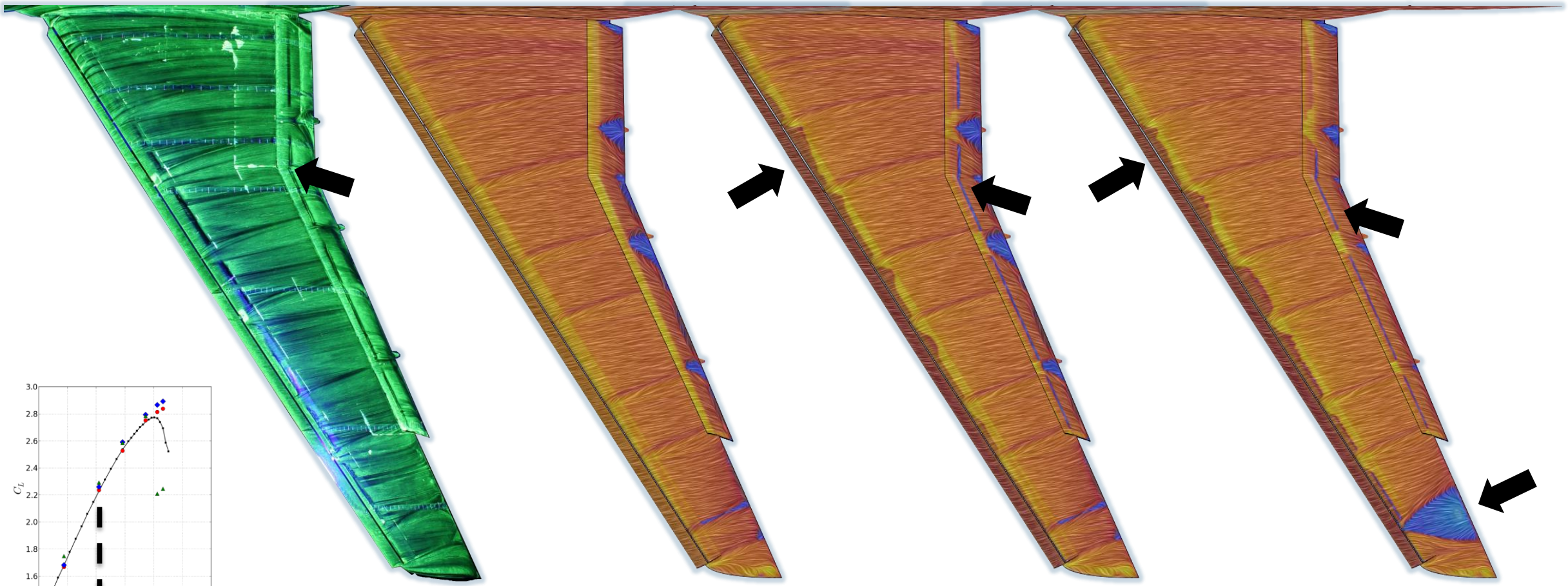
Flow visualisation on the upper wing surface

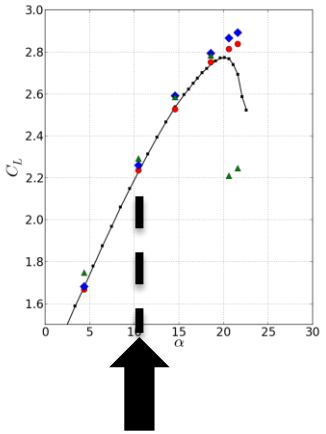
α = 10.47 deg

SIEMENS

Ingenuity for life

turbulent **γ-transition** **LagEB**





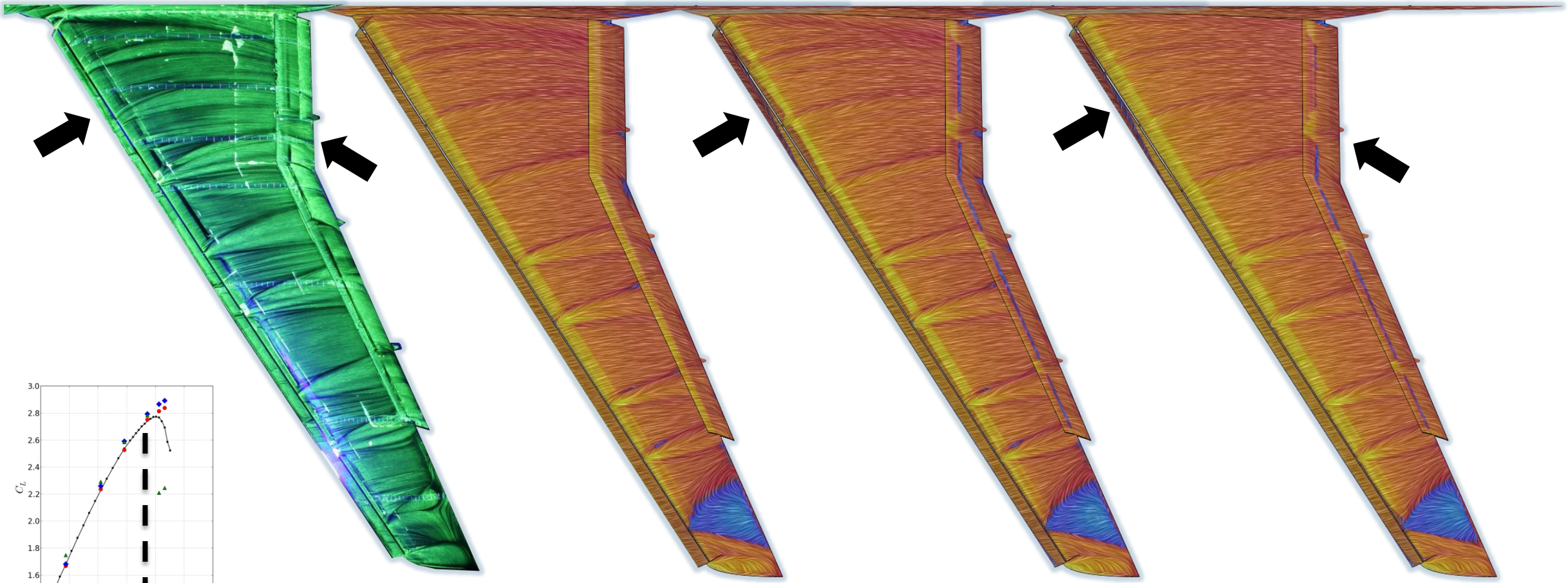
Flow visualisation on the upper wing surface

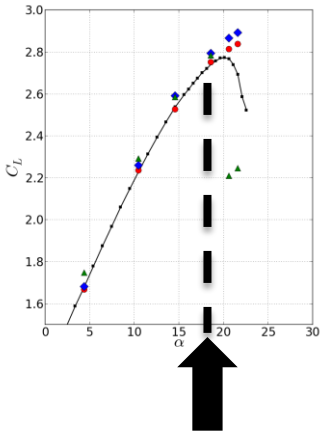
α = 18.59 deg

SIEMENS

Ingenuity for life

turbulent **γ-transition** **LagEB**





Skin Friction Coefficient

−0.005 0.000 0.005 0.010 0.015 0.020

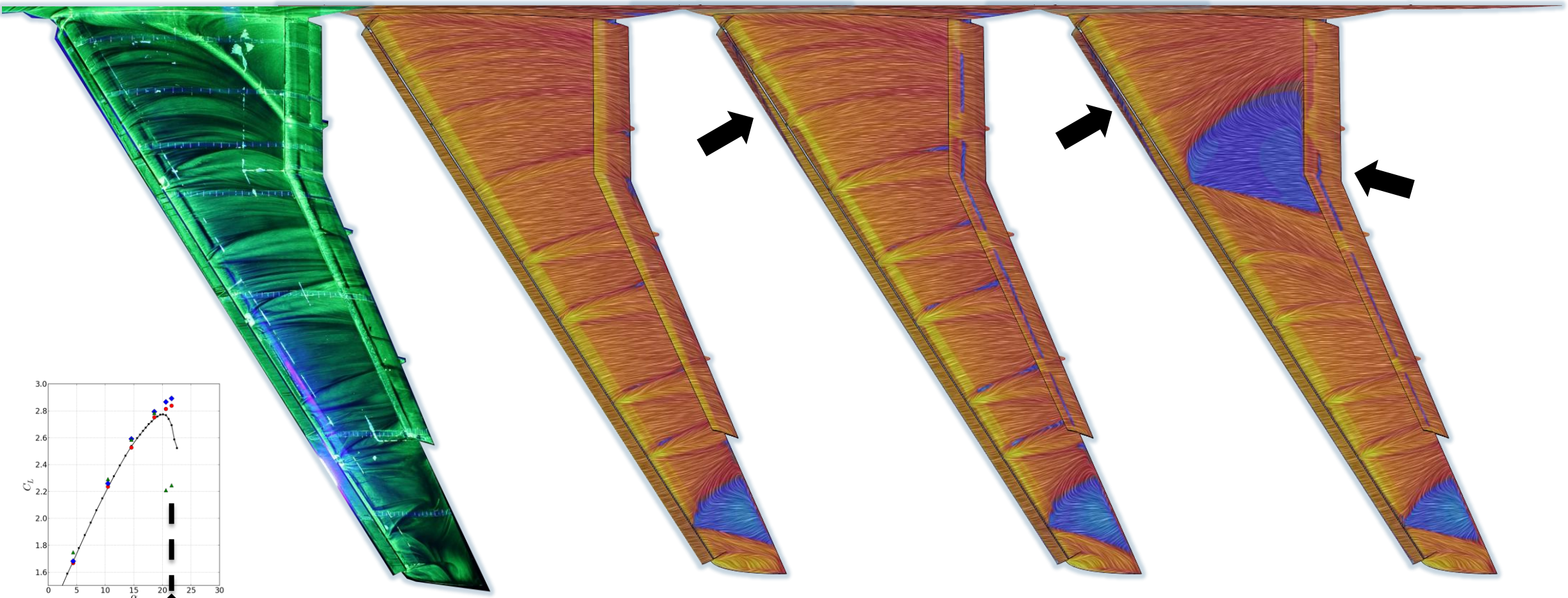
Flow visualisation on the upper wing surface

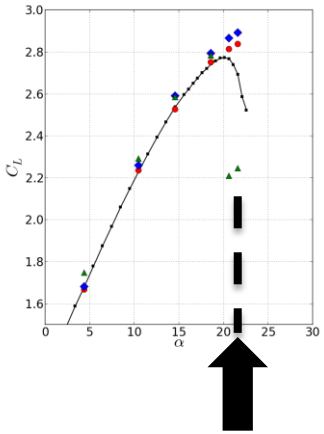
α = 21.57 deg

SIEMENS

Ingenuity for life

turbulent **γ-transition** **LagEB**





Summary

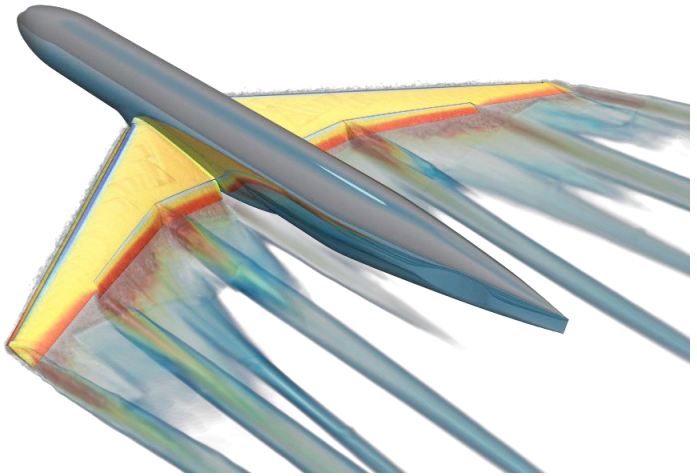
SIEMENS
Ingenuity for life

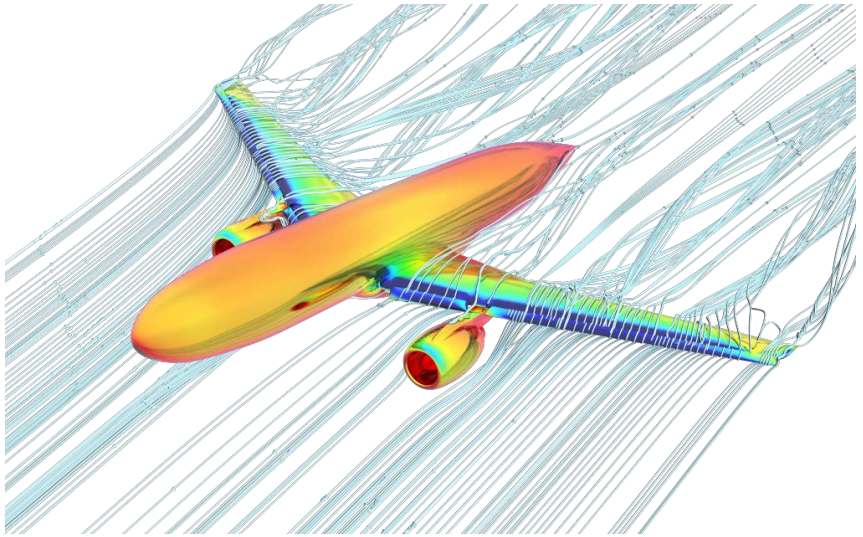
Case 1: HL-CRM

- Grid convergence study for 3 turbulent models:
  - SST
  - SA
  - LagEB
- Investigation of impact of gap sealing

Case 2: JSM

- Nacelle installation study
- Investigated impact of transition modelling





SIEMENS
Ingenuity for life

ACKNOWLEDGEMENTS

- Vivek Ahuja
- Girish Bhandari
- Doru Caraeni
- Kyle Hord
- Shaunak Pai
- Michael Stubert
- Venkat Venkatakrishnan
- John Wilson

Contact

SIEMENS
Ingenuity for life

Marian Zastawny
Development Support Engineer (Turbulence & Aeroacoustics)
Siemens Product Lifecycle Management Inc.

200, Shepherds Bush Green
W6 7NL London
United Kingdom

Phone: +4 20 7471 6301
Mobile: +44 0 796 491 1109

E-mail:
marian.zastawny@siemens.com

siemens.com