IMFT
Partnerwise presentation

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*IMFT

**IMFT-TUB

[1] Presently at CINES

***IMFT-IRIT-IMFS

Contribution of IMFT

- Task 3.2 Preconditionning aspects linked to advanced statistical (URANS) and Hybrid (DES) Turbulence Modelling

- **OES – organised Eddy Simulation – Statistical approach able to capture coherent features**
  Highly detached unsteady flows around bodies, High – Reynolds

- Anisotropic reinforcement of OES : The tensorial Eddy-Viscosity concept for non-equilibrium turbulence

- Implementation in the NSMB – Navier-Stokes MultiBlock code of the tensorial eddy-viscoosity modelling as well as of DRSM

- Study of robustness and convergence for high and for low Mach number applications

Turbulence modelling approaches used in ECINADS

- **URANS** : Spalart – Almaras (SA), k-ε, k-ω-BSL, k-ω-SST

- **OES** standard (e.g. Boussinesq based) and anisotropic (tensorial ν_t derived from DRSM),
  OES-k-ω, OES-k-ε, OES-DRSM (implemented)

- **Hybrid Turbulence modelling:**
  Delayed Detached Eddy Simulation, DDES using:
  - SA, k-w SST in the RANS part,
  - **Improved** DDES using OES k-ω in the RANS part: **DES-OES**

  -**DES-A-OES** : using the tensorial Eddy-Viscosity concept in the RANS part

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Current developments:

- **OES** with upscale turbulence modelling using stochastic forcing (Deri, Braza, Hunt, Ouvrard, ETC13 – European Turbulence Conference)
  Capturing of *thin* shear layer turbulent/non-turbulent interfaces
  Inverse cascade

Test-Cases running:

- **OAT15A : Transonic buffet over a supercritical airfoil**

- **High-Re subsonic turbulent flow around a tandem cylinder:**
  calculation of predominant frequencies for aeroacoustics of landing gear
  generic configuration

- **High-Re subsonic strongly detached turbulent flow around a rectangular plate in incidence of 14°**

- The 'IMFT's circular cylinder test-case, Re=140,000

- Current developments for advanced turbulence modelling assessment for capturing aeroelastic flutter around the AGARD wing 445.6

Representative Results

The tandem Cylinders

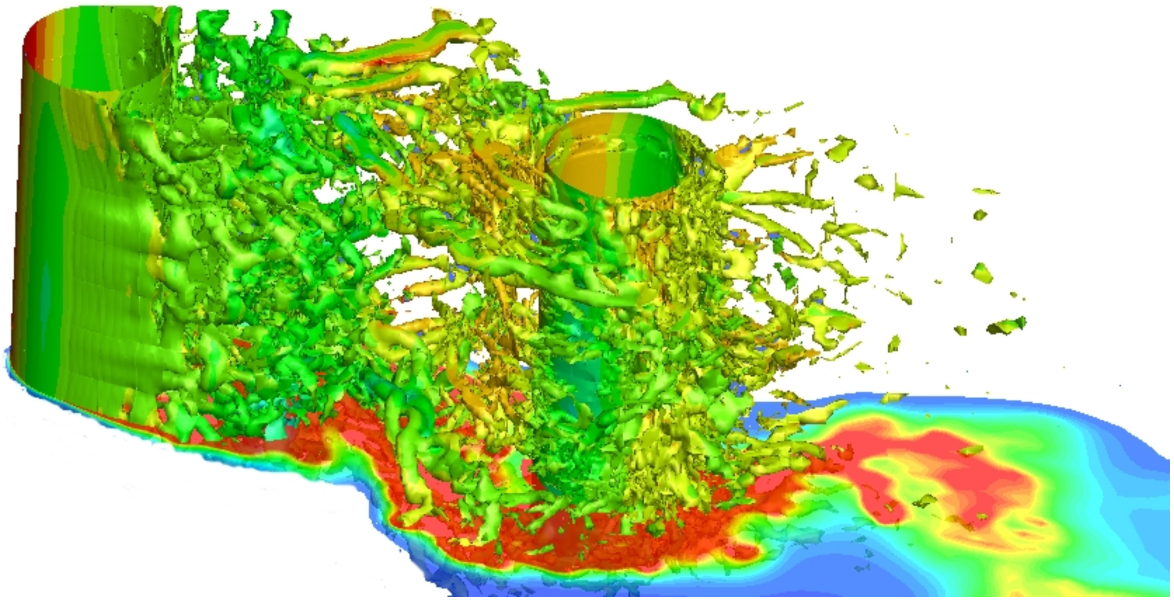
Exp. results at NASA-Langley, Jenkins et al, AIAA J. 2010 Re=1,6 x 10^5

- **Capturing of the shear layer dynamics**
  and of pressure fluctuations responsible for aerodynamic noise during landing phase

- **Capturing of the predominant frequencies and amplitudes**

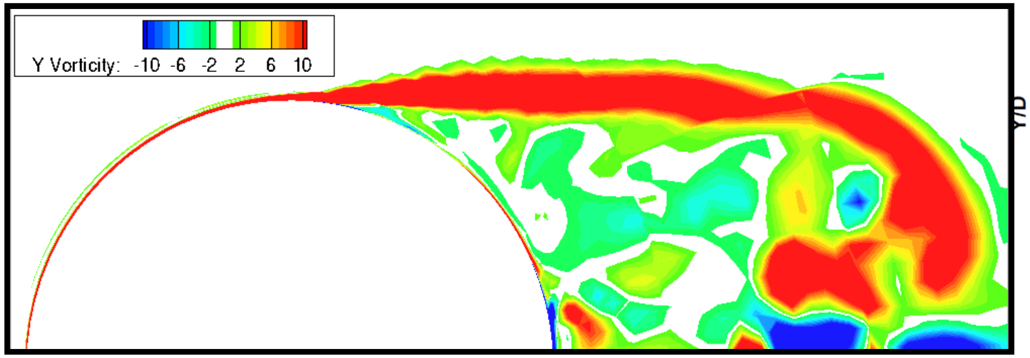
- **Assessment of the predictive abilities of turbulence modelling (statistical and hybrid, standard and improved) for capturing of thin shear layer dynamics**

ST11 – Tandem Cylinder

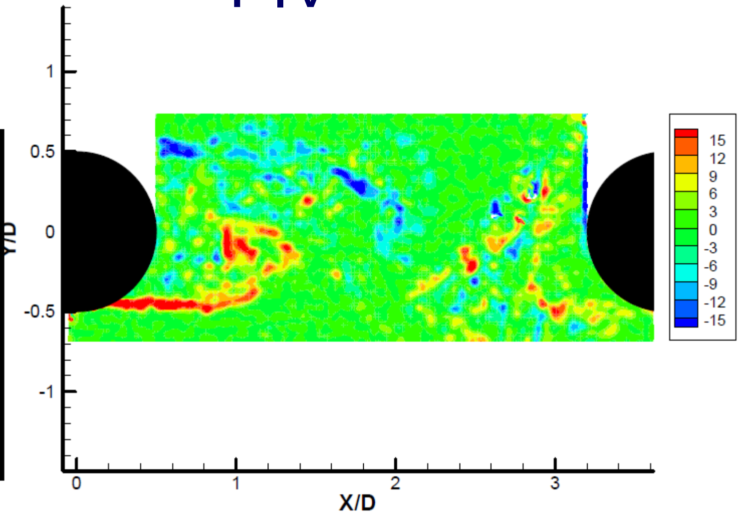


DDES ***k*-*ω***-OES

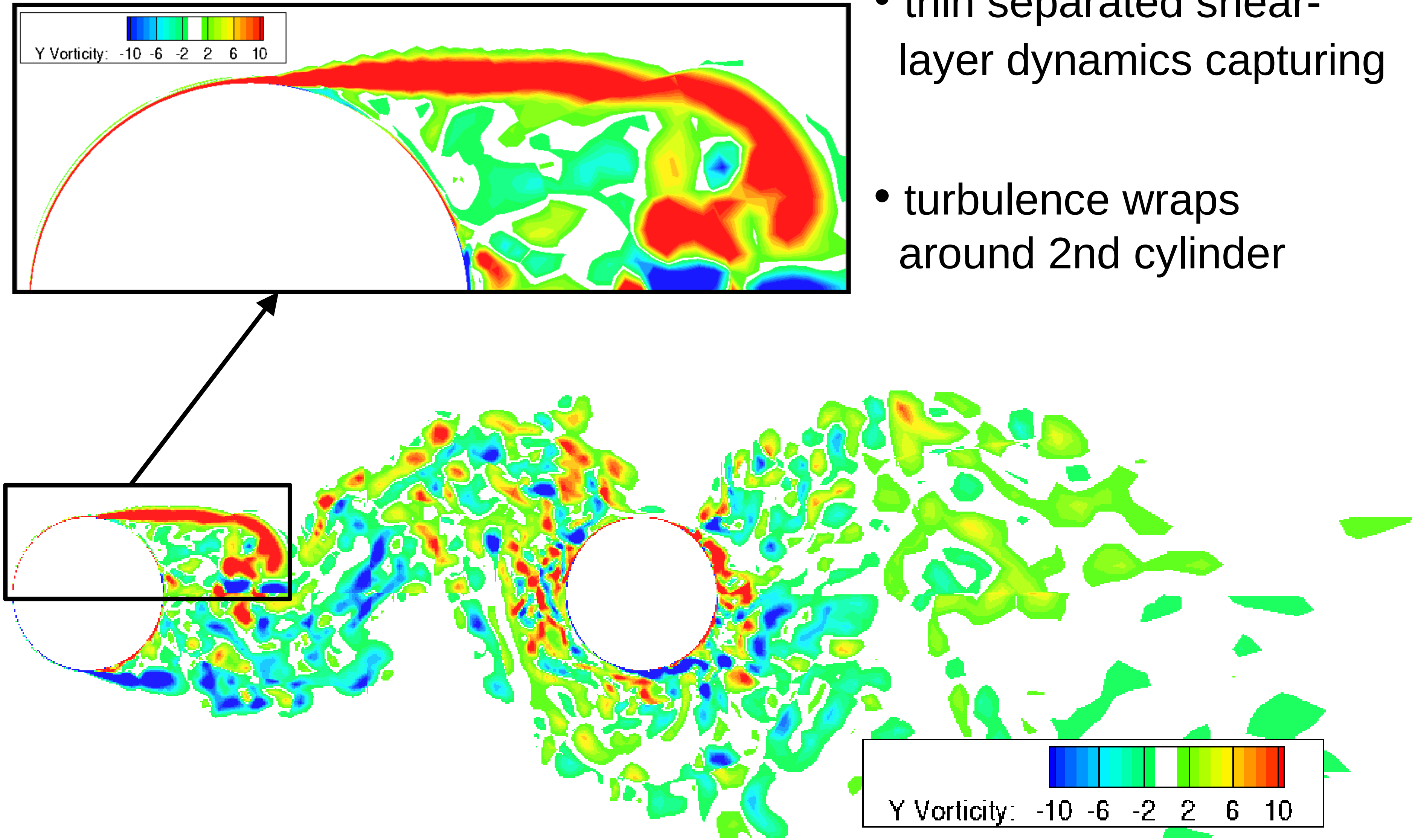
Aerodays March 2011, M. Gual-Skopek



PIV

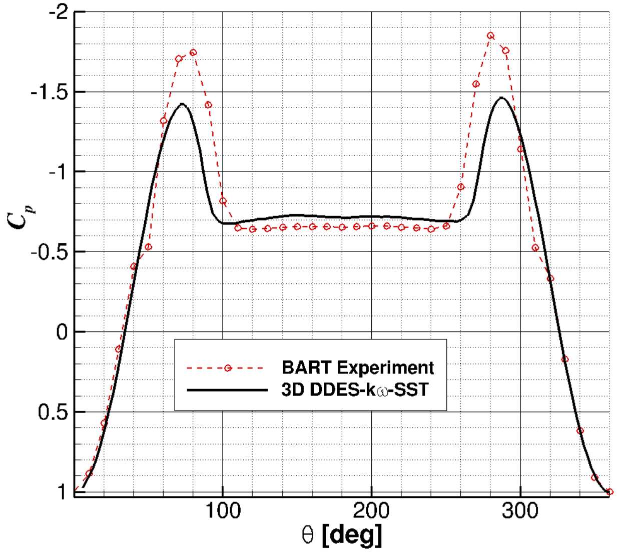


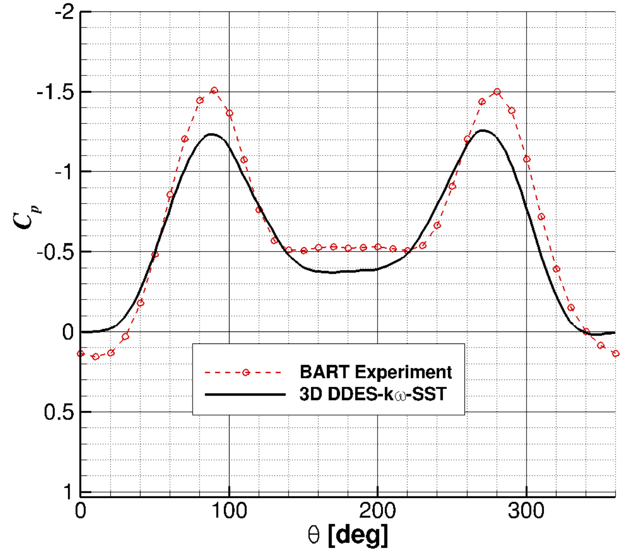
ST11 – Tandem Cylinder



- thin separated shear-layer dynamics capturing
- turbulence wraps around 2nd cylinder

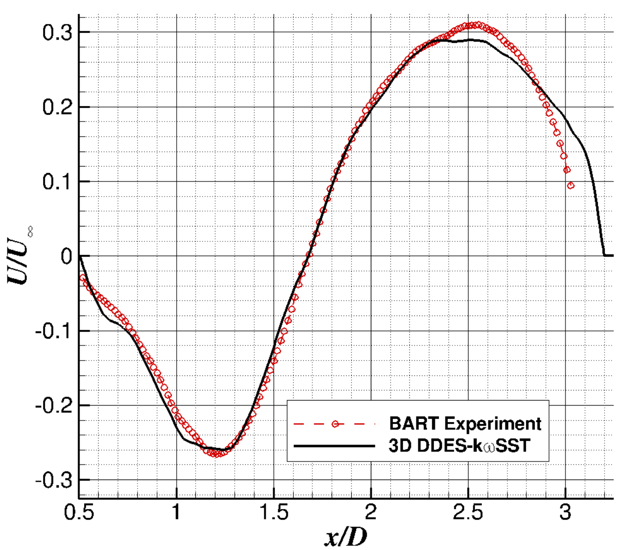
Time-averaged results

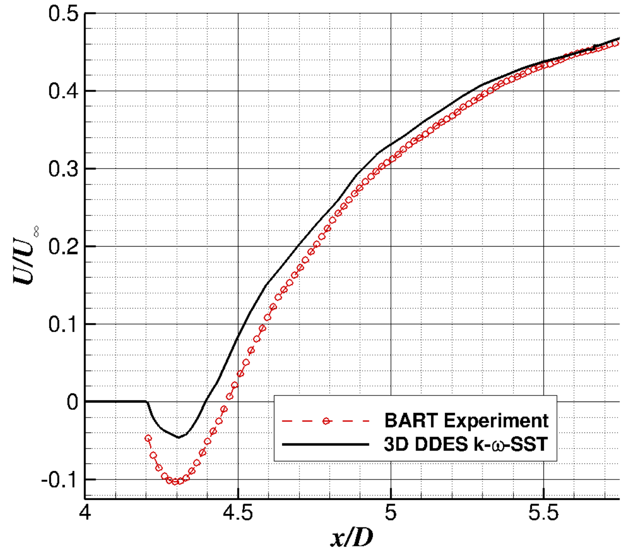




cp-curves

- 1st cylinder
- 2nd cylinder

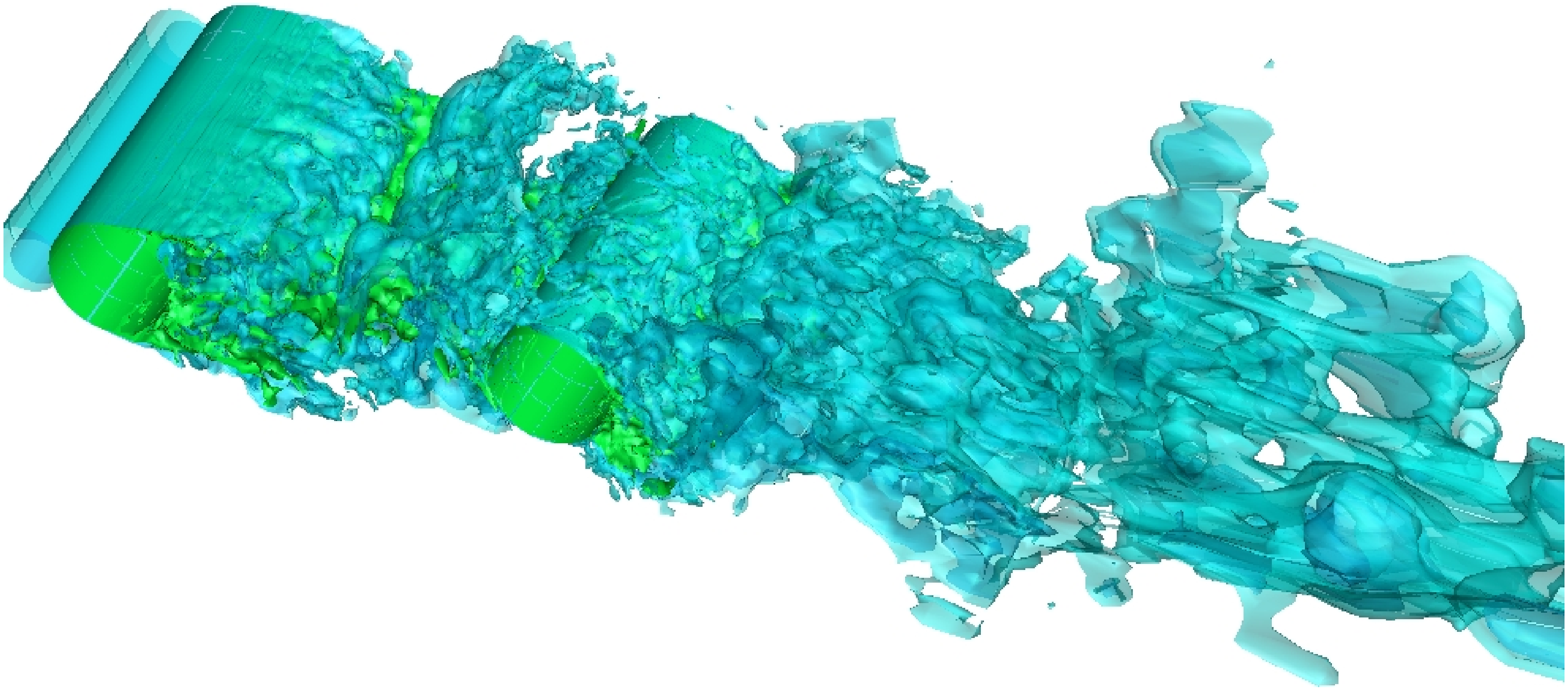




Velocity profiles

- Gap region
- Rear flow

ST11 – Iso-velocity profiles



The OAT15A

Exp. results by Jacquin et al, ONERA Meudon, AIAA J. 2009, 2010

- **Capturing of the natural unsteadiness of the buffet phenomenon arising at Mach number (0.7-0.8)**
- **Study of the shock-vortex interaction with the von Karman mode in the wake**
- **Assessment of the predictive abilities of turbulence modelling (statistical and hybrid, standard and improved) for buffet and shock-vortex interaction capturing**

3D computaitons under way

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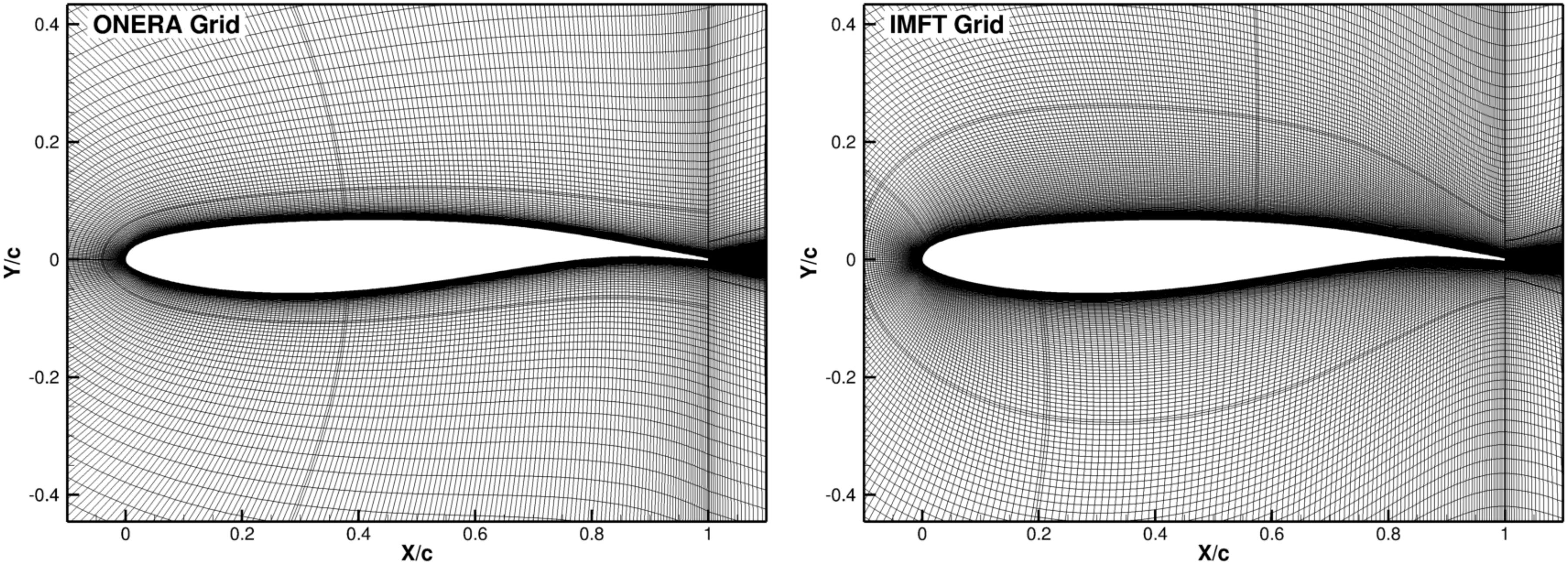
- Grid test

2D unsteady simulations using the SA model



M1: ONERA Grid: ≈ 110 000 cells in 2D 41 cells in 3D, s=0.246*c*

M2: IMFT Grid: ≈ 131 000 cells in 2D 64 cells in 3D, s=0.246*c*, **8,3 M points**

For URANS: grid-independence. For hybrid modelling: suggested grid M2

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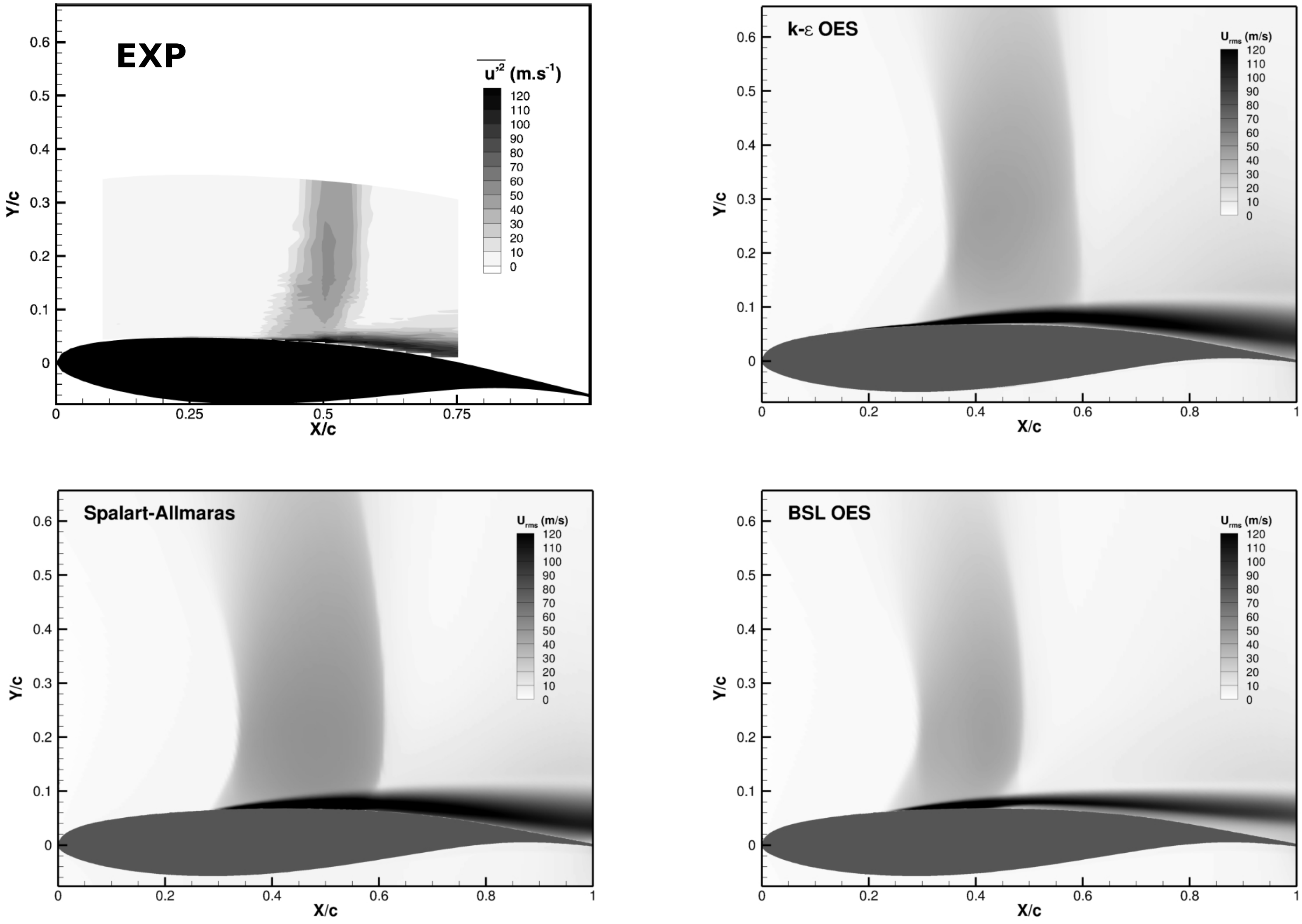
Longitudinal velocity rms fields



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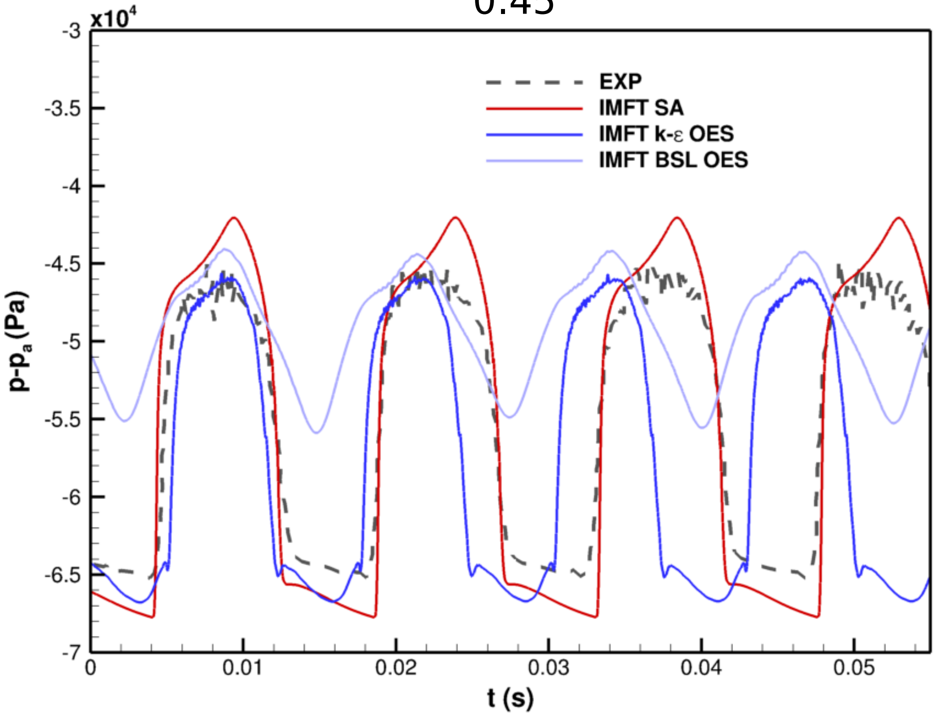
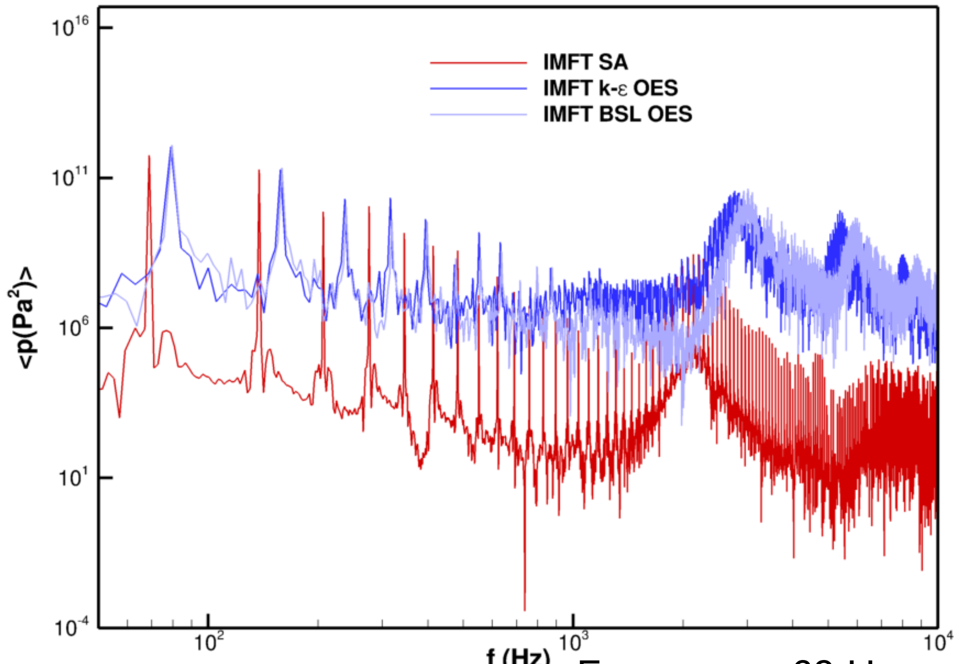
Time-evolution of surface pressure at X/c = 0.45



Pressure power spectra at X/c = 0.45



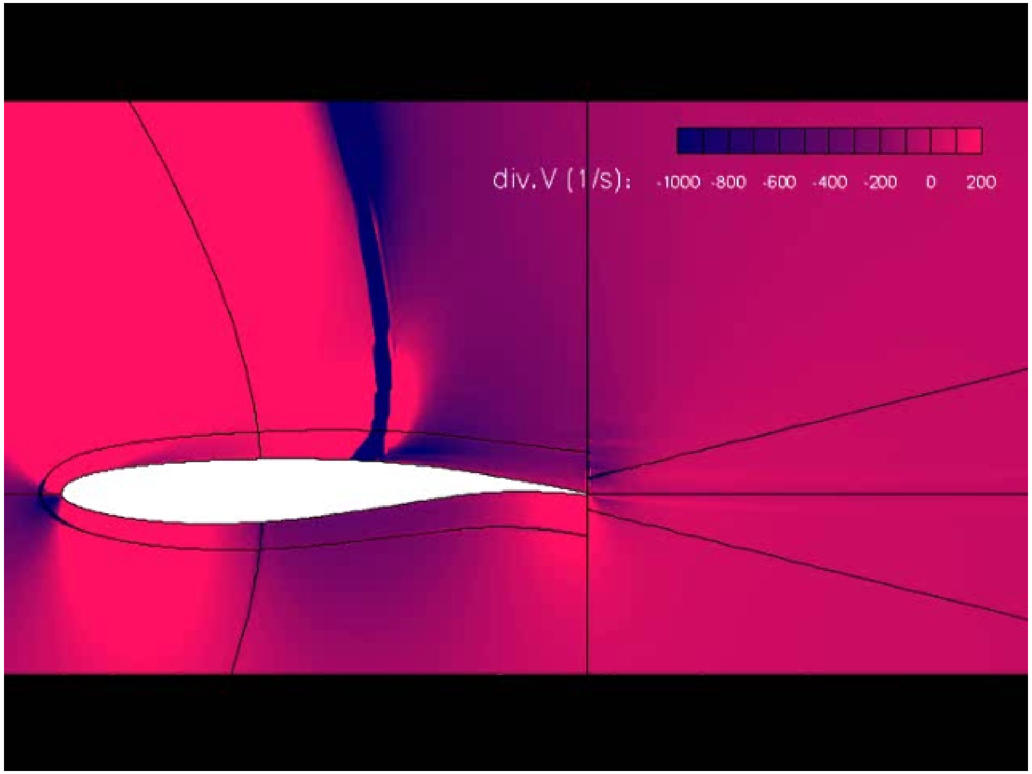
Fbuffet_exp=69 Hz

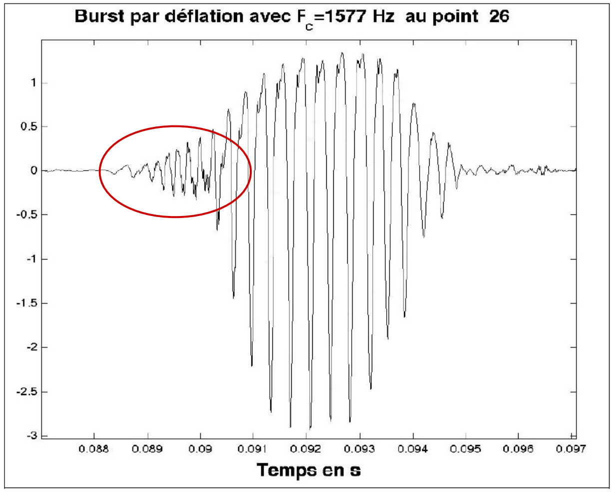
- Amplitude is over-predicted by the SA model
- Unsteady behavior well reproduced by the k-ε OES. The model captures the secondary oscillations as in the experimental data.
- All models show a bump in the high-frequencies corresponding to the von Kármán mode (≈ 30-40 times the buffet frequency)

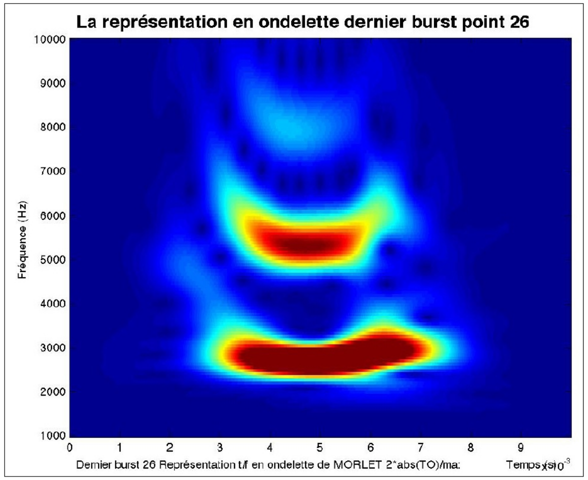
ST06 : Transonic buffet

over a supercritical airfoil – OAT15A

Iso- div (V): illustration of SWBLI and shock-vortex (Von Karman) interaction







***k*-*ε*-OES**

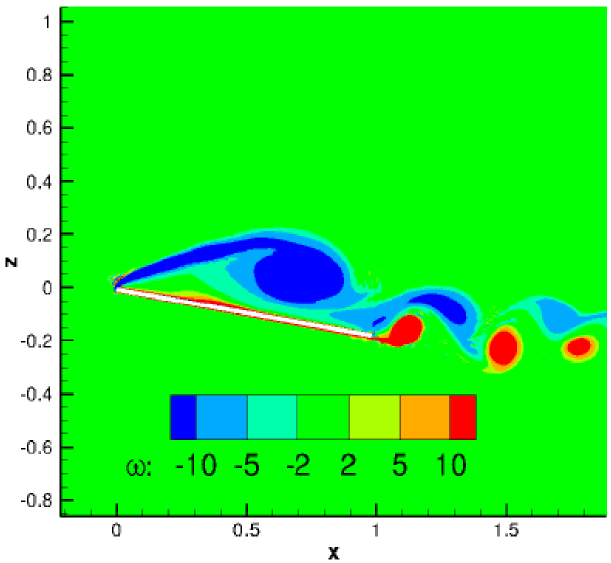
F. Grossi

A. Sevrain

Design of turbulence approach for inhomogeneous and anisotropic turbulence

- Vortex shedding flows, highly shearing regions
- Rotational/irrotational regions

- Starting from Organised Eddy Simulation (OES) modelling
- Taking account backscatter phenomenon
- Economical numerical grids

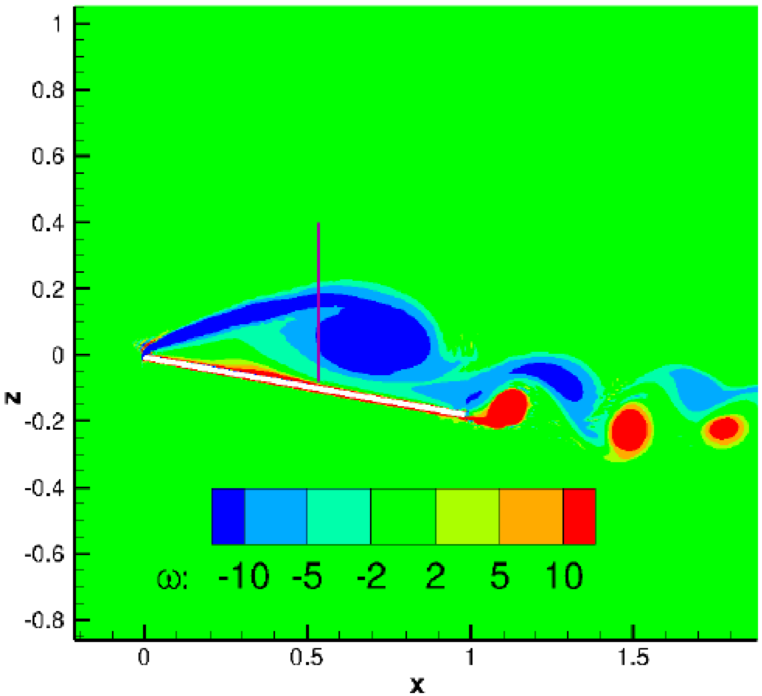


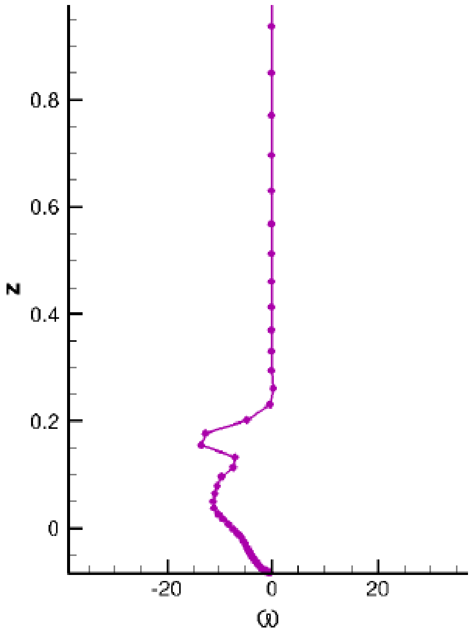
Flat strut- RTRA configuration

Flat plate ('strut') Test-case, Re=200,000 and 400,000

Capturing thin shear layer : decisive for reliability of the overall simulation

$\Rightarrow$ Correct prediction of aerodynamical coefficients, fluctuation of pression





Conclusions and Outlook

- **Reinforcement of robustness for OES with tensorial eddy-viscosity modelling**

- **Optimum preconditionning for unsteady low Mach flows**

- **Reinforcement of robustness for the DRSM**

- Assessment of Turbulence Modelling abilities with the numerics improvements for capturing of the aeroelastic flutter – AGARD 445.6

- Use of adjoints evaluation provided by INRIA for shape optimisation