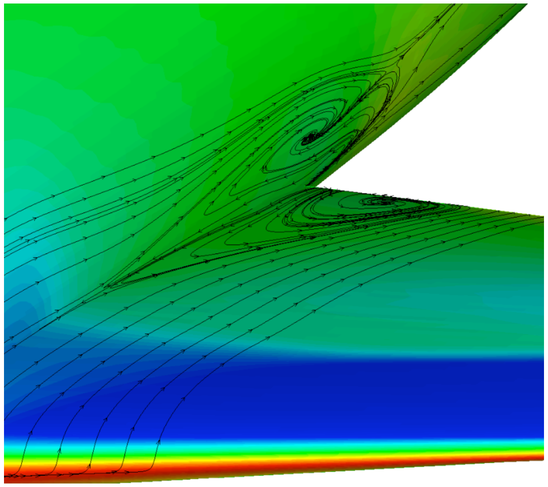
DPW3 results for the DLR F6 WB and WBF



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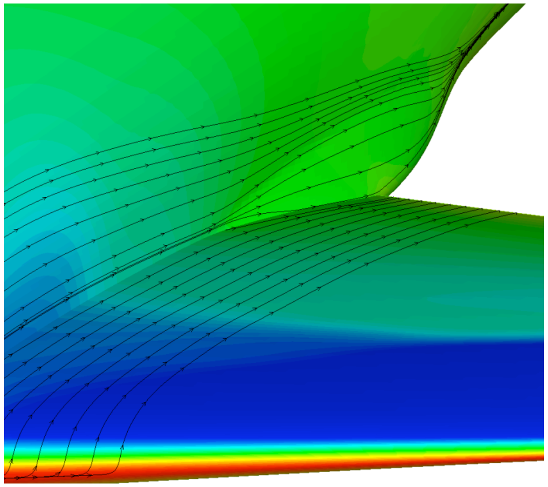


Third Drag Prediction Workshop
San Francisco, CA, June 3-4, 2006

Outline

- Numerical algorithm
- Turbulence models
- Platforms/Wall clock times
- Results
- Future work

Numerical algorithm

- Cell-centered Finite Volume discretization.
- Central discretization of the advective terms plus scalar artificial dissipation for the mean flow.
- Upwind discretization of the advective terms for the turbulence equations, either 1st or 2nd order (with MinMod limiter).
- Compact central discretization of the viscous fluxes.
- Geometrical multigrid in combination with Runge-Kutta type explicit smoothers for the mean flow.
- Segregated solution of the turbulence equations using DD-ADI schemes. No multigrid for the turbulence.
- “Automatic” parallelization $\Rightarrow$ #processors independent of #blocks

Turbulence models

- Spalart-Allmaras.
  - Used in fully turbulent mode.

- v^2-f, 4-equation model developed by Durbin.
  - k-ε model extended with two additional equations.
  - v: fluctuation energy normal to the wall (channel flow)
  - f: models non-local effects, in particular the influence of the wall
  - solved as two 2X2 coupled systems.
  - free-stream eddy-viscosity ratio ≥ 3.6 to avoid negative k.

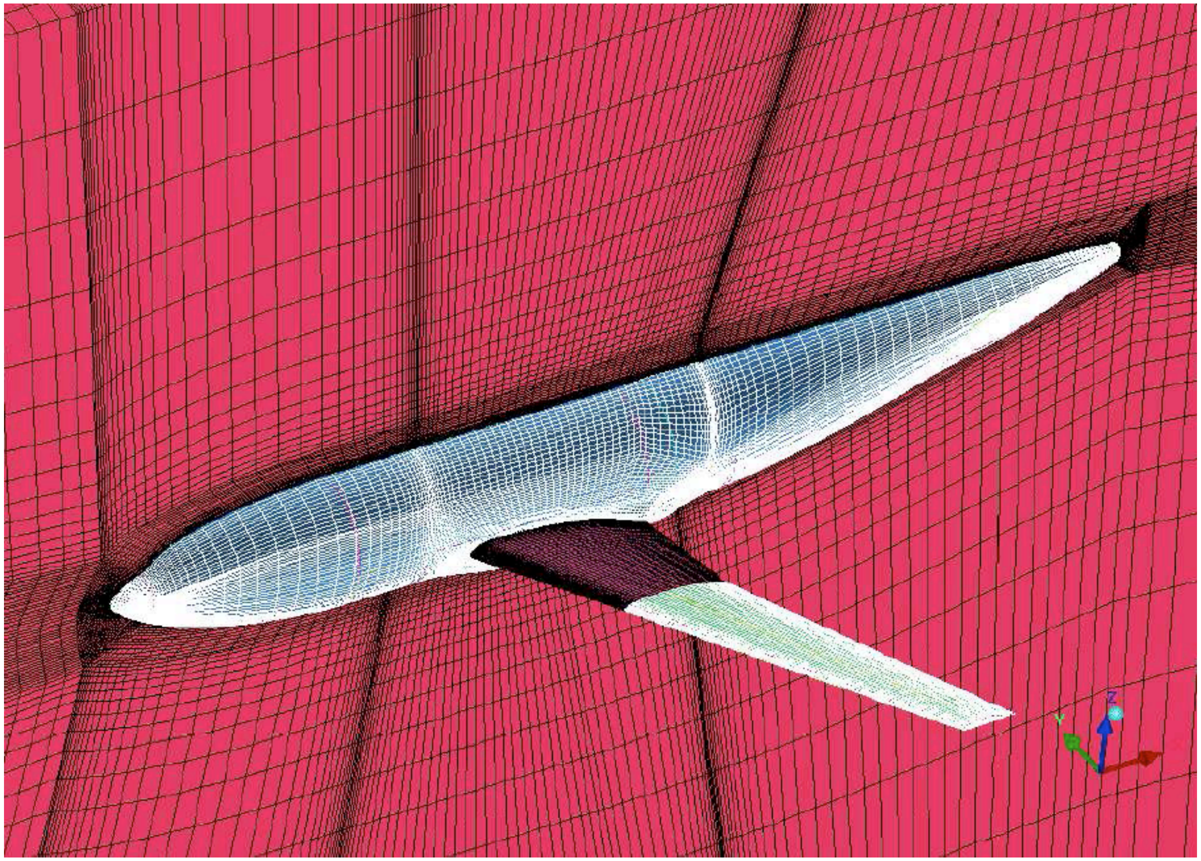
Platforms/Wall clock times

- Linux cluster, 3.6 GHz dual Xeon processors.
  - Wall clock time, 32 processors, medium mesh (9.5 million cells): 5-10 hours

- ASCI QSC (Los Alamos), 1.25 GHz Dec Alpha processors.
  - Wall clock time, 64 processors, medium mesh (9.5 million cells): 7-14 hours

Grid (modified Icem grid)

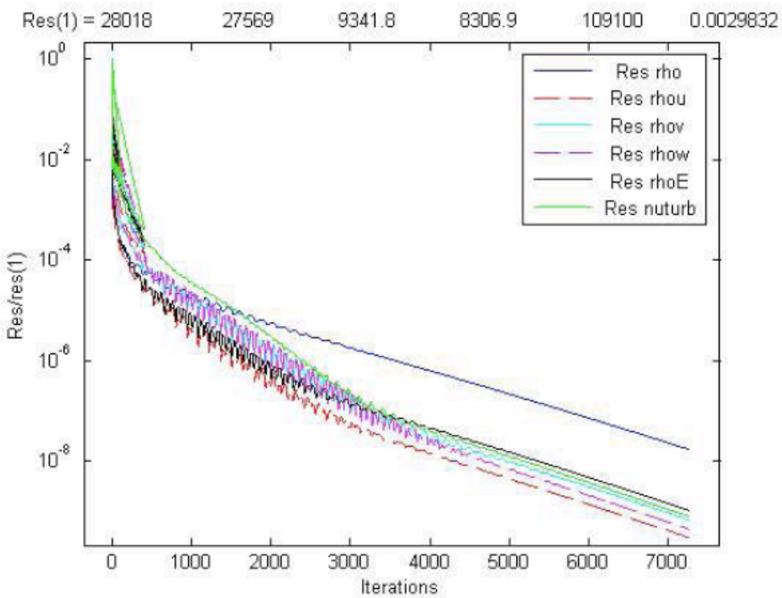
- Higher resolution on the wing and fuselage
- Less points in the farfield
- 3-level multigrid
- Coarse grid: 3 million cells. Medium grid: 9.5 million cells.



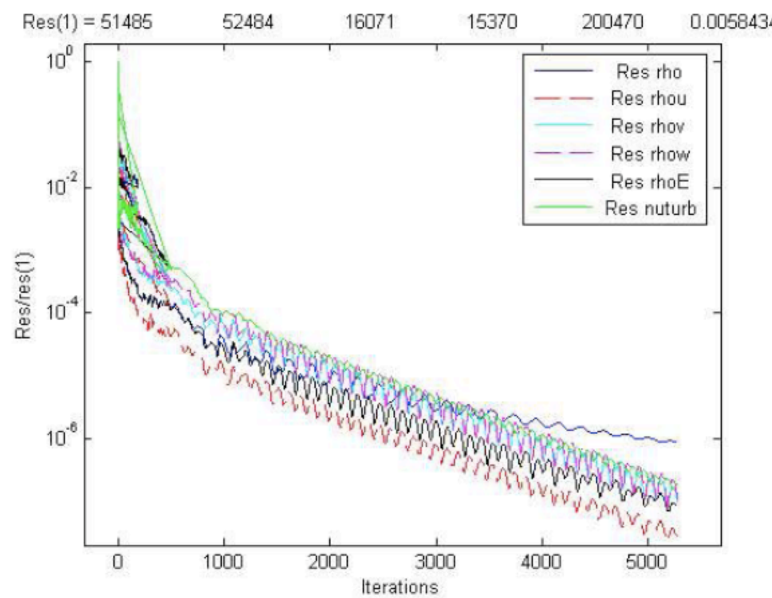
Convergence Wing Body plus FX2B fairing

$M_\infty = 0.75$, $\alpha = -3.0°$, $Re_c = 5 \cdot 10^6$, c = 141.2 mm, Spalart-Allmaras model

Coarse grid



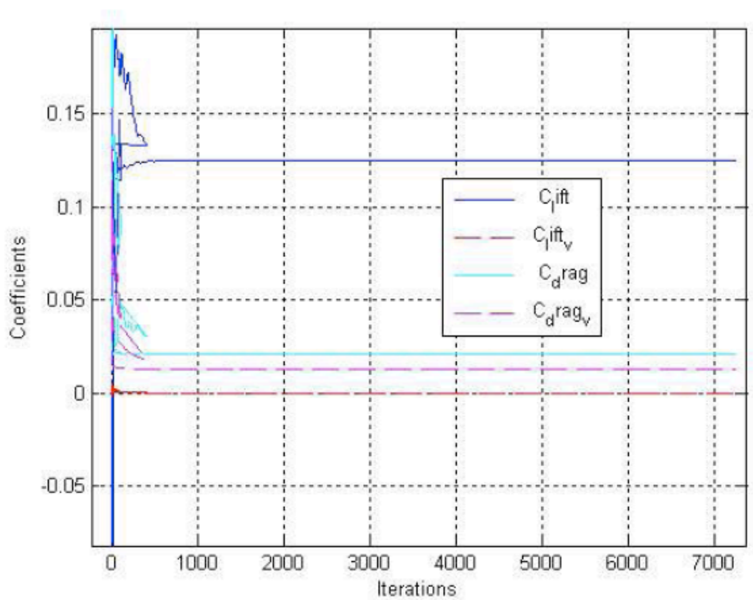
Medium grid



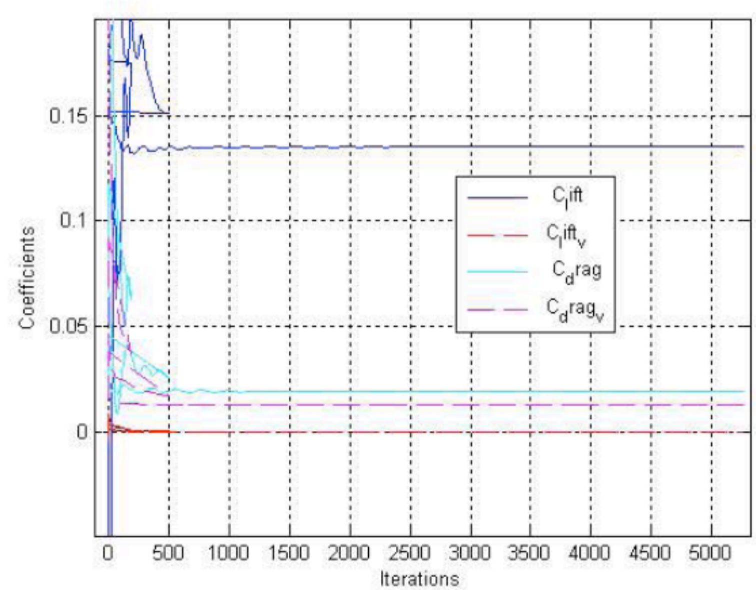
Convergence Wing Body plus FX2B fairing

$M_\infty = 0.75$, $\alpha = -3.0°$, $Re_c = 5 \cdot 10^6$, $c = 141.2$ mm, Spalart-Allmaras model

Coarse grid



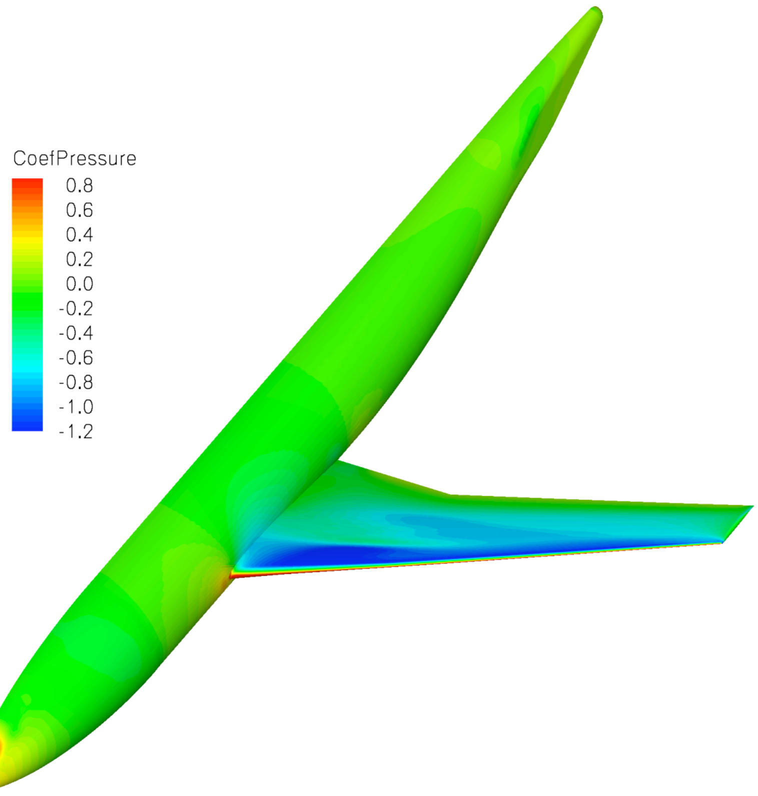
Medium grid



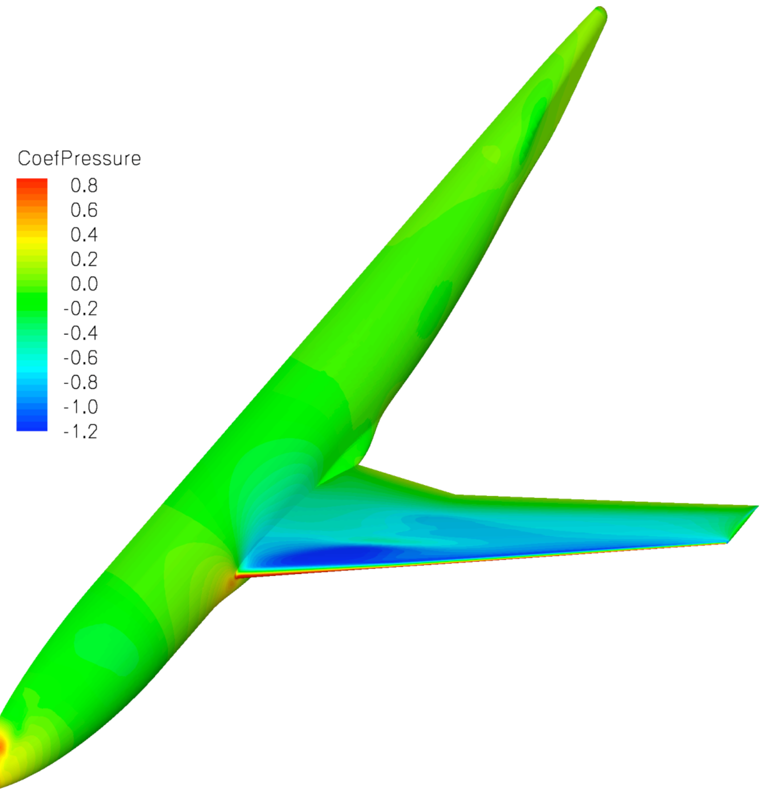
Pressure distributions

$M_\infty = 0.75$, $C_L = 0.5$, $Re_c = 5 \cdot 10^6$, $c = 141.2$ mm, Spalart-Allmaras model

Wing body

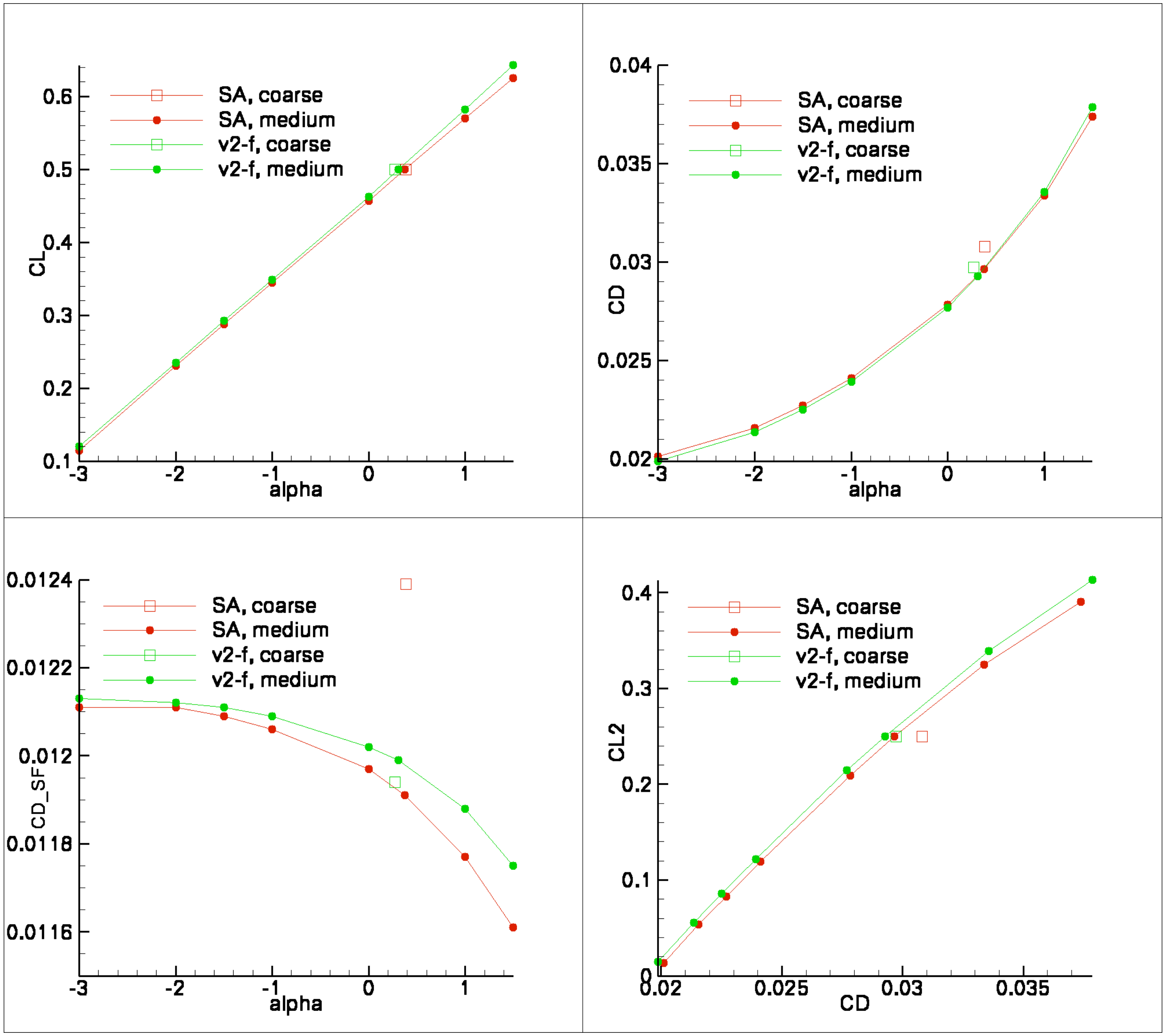


Wing body plus FX2B fairing



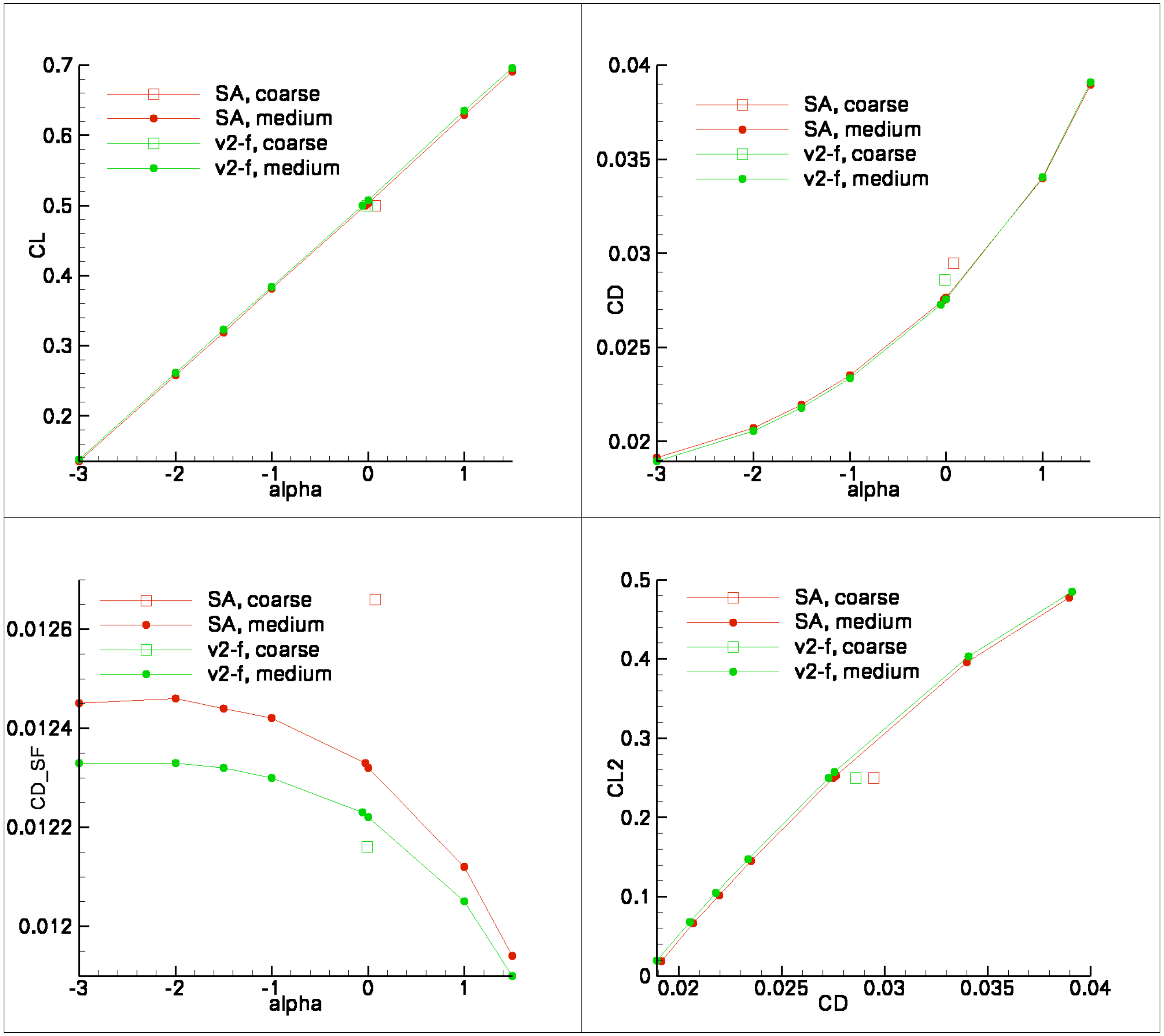
Coefficients Wing Body

$M_\infty = 0.75$, $Re_c = 5 \cdot 10^6$, $c = 141.2$ mm



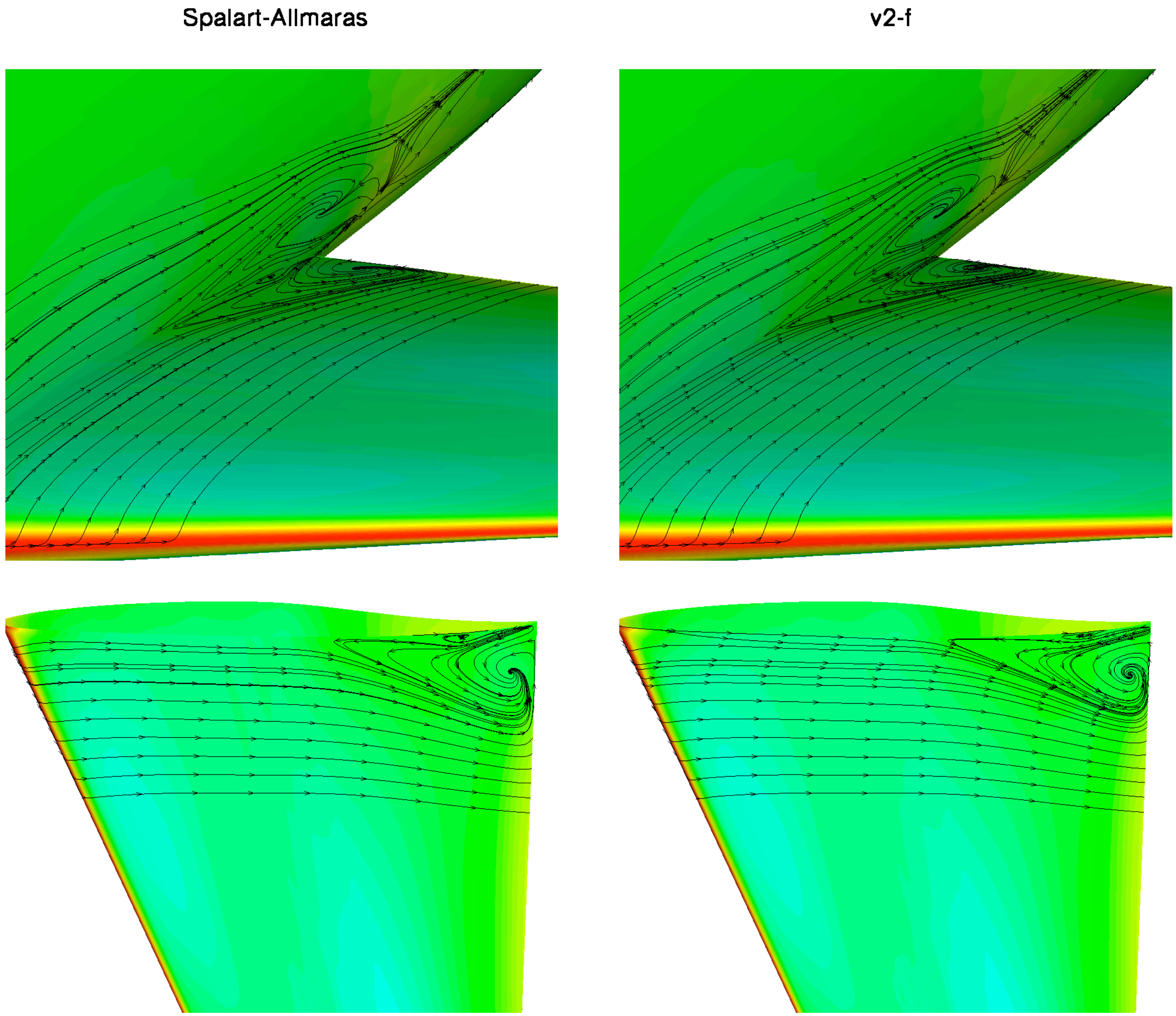
Coefficients Wing Body plus FX2B fairing

$M_\infty = 0.75, \; Re_c = 5 \cdot 10^6, \; c = 141.2 \text{ mm}$



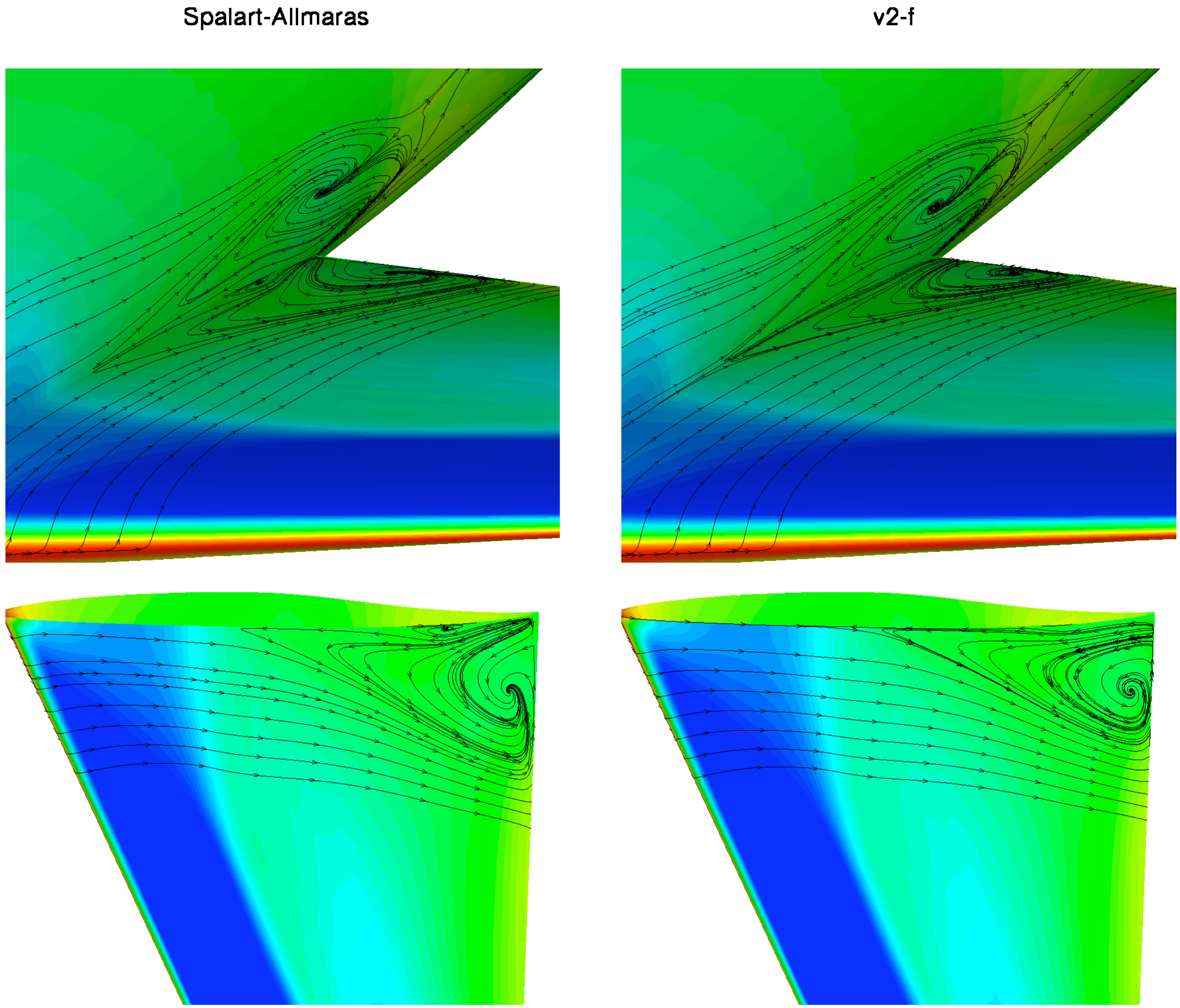
Oilflow Patterns (1)

Wing body, $M_\infty = 0.75$, $\alpha = -3.0°$, $Re_c = 5 \cdot 10^6$, c = 141.2 mm



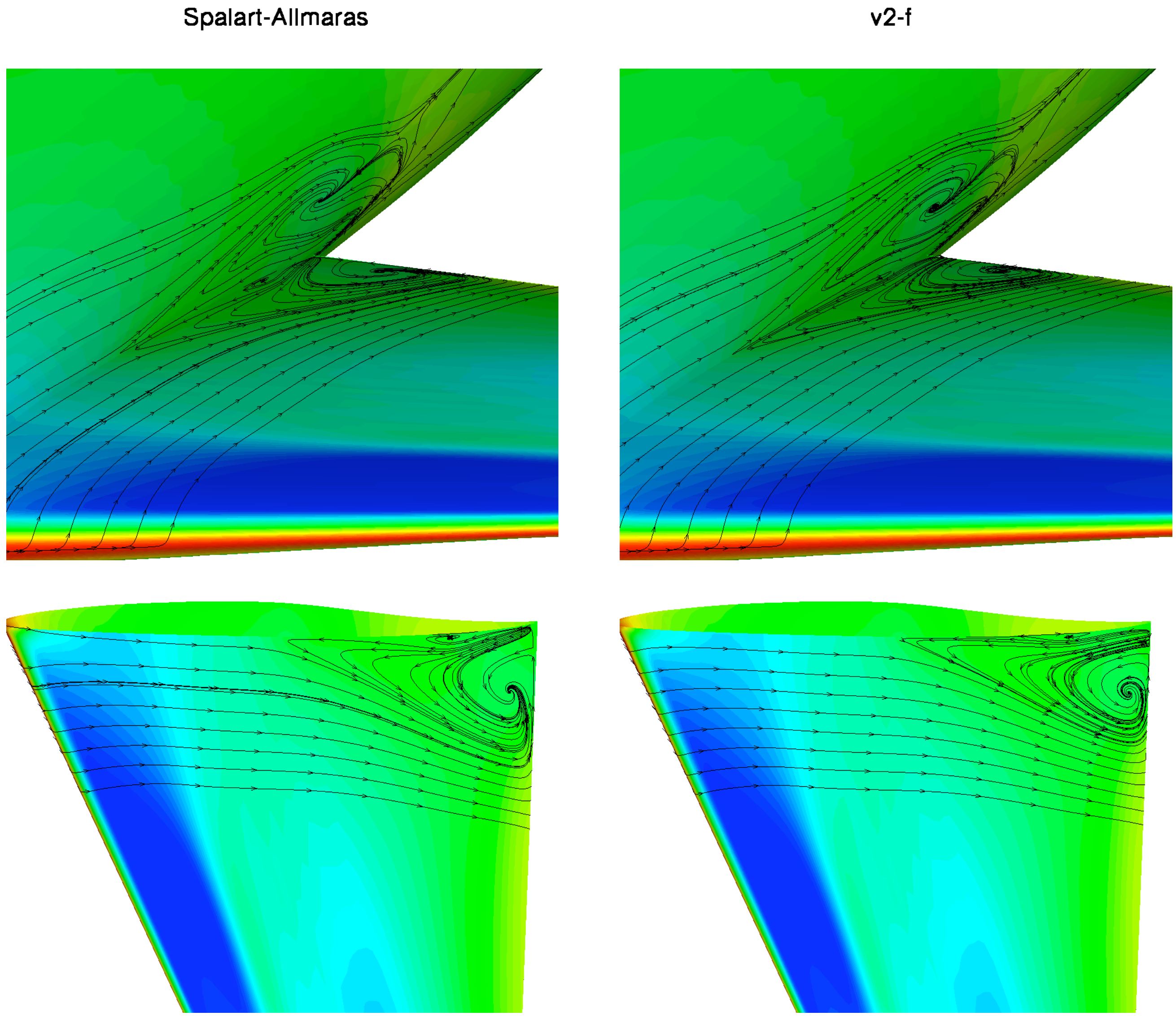
Oilflow Patterns (2)

Wing body, $M_\infty = 0.75$, $\alpha = 1.5°$, $Re_c = 5 \cdot 10^6$, $c = 141.2$ mm



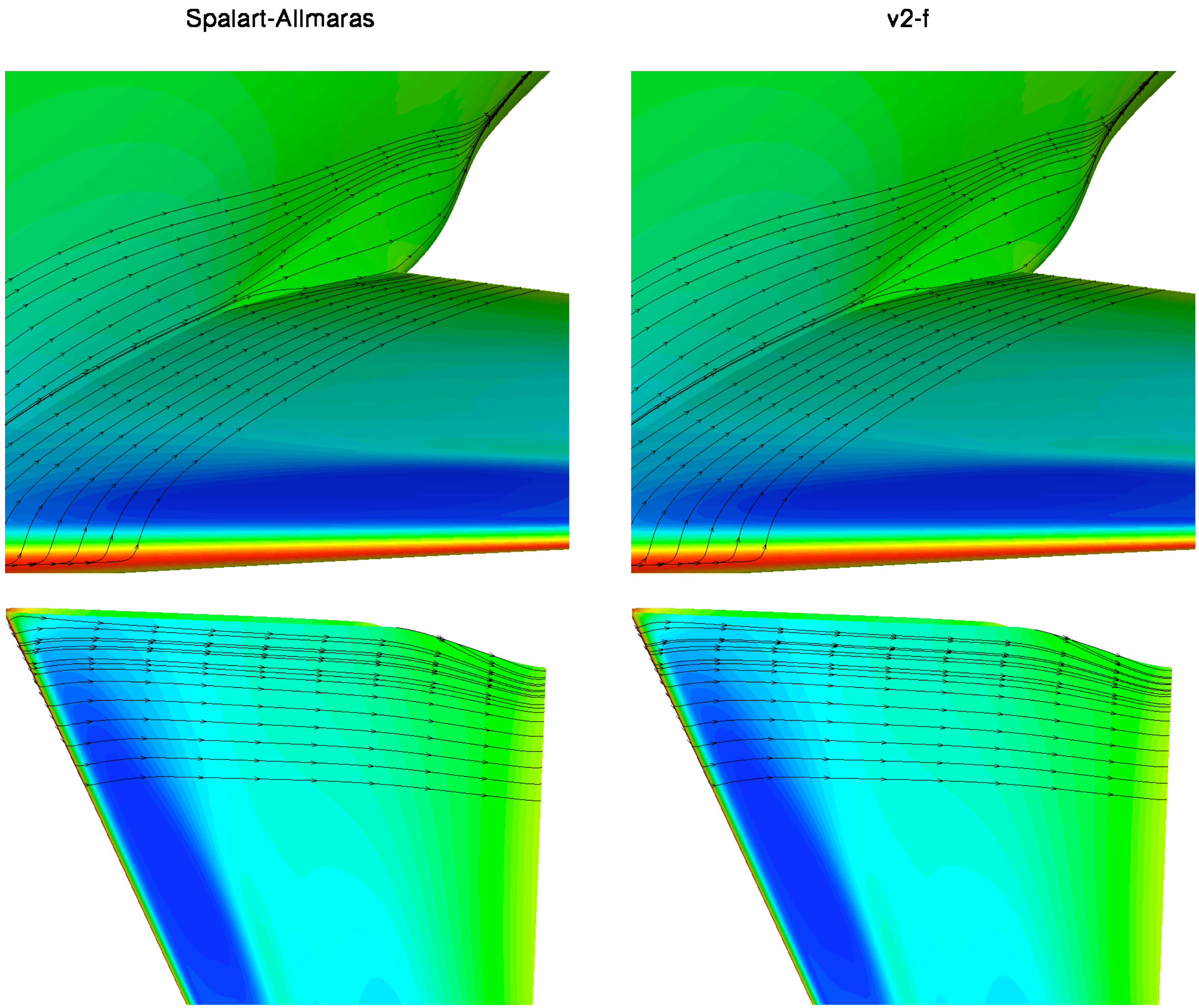
Oilflow Patterns (3)

Wing body, $M_\infty = 0.75$, $C_L = 0.5$, $Re_c = 5 \cdot 10^6$, c = 141.2 mm



Oilflow patterns (4)

Wing body FX2B fairing, $M_\infty = 0.75$, $C_L = 0.5$, $Re_c = 5 \cdot 10^6$, $c = 141.2$ mm



Future work

- Vertex-centered discretization (possibly higher order) under development.
- DD-ADI schemes for the mean flow to speed up convergence.
- Use other turbulence models, e.g. k-ω, Menter's SST.
- Perform the fine grid computations.
- Abstract submitted for Reno 2007.