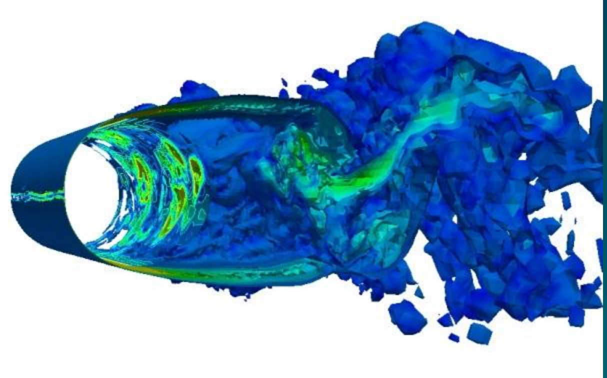
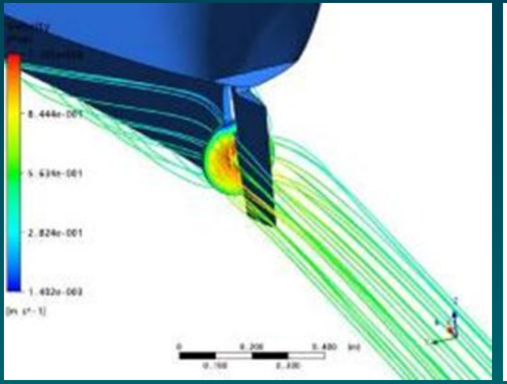
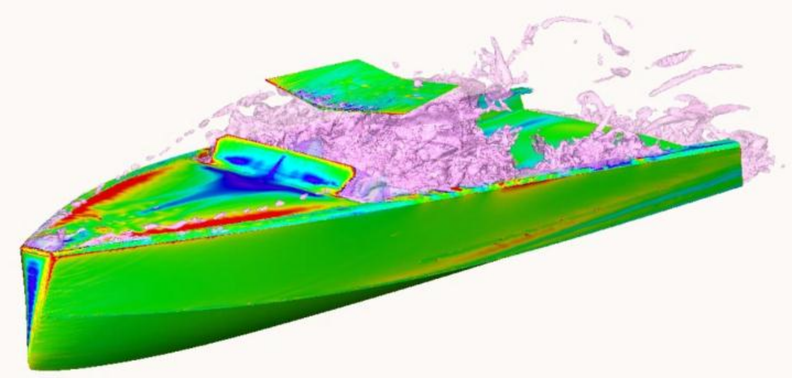
2nd Gothenburg OpenFOAM user-group meeting
Chalmers University, 14th November 2012

University of Southampton Fluid-Structure Interactions Group OpenFOAM Research

Tom Lloyd – T.P.Lloyd@soton.ac.uk
Marion James – M.James@soton.ac.uk

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- 700 members across different faculties
- Iridis 3 SuperComputer – Largest academic computer cluster in the UK
  -> 12000 processors, 22.4TB RAM

Faculty of Engineering and the Environment

Aeronautics, Astronautics and Computational Engineering Unit (AACE)

Civil, Maritime and Environmental Engineering and Science Unit (CMEES)

Engineering Sciences Unit (ES)

Institute of Sound and Vibration Research (ISVR)

Contents

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SHIP HULL & FREE-SURFACE

- ‘Design of retro-fit devices using CFD, validated with wind tunnel tests’ – Marion James
- ‘Powering performance of ships in waves’ – Bjorn Winden
- ‘OpenFOAM simulation of regular waves and wave load on cylinder’ – Linghan Li

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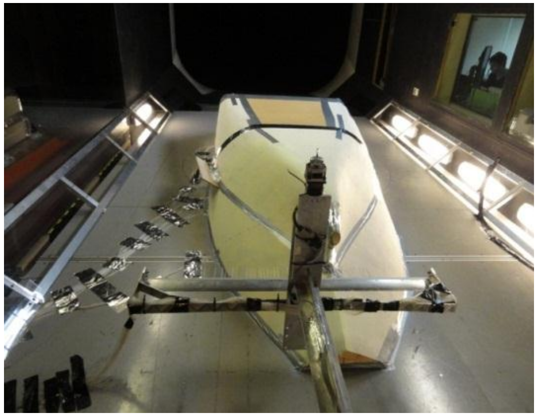
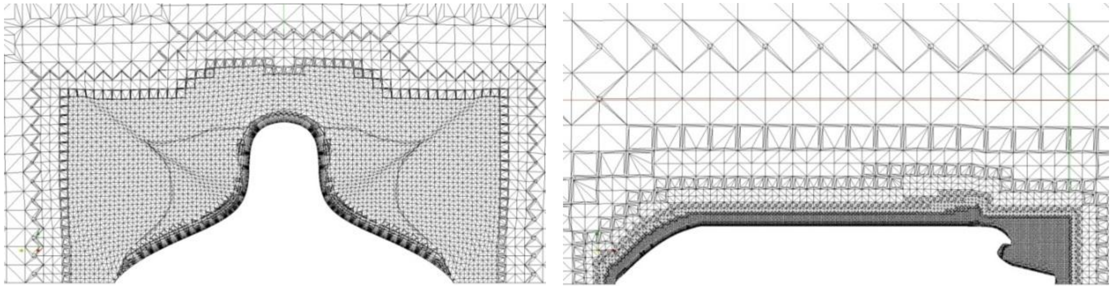
- ‘Consulting CFD to Industry’ – Wolfson Unit

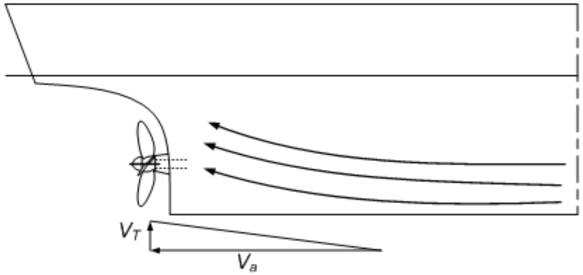
Design of retro-fit devices using CFD, validated with wind tunnel tests

- Aims: To increase the efficiency of an existing tanker hull form by 10% using cost-effective retro-fit devices, while maintaining the operational requirements.
- Experiment Mitchel Wind Tunnel
- Numerical Analysis: OpenFOAM
  - Meshing using snappyHexMesh in OpenFoam 1.6
  - Solving in OpenFoam 2.0 – SimpleFoam with k-omega SST turbulence model (y+ = 30)





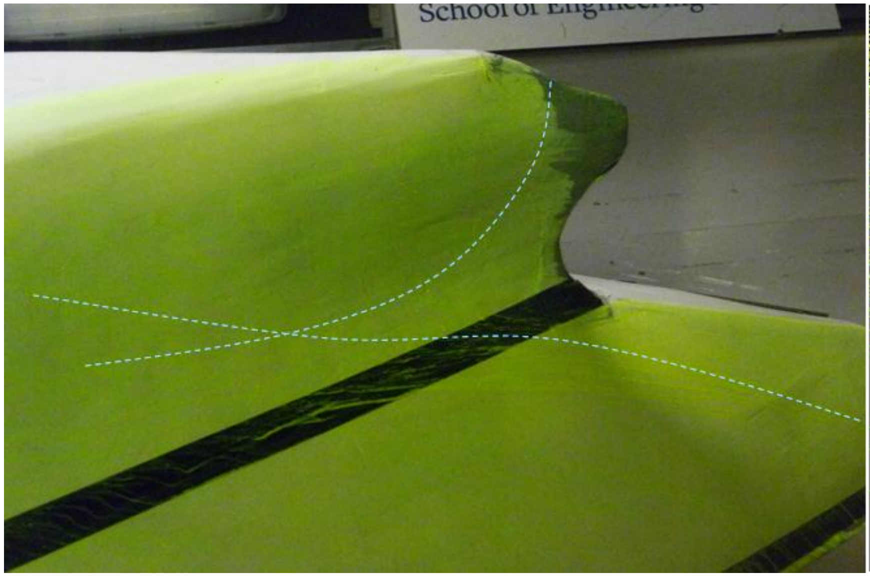
- Blade-Element Momentum Theory
  - Used as a diagnostic to replace the propeller not simulated in CFD

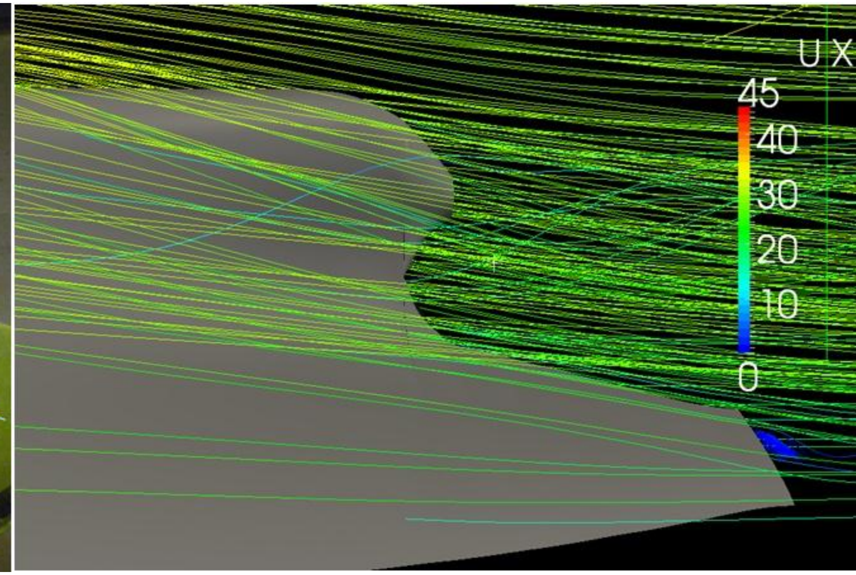


Marion James – M.James@soton.ac.uk

Design of retro-fit devices using CFD, validated with wind tunnel tests

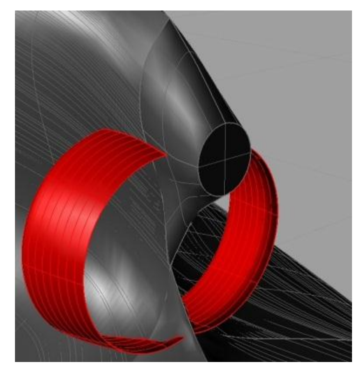
Streamlines -> Flow diverted away from the propeller plane -> Need for retro-fit devices





Vortex generators

Duct (based on Mewis Duct)



Wake Equalising Duct

Marion James – M.James@soton.ac.uk

Design of retro-fit devices using CFD, validated with wind tunnel tests

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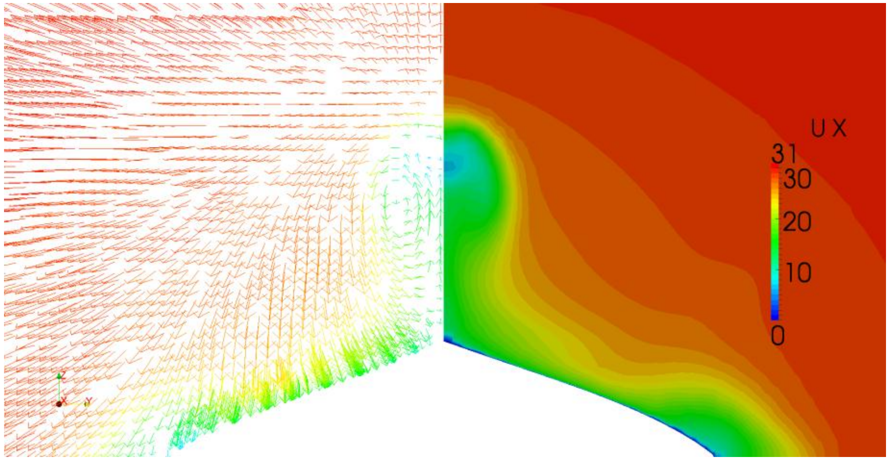
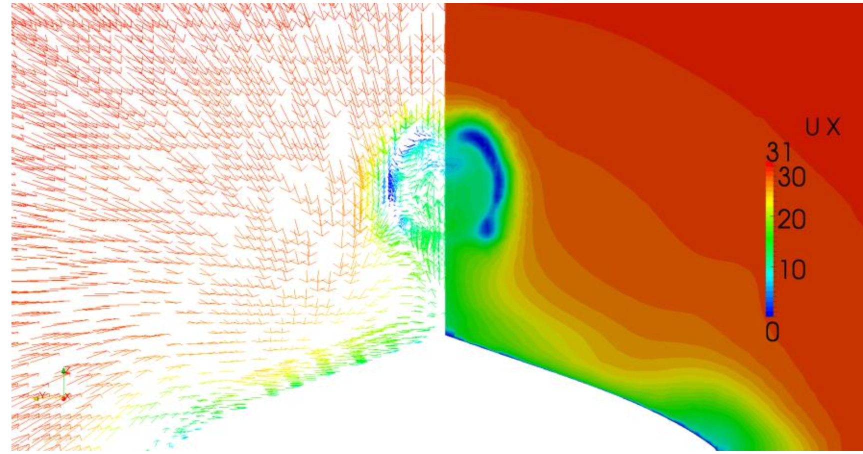
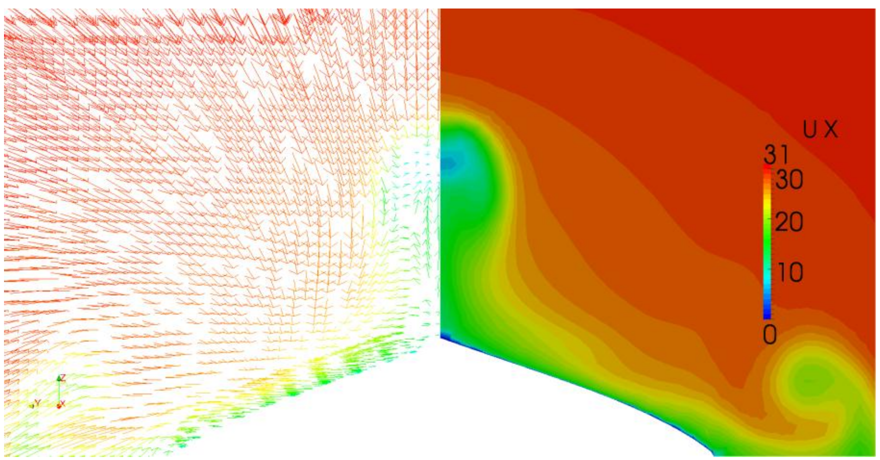


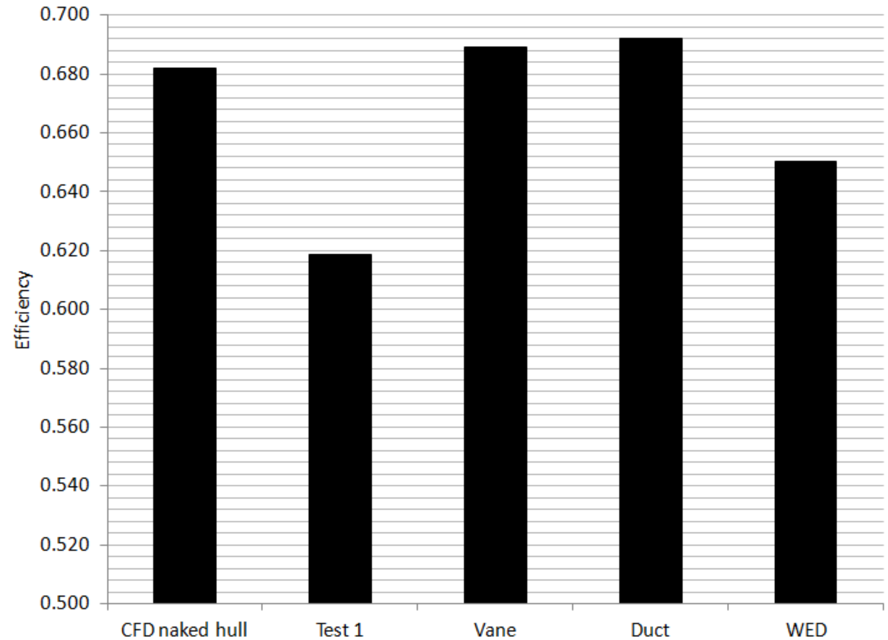
Naked hull wake at propeller plane



Effect of duct on wake at propeller plane

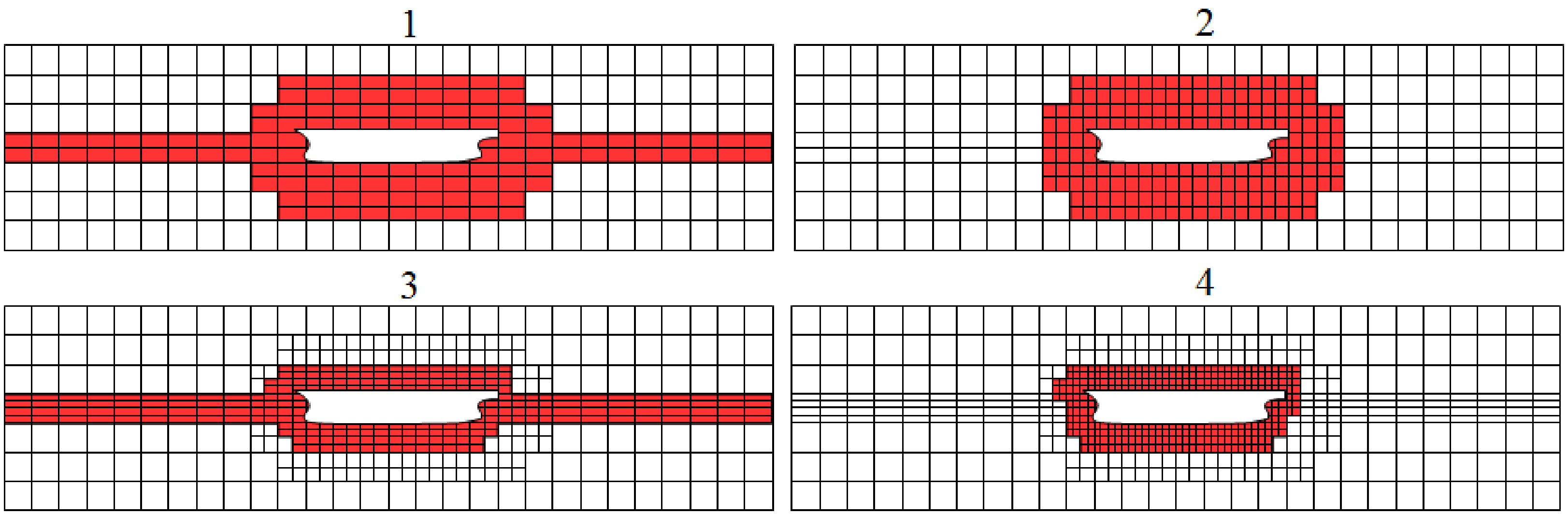


Effect of vane on wake at propeller plane



Marion James – M.James@soton.ac.uk

- Aims
  - To study the self propulsive performance of ships using a RANS-method
  - To start from a simplified model to:
    - ➢ Identify underlying sources of error
    - ➢ Study the physics
  - To develop tools within OpenFOAM to achieve the above
- Automated meshing algorithm for free-surface/near hull mesh blending created
- Using OpenFoam utilities, refineMesh, and snappyHexMesh



Bjorn Winden – B.Winden@soton.ac.uk

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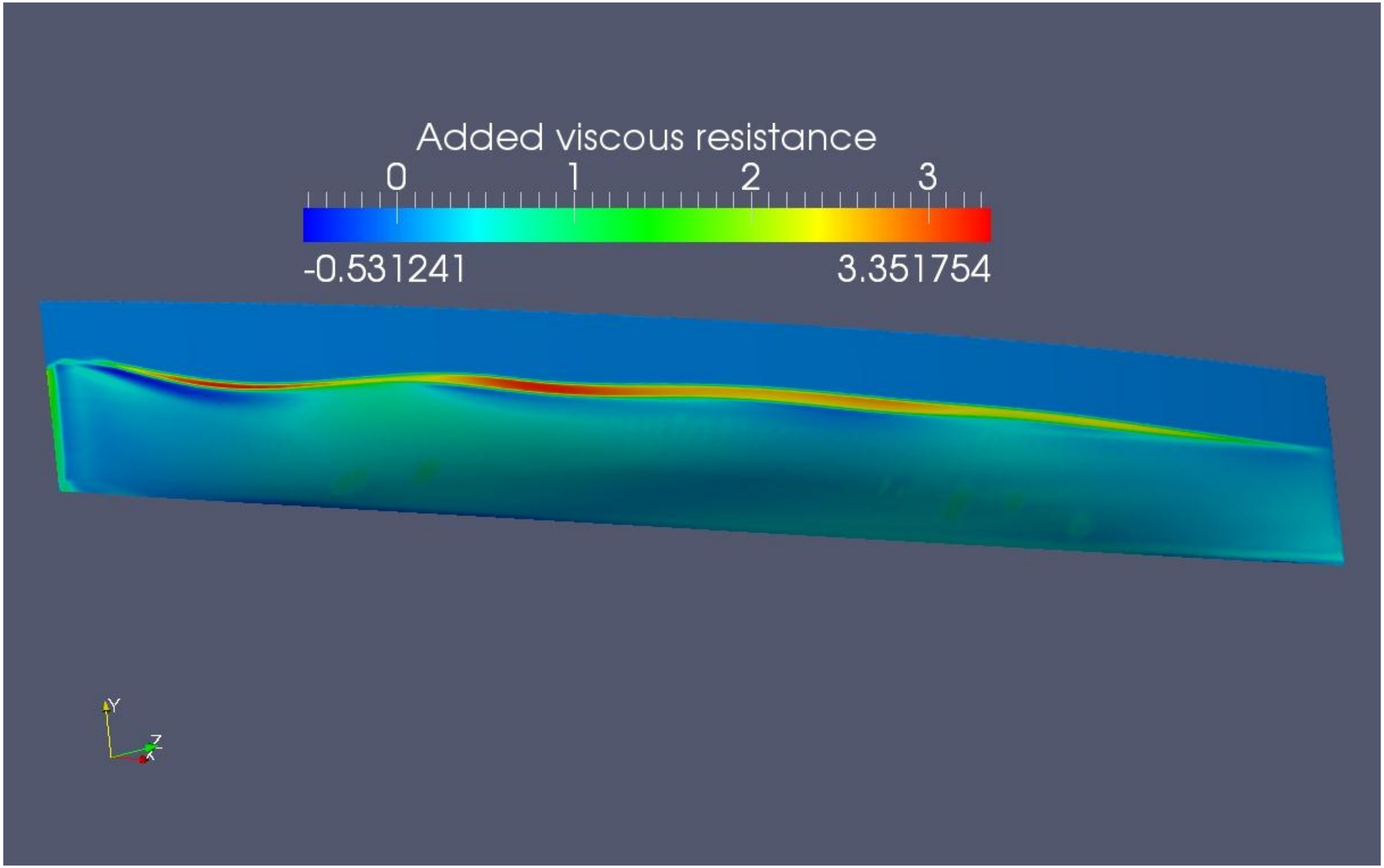
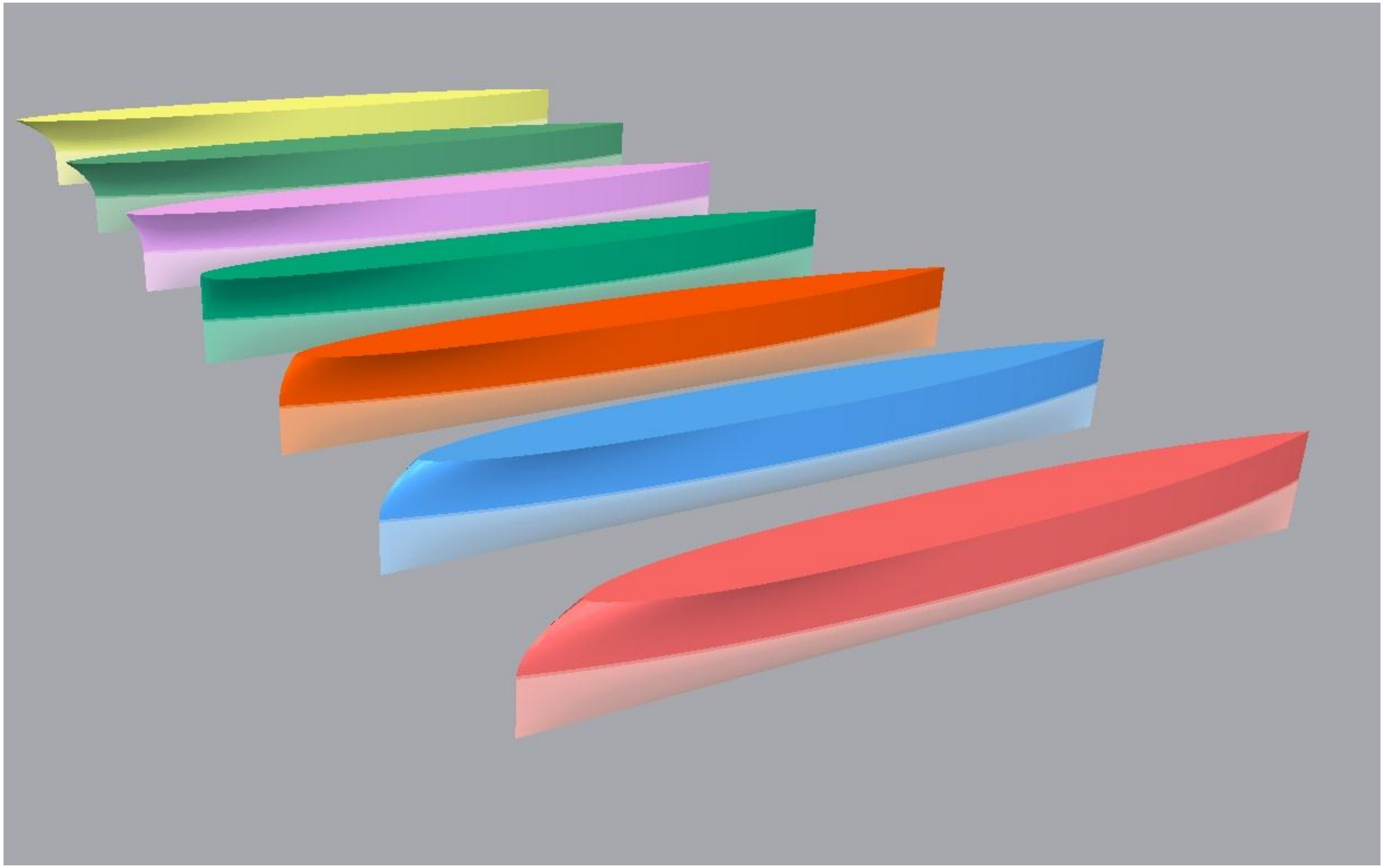
Force visualisation implemented in OpenFoam



Bjorn Winden – B.Winden@soton.ac.uk

Current study: above water shape influence, implementation of propeller model and the influence of surge motion



Bjorn Winden – B.Winden@soton.ac.uk

- Aims
  - To develop a numerical method to test floating wave energy converted performance
  - To improve this method by adopting soft-bodied structure

- Problem specification

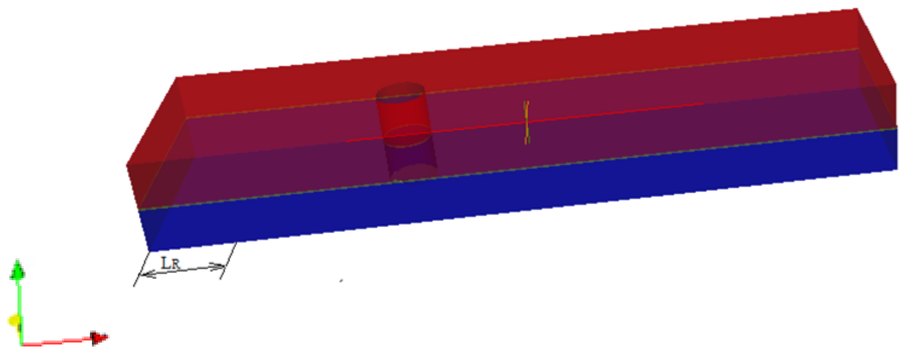


Figure 1 – Wave tank with vertical cylinder

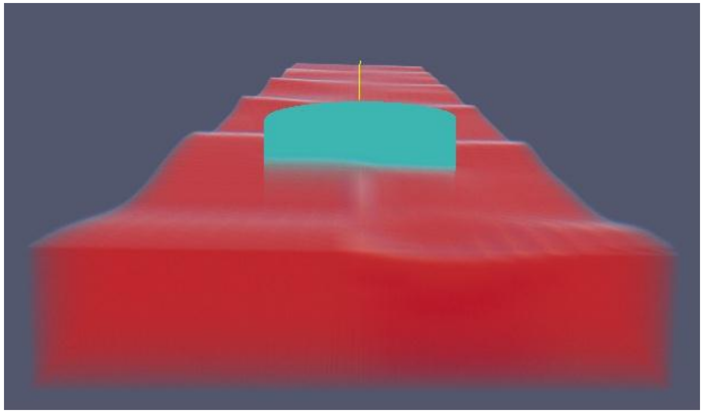


Figure 2 – Free-surface elevation

- Utilities developed in OpenFoam:
  - Free-surface sampling
  - Forces calculation: separated forces calculation for different phases (air/water)

Results for fixed horizontal and vertical cylinder

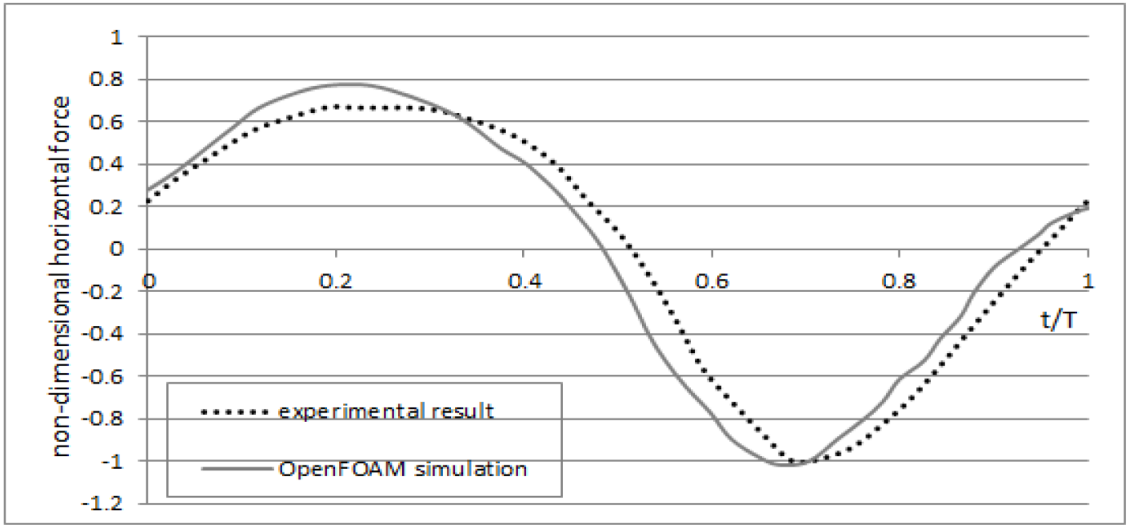


Figure 4 – Comparison of experimental data (Westphalen et al., 2012) and simulation results of non-dimensional horizontal force

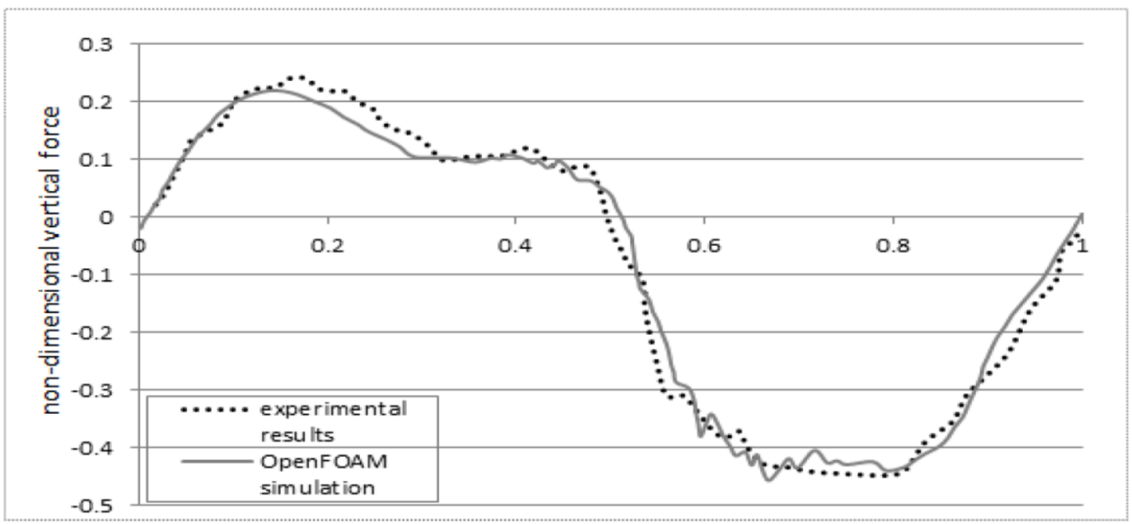


Figure 5 – Comparison of experimental data (Westphalen et al., 2012) and simulation results of non-dimensional vertical force

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Propeller / Rudder interaction

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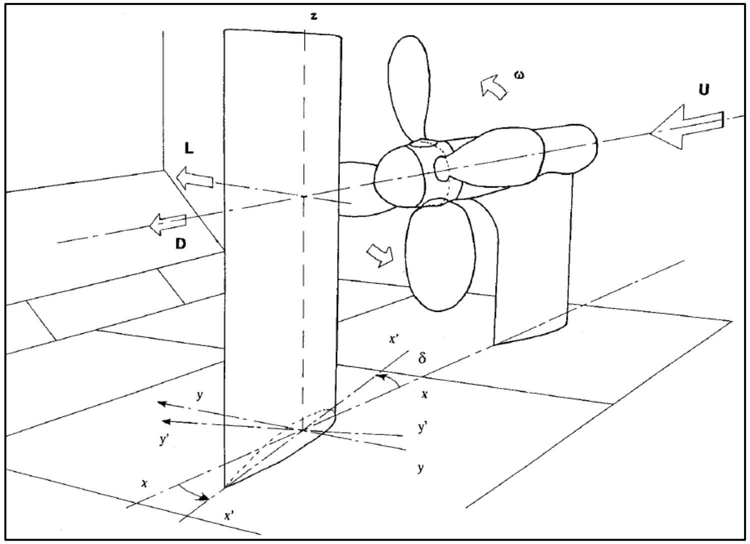
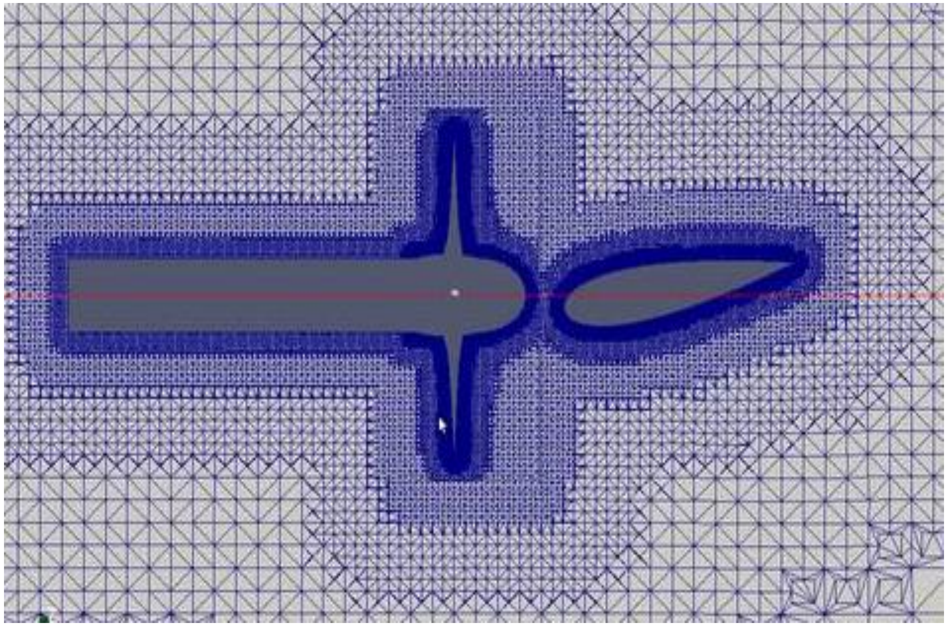
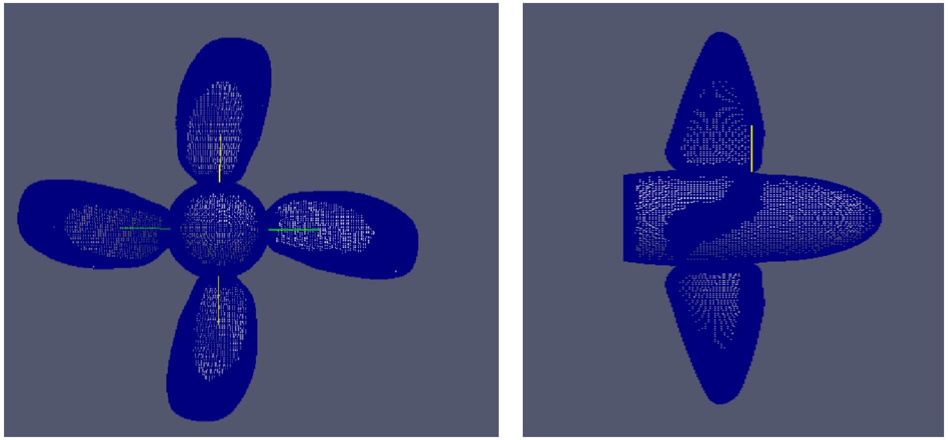


Parameter	Setting
Mesh Type	Unstructured (Hexa)
No. of Elements	Approx. 2.5M
y^+	30
Inlet	Freestream (10m/s)
Outlet	Zero gradient
Tunnel floor/side walls	Slip
Tunnel roof	Slip
Rudder	No Slip
Propeller	Moving wall vel.
Turbulence model	k- ω SST Turbulence
AMI	Cyclic

Table 1: Numerical model



Cross section grid around rudder-propeller



Propeller mesh

Charles Badoe – cb3e09@soton.ac.uk

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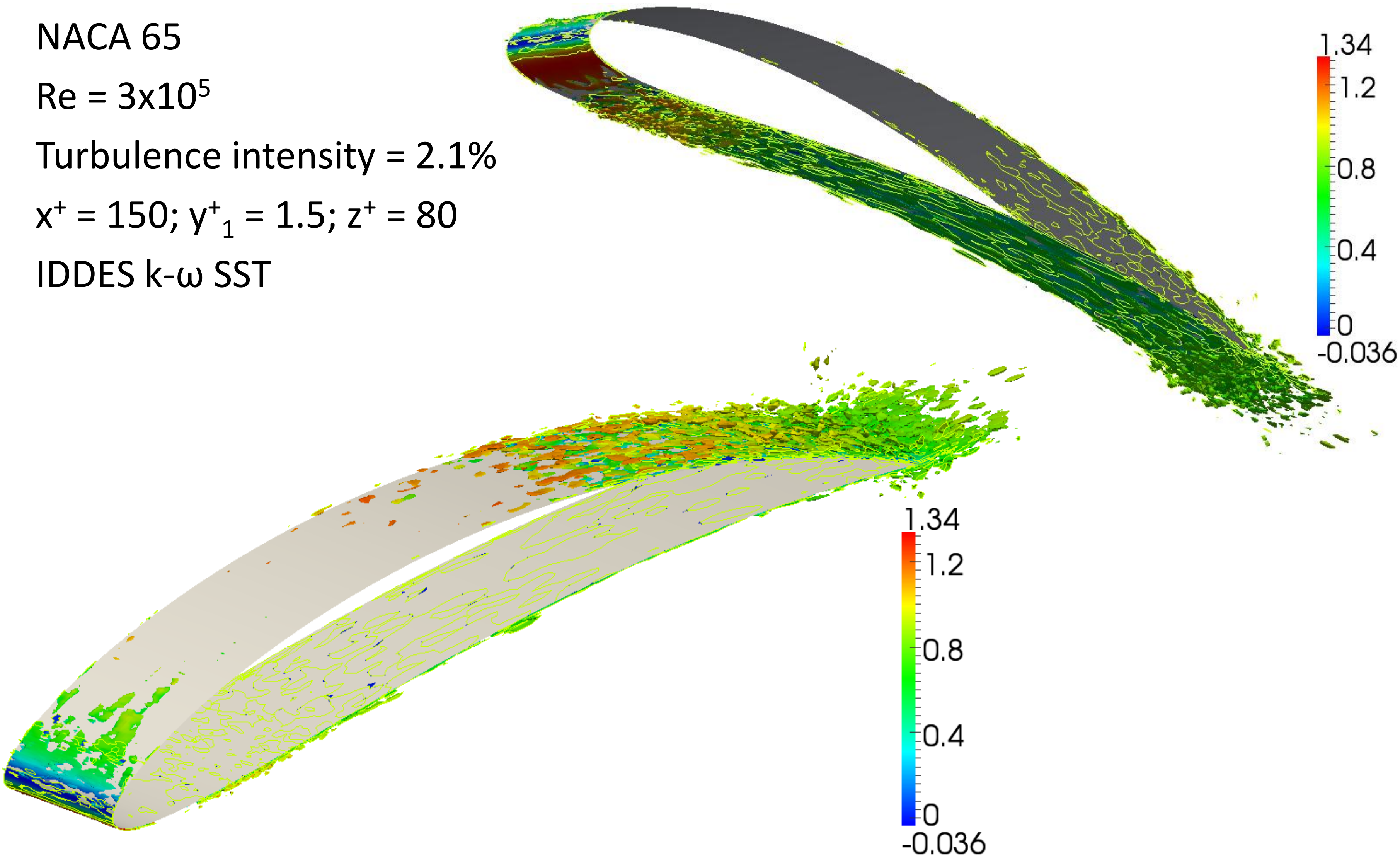
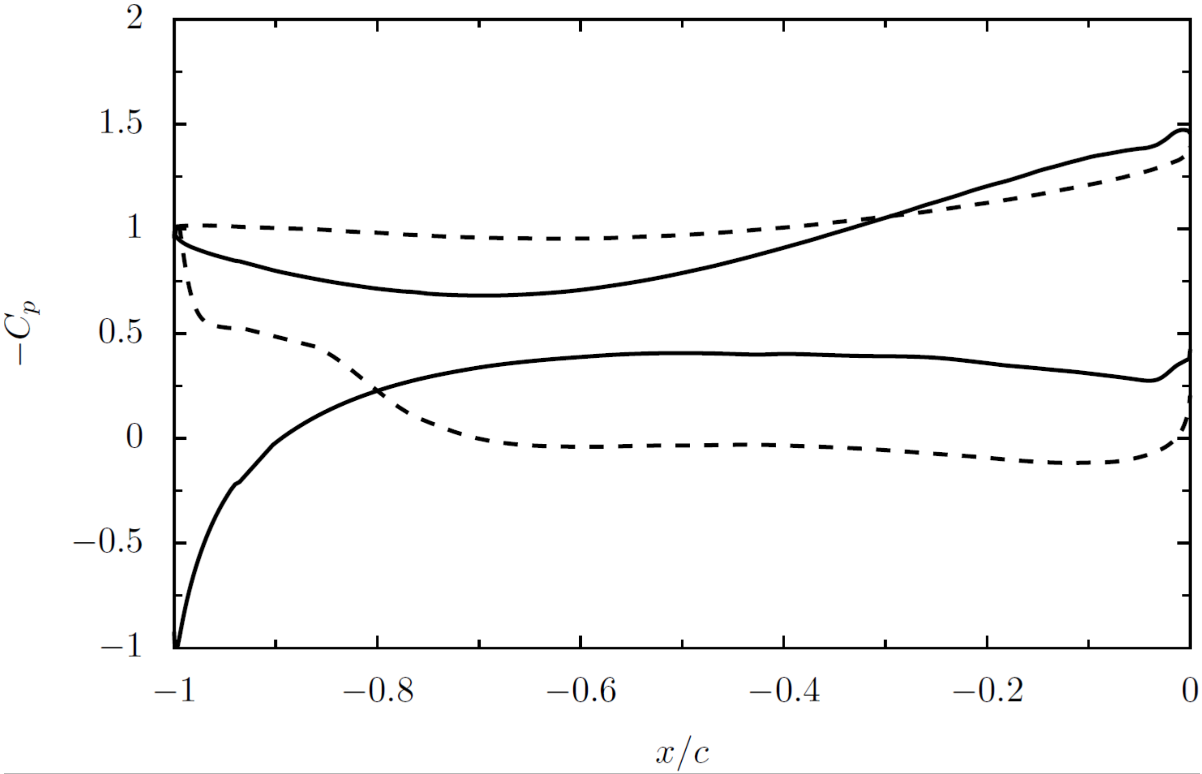
- NACA 65
- Re = 3×10^5
- Turbulence intensity = 2.1%
- $x^+ = 150$; $y^+_1 = 1.5$; $z^+ = 80$
- IDDES k-ω SST

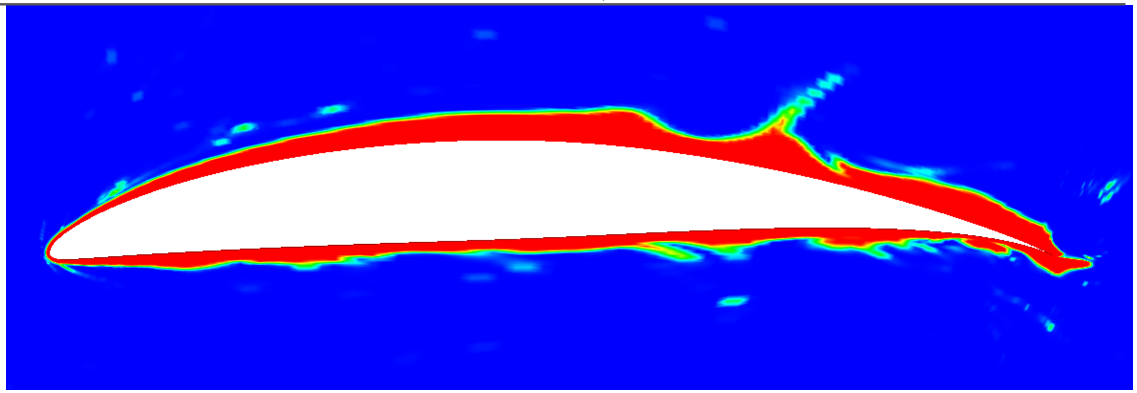


Foils encountering flow turbulence



Mean C_p

RMS C_p

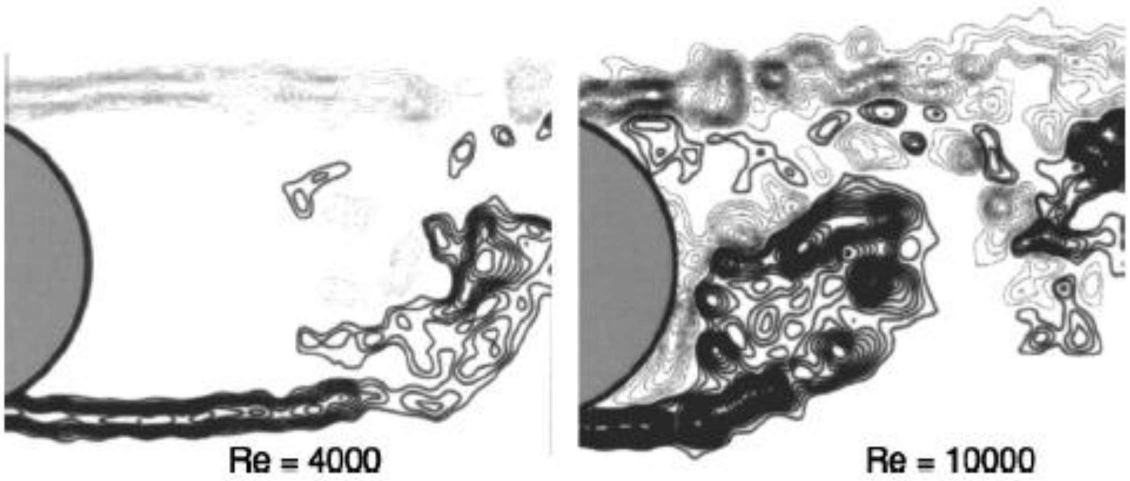


IDDES blending function

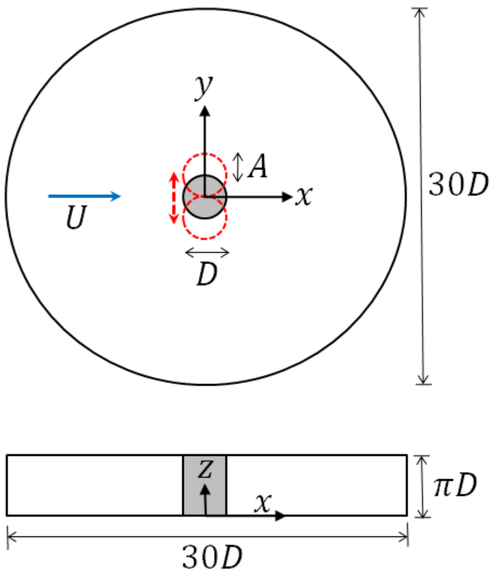
RANS

LES

- Motivation & Background
  - Reproduce controlled oscillating cylinder experiments
    - ➢ shows switching process of vortex timing and characteristic wake modes observed in exp.
  - The flow regime is under subcritical flow
    - ➢ shows laminar boundary layer, turbulent wake, separated shear layer



Flow visualisation in PIV experiments



Solution domains

LES of the wake over an oscillating circular cylinder at Reynolds number Re = 5500

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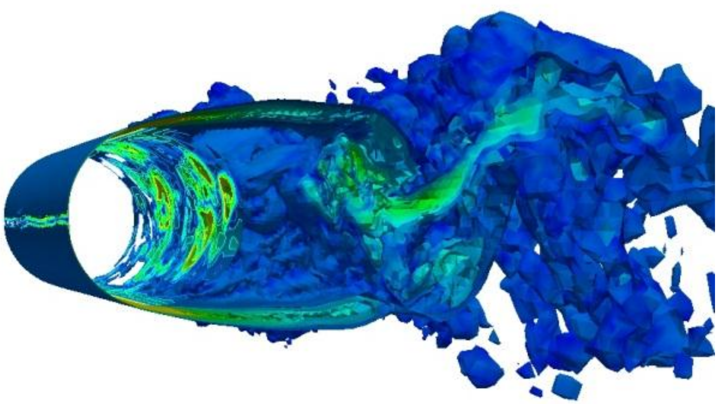
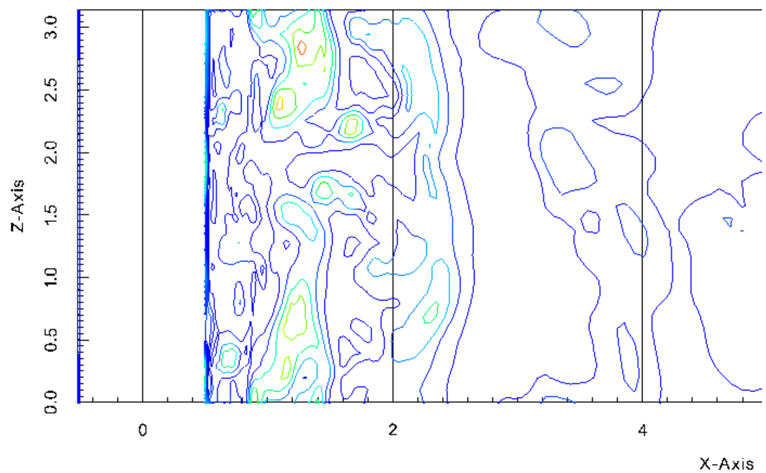
- Numerical method
  - OpenFOAM 2.1
  - LES approach (Smagorinsky type model, Cs=0.1)
  - Wall resolving LES (Y+ < 1.0)
  - PimpleDyM Foam for Dynamics mesh
  - 2nd order central-difference for spatial terms to capture correct wake parameters
  - 240 CPUs for parallel computing by IRIDIS



Instantaneous 3D vortex contour
: shows two separating shear layers
: shows Kelvin-Helmholtz structure in shear layers

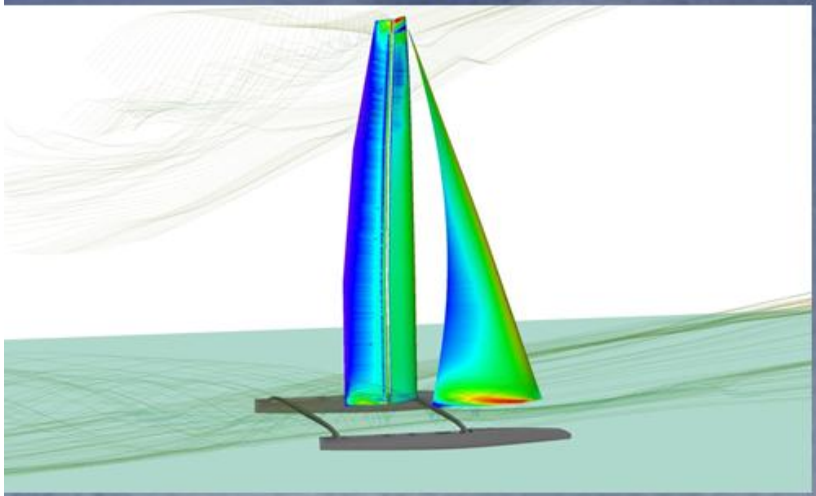


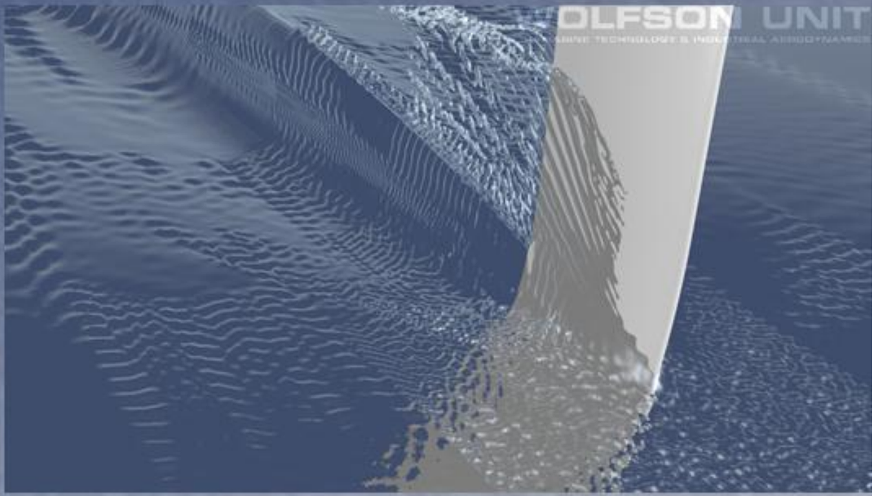
Q-criteria
: shows vortical structures in spanwise direction

Consulting CFD to Industry

Type of problems : Single phase, free surface , DES & AMI

Industries : Naval Architecture, Yacht & small craft, Renewable Energy , Offshore oil/gas



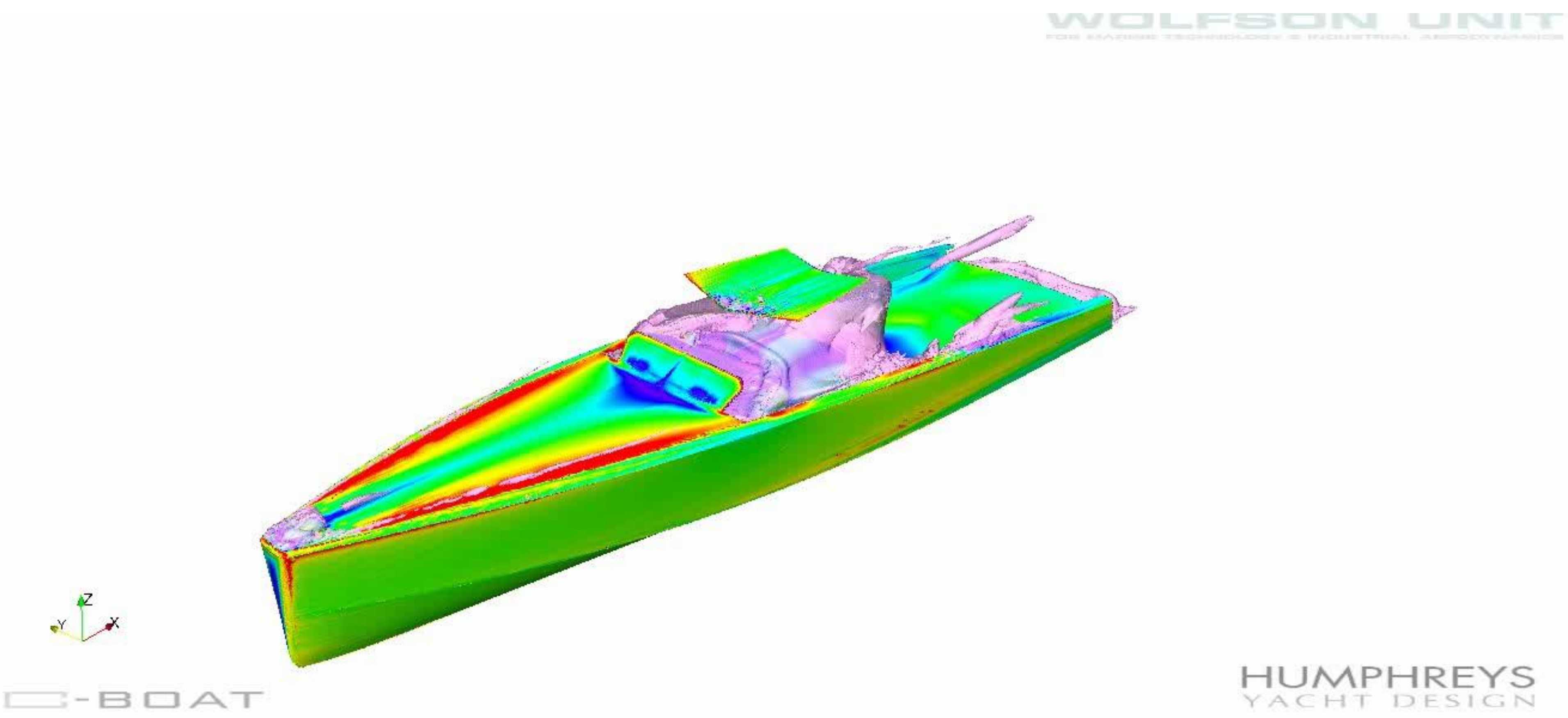


Typical run size : 5 – 75 M cells, 24 – 96 processor

Resources : Iridis 3 Supercomputer (> 12000 processors)

WOLFSON UNIT


C-BOAT
HUMPHREYS
YACHT DESIGN


WOLFSON UNIT
HUMPHREYS
YACHT DESIGN
-BOAT
Z
Y
X

Summary

University of Southampton

- February 2010 - 1st OpenFOAM project on hull wake with a free-surface
- Summer 2010 – First commercial projects for the Wolfson Unit
- Over two years of experience with OpenFOAM within the FSI Group
- Southampton user-group growing -> now over 25 members
- Research topics covered:
  - ✓ Free-surface flows (ship hydrodynamics,)
  - ✓ Rotating bodies (propellers, renewable energy devices)
  - ✓ Separated flows (Vortex induced vibrations, external aerodynamics)

Summary

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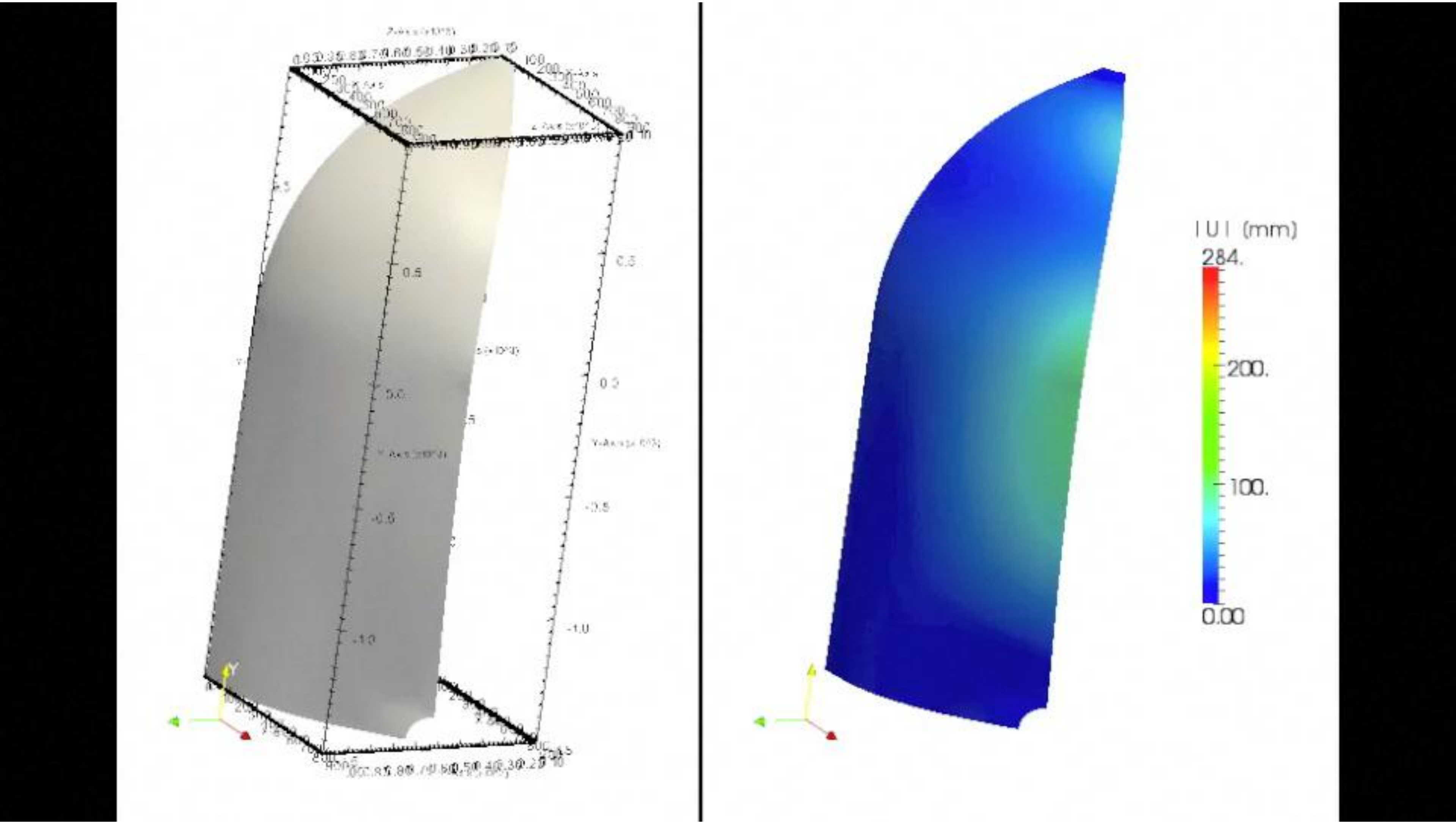

Thank You!

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