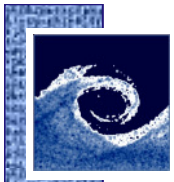

Large Eddy Simulation of Flow Around an Airfoil

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RAF6-E airfoil geometry

The project evaluation:

#1 initial idea: fan + CAA

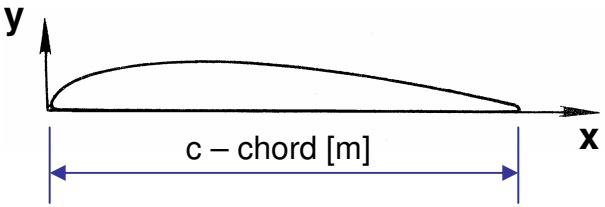
#2 flow field with LES

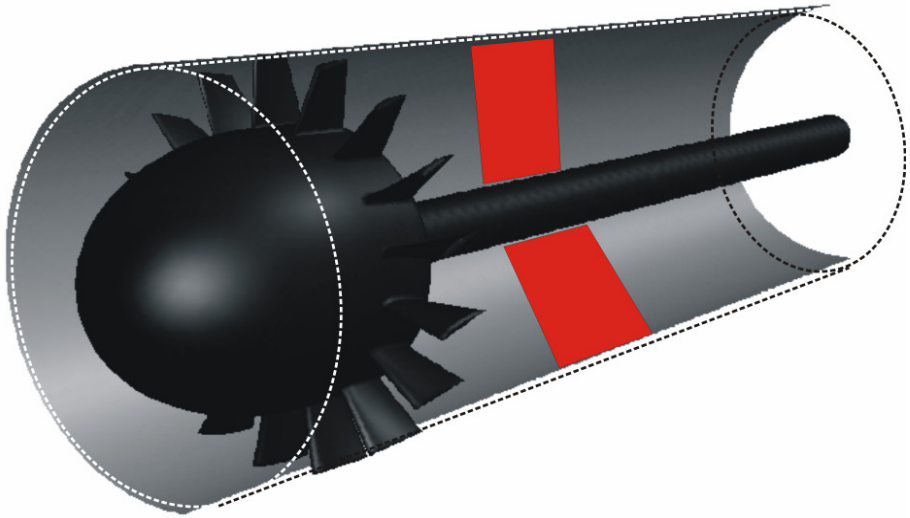
#3 fan → airfoil

#4 LES with zonal approach

#5 Zonal/hybrid RANS/LES approach in two steps

Airfoil geometry	RAF-6E
Reynolds number $Re = \frac{U_0 c}{\upsilon}$	$1.22 \cdot 10^5$
Mach number	~0.06
Incidence	5°

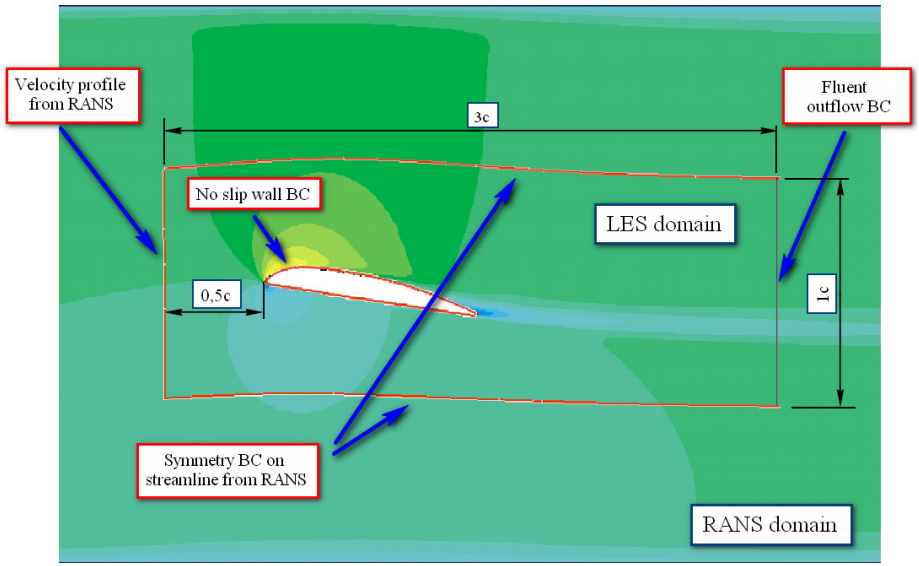




- Simple fan blade geometry
- Flat pressure side
- Available in-house measurements data
- Max. thickness at 0,103c
- Max. thickness location is 0,35c.
- LE radius is 0,0115c.
- TE radius is 0,0076c.

Grid parameters

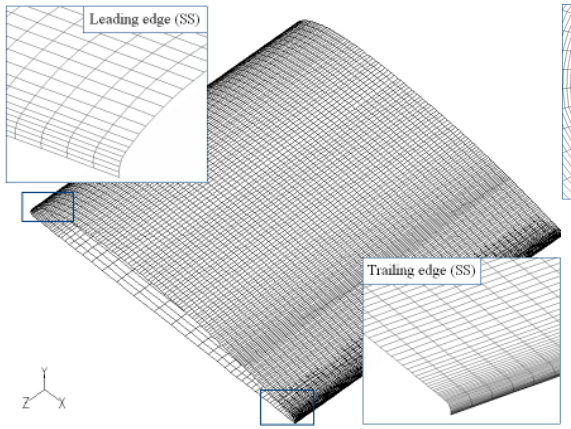
- O-H type, structured mesh
- Hexahedron cells
- First cell at LE: $2.5*10^{-4}c$
- First cell at TE: $4.1*10^{-4}c$
- $y^+<1$
- Cell size growth appr. 7%
- Velocity inlet profile coming from the previous RANS with k-e simulation

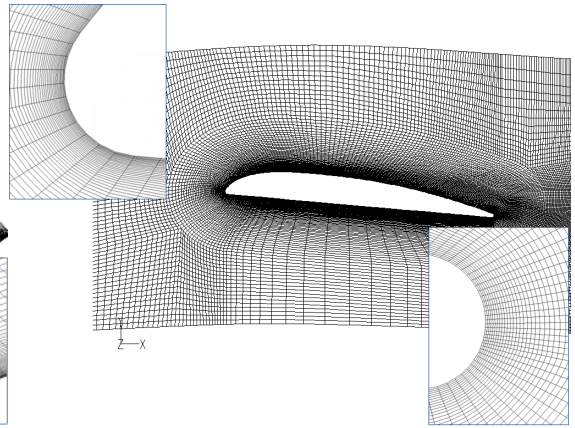


Wake length	1.5c
Domain length	3c
Domain width	Depend on the case

Spanwise extension (L_z)	Spanwise resolution	Grid size
1c	50	2 006 150
0.5c	50	2 006 150
0.25c	50	2 006 150
0.125c*	50	2 006 150
0.25c*	25	1 003 075
0.5c*	50	2 414 150
0.5c*	100	4 012 300

* Results without postprocessing

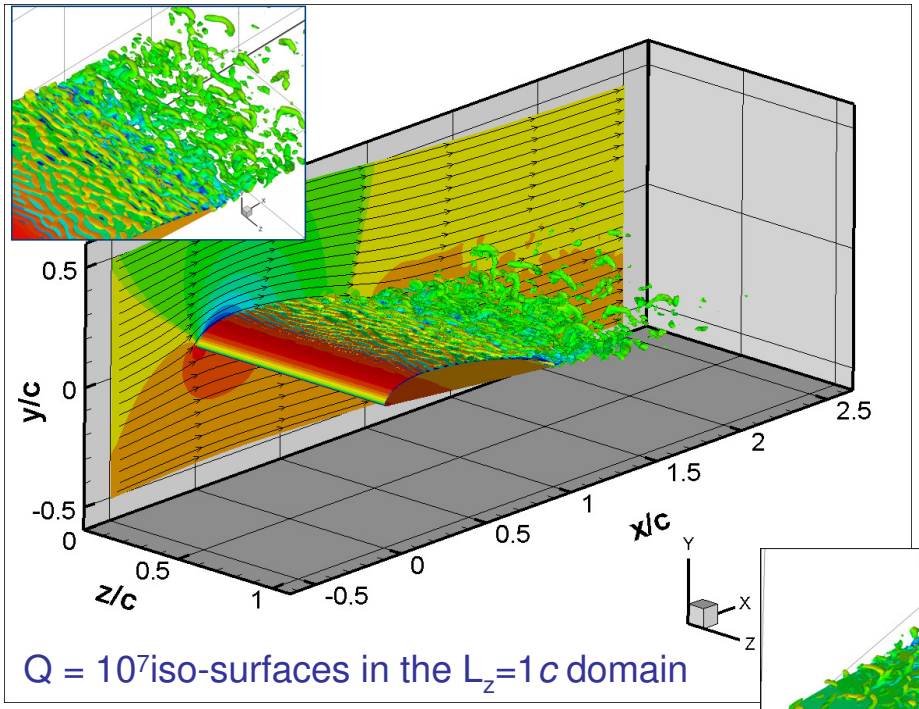




Solver

- Finite volume solver **ANSYS Fluent 6.3** & ANSYS Fluent 12.0.4 beta
- **Cell centred** collocated variable arrangement
- **Constant density** solver
- **Segregated** solver for sequential solution for governing equation
- Bounded Central Differencing (**BCD**) Scheme for momentum
- Pressure in momentum equation was discretised with **standard first-order** and **second order** scheme
- The pressure and the velocity coupling in the momentum equation was absolved with the Fractional Step Method (**FSM**)
- The time discretization was realised with the non-iterative time-advance (**NITA**) scheme
- The turbulence modelling was realized with the **LES** approach, based on the **Smagorinsky Subgrid-Scale** model using the dynamic approach
- The time step for all of the simulation is set to match the required aerodynamic time resolution, to follow the Courant-Friedrichs-Lewy (**CFL**) criteria
- The time step was depend on the case. The maximum CFL number was smaller than 0.9 for every cases in each time instance

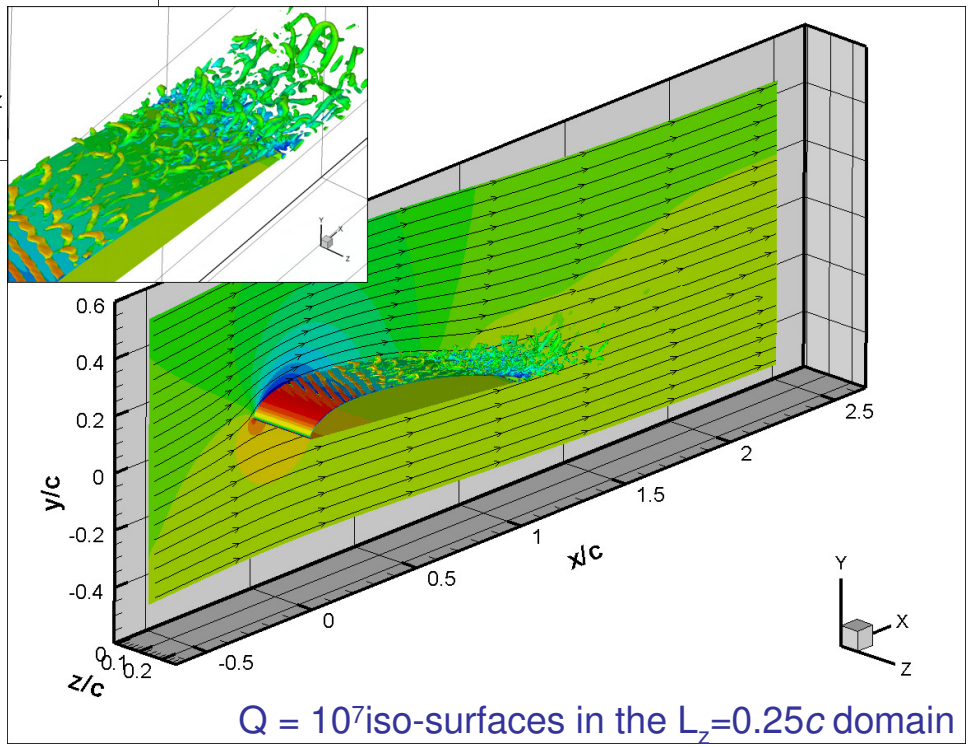
Results #1, flow field



Q = 10^7iso-surfaces in the L_z=1*c* domain

To visualize the coherent structures in the flow field, the **Q-criteria** is applied to the instantaneous flow field.

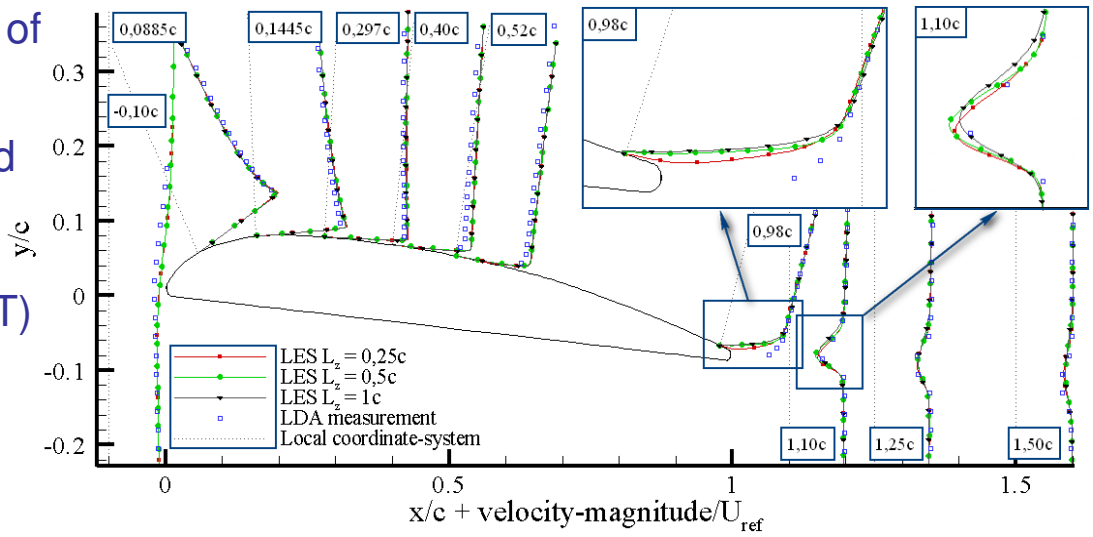
- **Time-avereged** and **spatial-avereged** data on symmetry
- Pressure distribution on symmetry
- The iso-surface coloured by magnitude-veloctiy

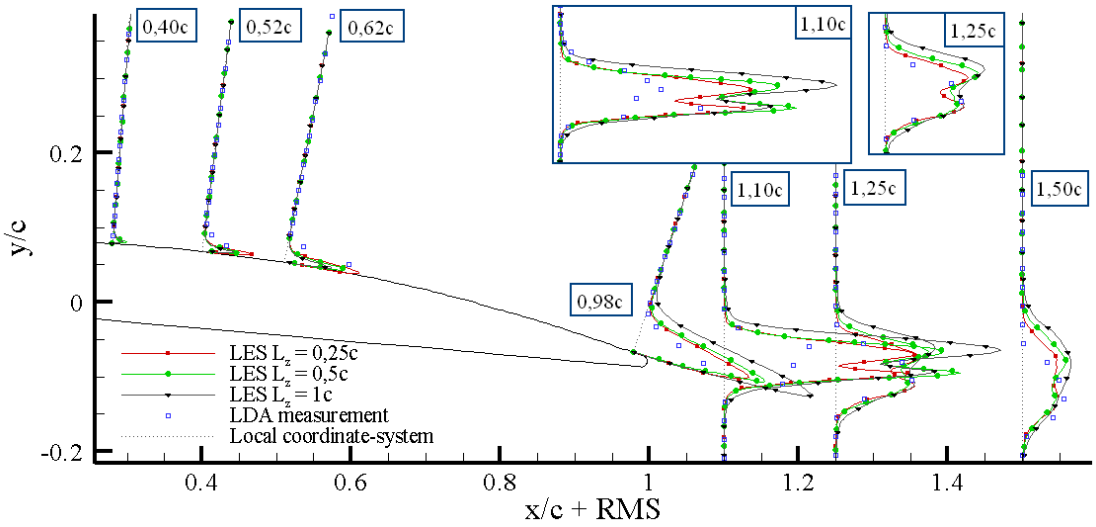


Q = 10^7iso-surfaces in the L_z=0.25*c* domain

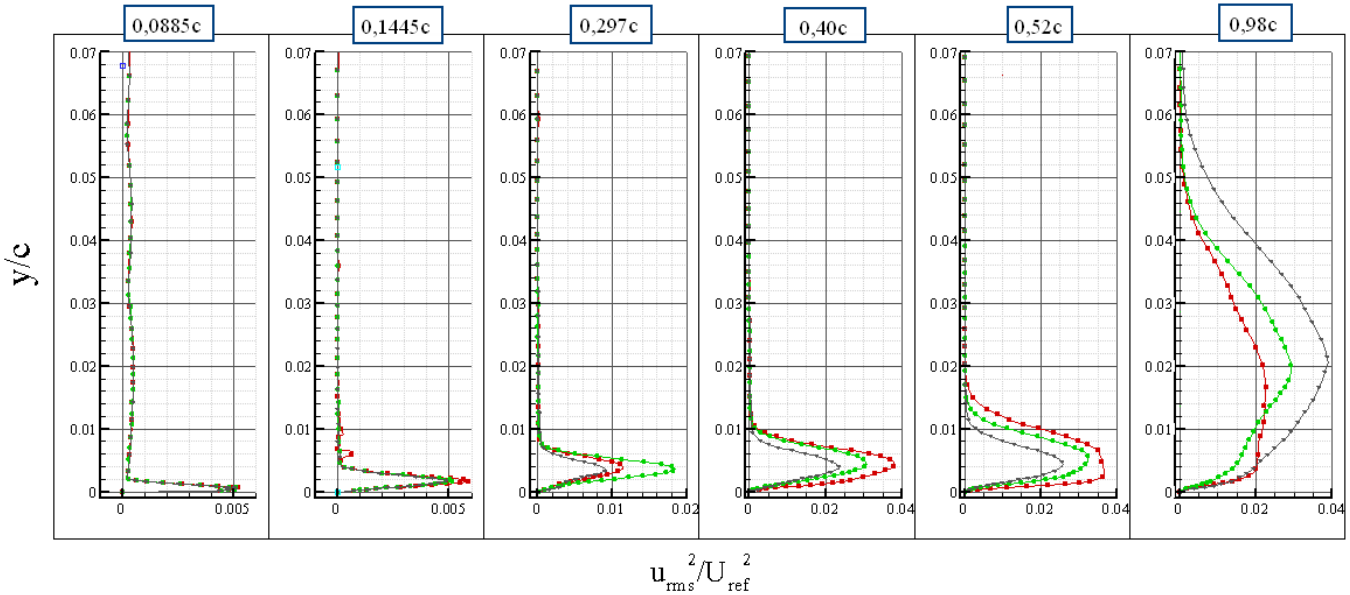
Results #2, postprocessing line

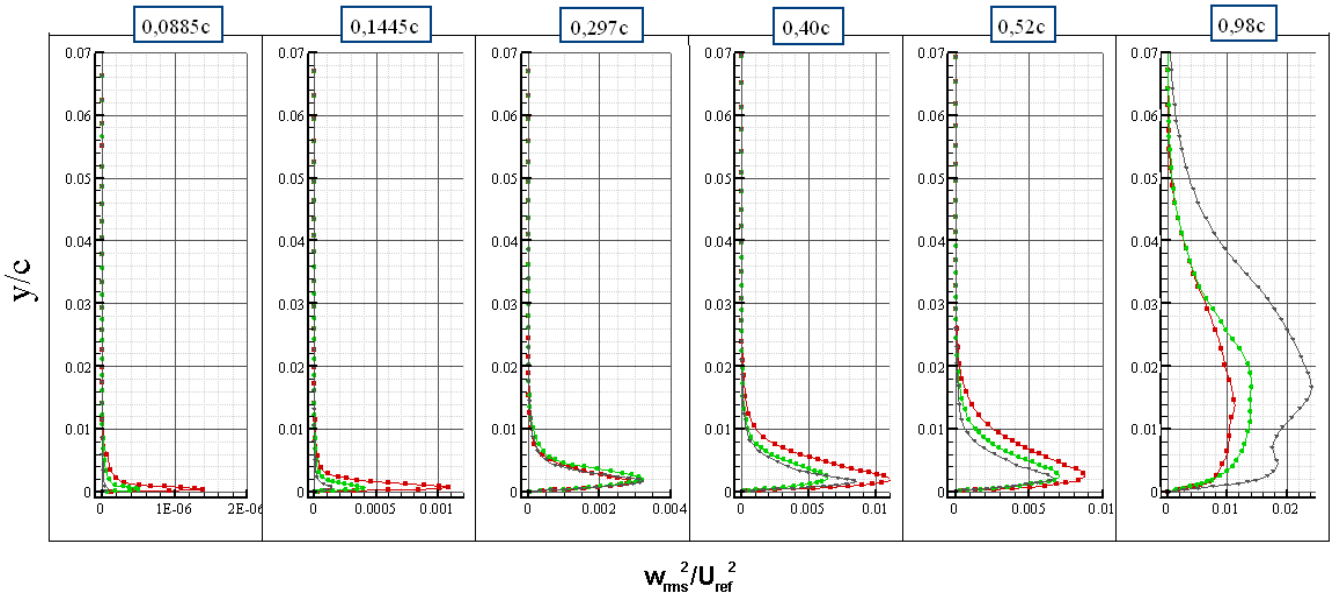
- Time averaged pressure
- **Time averaged** component of the averaged velocity.
- The postprocessing is based on the **fluctuating component** of the resolved Reynolds stress tensor (RST)

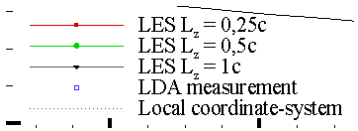




Results #3, RMS

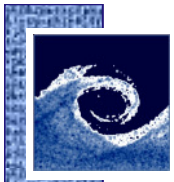






Proposal

- Postprocessing the last four simulations
- Grid dependency test
- Spatial average of wall shear-stress on the airfoil
- …



Thank your attention!