HPC and CFD in the Marine Industry: Past, Present and Future

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Overview

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  - Ship Radiated Underwater Noise
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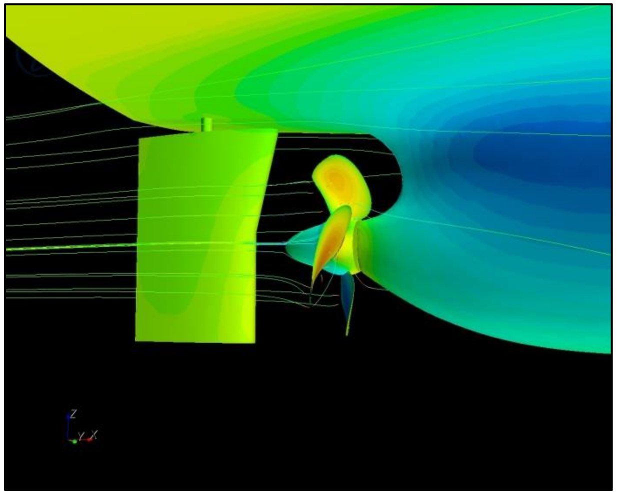
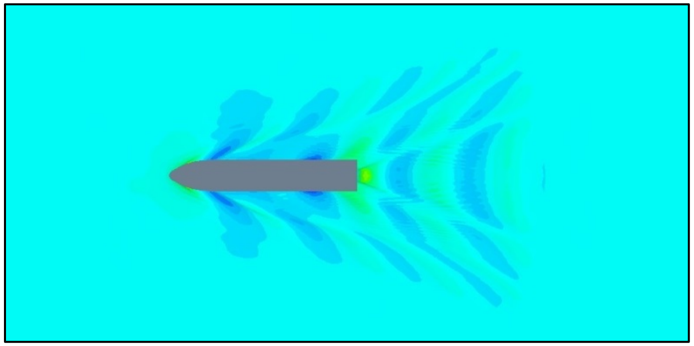
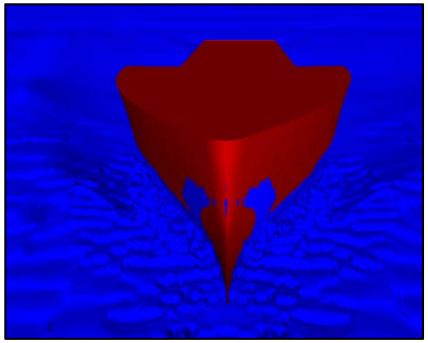
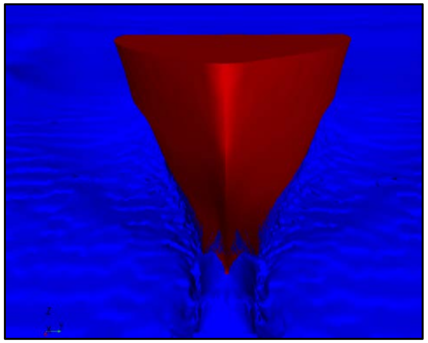
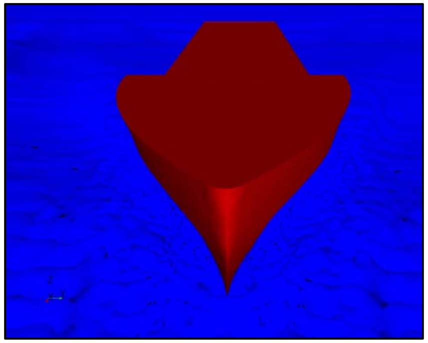
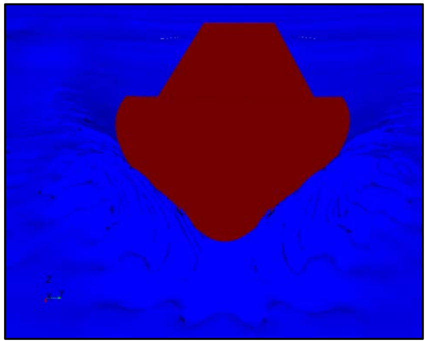




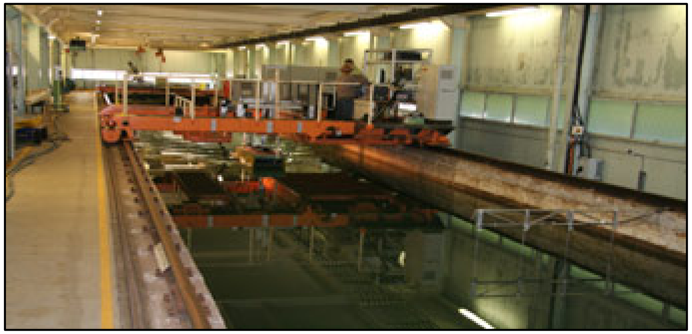
Introduction

- CFD stands for Computational Fluid Dynamics
- Presenting HPC from the viewpoint of a user
- Demonstrate an application of high performance computing
- Highlight the importance of these capabilities for the marine sector and in particular for industry

Importance of CFD in Naval Architecture

- It is not feasible to build proto-types
- There are long timescales for design and build
- Model scale experiments are costly and time-consuming
- Errors associated with experiments can be significant
- There are limits to what can be re-created and measured in model scale experiments



Past Computational Limits

- Use of potential flow / panel method approaches which neglect the viscosity of water
- Limited mesh sizes and refinement due to computational demand, leading to lack of accuracy
- Limit to geometrical complexity which can be studied
- Time-consuming convergence meant design variations and optimization were not possible

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Current State of the Art: Ship Resistance and Fouling

Fouling → Roughness → Increase in Resistance → Increase in required Power and Fuel consumption

↓

Increase in GHG Emissions

Negative Effects on Environment

To avoid fouling

Biocide accumulation and negative effects on non-target species

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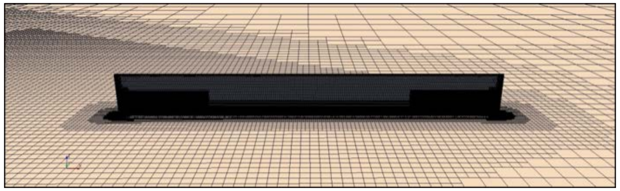
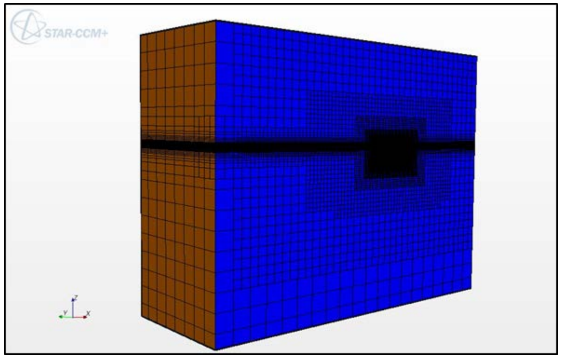
Biocidal antifouling coatings → Biocide releasing to environment

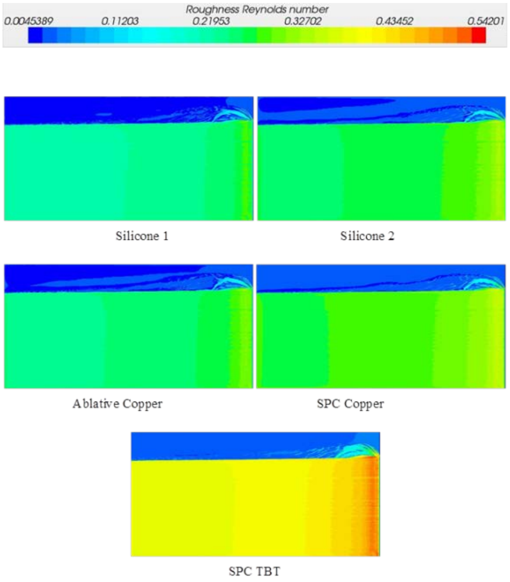
Current State of the Art: Ship Resistance and Fouling



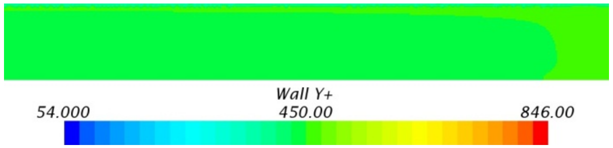
Mesh configuration	Total No. Cells	C_F (CFD)	% Experiment
Coarse	1.5 $\times 10^6$	[ ]	[ ]
Medium	2.5 $\times 10^6$	0.003805	0.60
Fine	4 $\times 10^6$	0.003776	-0.19
Very Fine	6 $\times 10^6$	0.003785	0.07

Mesh configuration	Total No. Cells	C_F (CFD)
Coarse	1.8 $\times 10^6$	0.001574
Medium	2.5 $\times 10^6$	0.001576
Fine	4 $\times 10^6$	0.001584
Very Fine	5.5 $\times 10^6$	0.001584



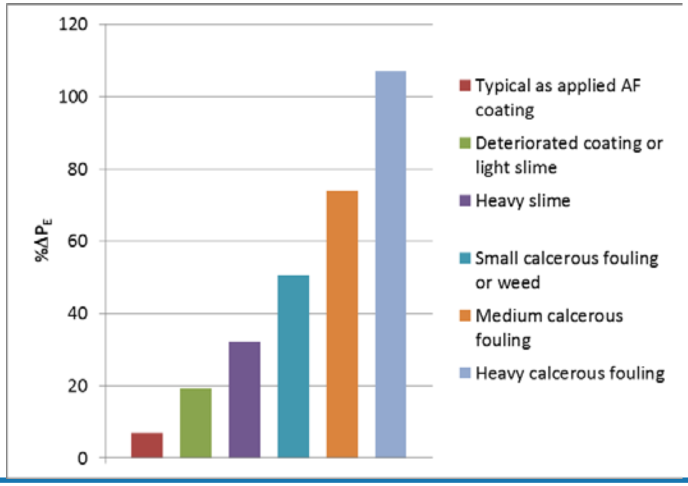


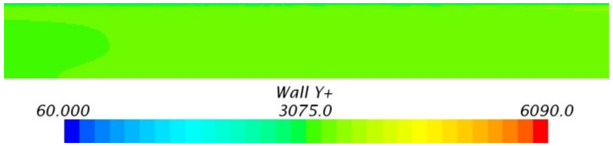
Current State of the Art: Ship Resistance and Fouling



C_F results at different mesh configurations for the tanker

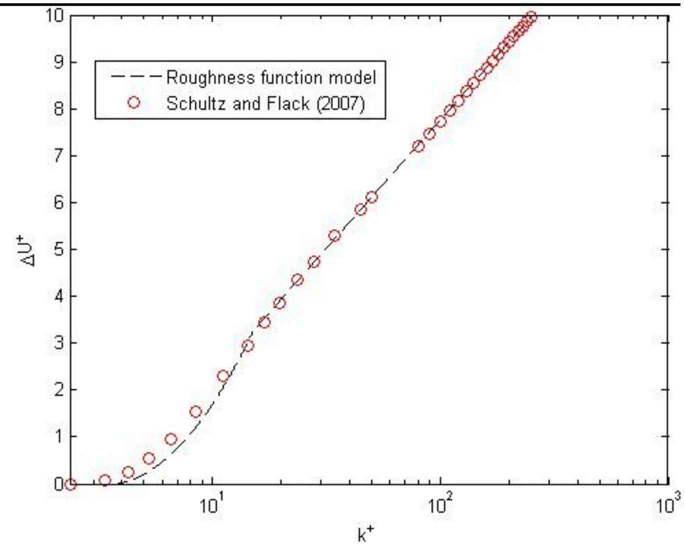
Mesh configuration	Total No. of Cells	C_F (CFD)
Coarse	1.7×10^6	0.0020929
Medium	2.5×10^6	0.00209312
Fine	4.2×10^6	0.0021030





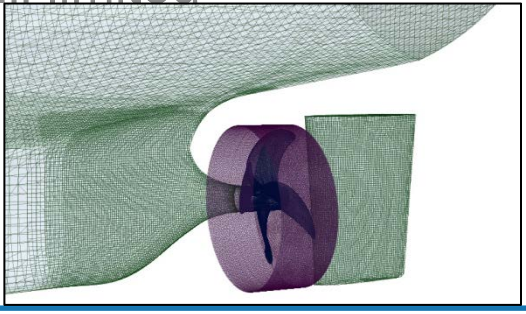
C_F results at different mesh configurations for the containership

Mesh configuration	Total No. of Cells	C_F (CFD)
Coarse	2.2×10^6	0.0020086
Medium	3.3×10^6	0.0020145
Fine	5.5×10^6	0.0020222



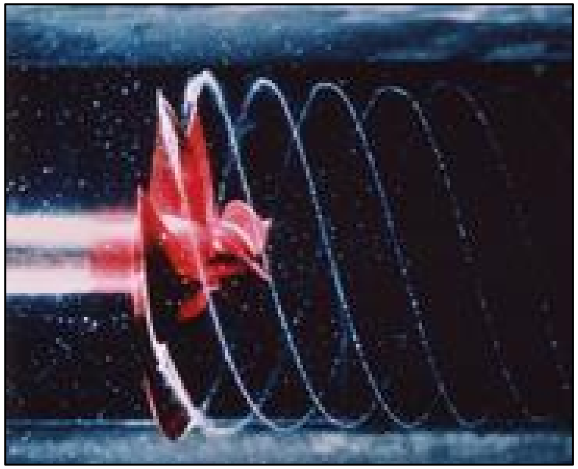
Current State of the Art: Ship Radiated Underwater Noise

- The prediction of ship radiated noise at design stage is becoming increasingly important in the marine industry
- Current computation capabilities allow simulation of vessel in full scale, removing scaling errors
- Simulations can include a rotating propeller geometry
- Simulations generally only in calm and deep water conditions
- Prediction of cavitation behaviour and noise still limited

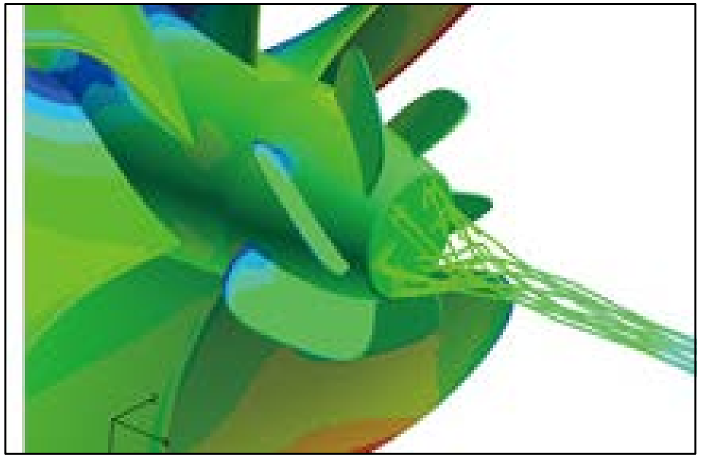


Current State of the Art: Propeller Boss Cap Fins

Experimental Methods



CFD Methods



Propeller Boss Cap Fins: Tools

CFD Solver

CD-adapco

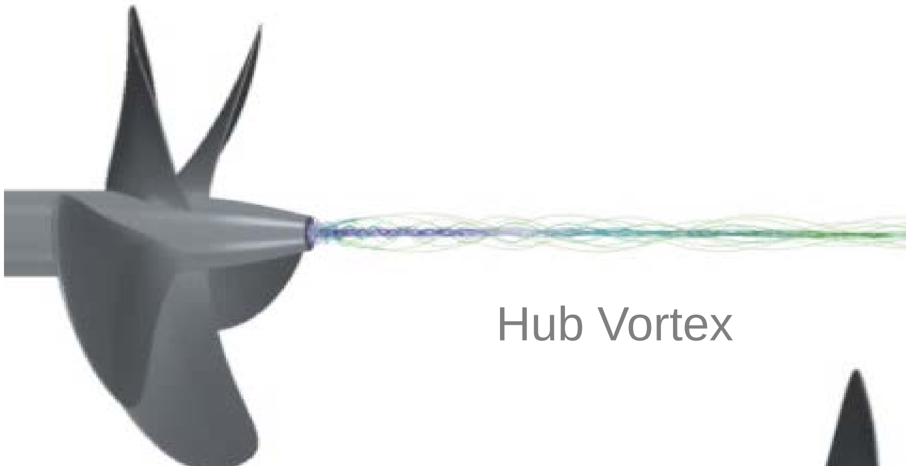
Parametric Modeller/ Optimiser

FRIENDSHIP SYSTEMS
a DNV GL company

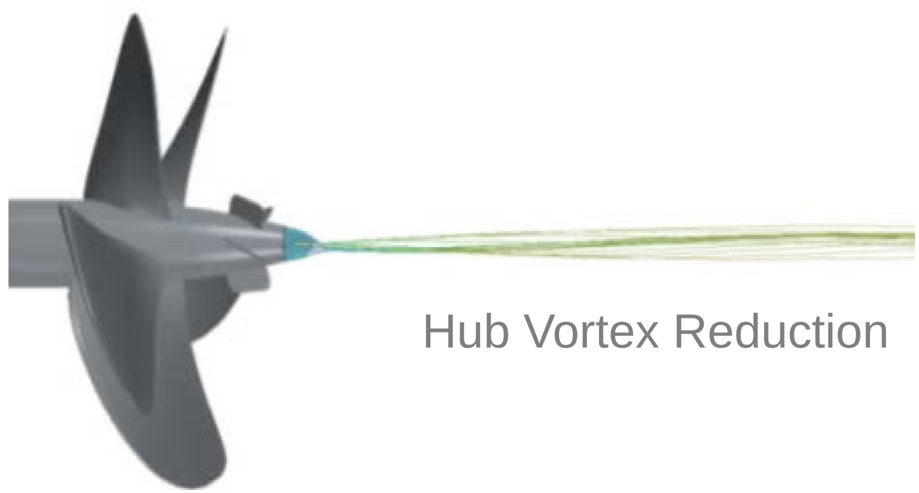
High Performance Computer

ARCHIE-WeSt
Academic and Research Computer Hosting Industry and Enterprise in the West of Scotland

Propeller Boss Cap Fins: Further Studies



Hub Vortex



Hub Vortex Reduction

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Future Possibilities

- Access to Exascale computing capacity will allow for finer meshes, more complex simulations and more realistic scenarios
- However future development will also be dictated by:
  - Political “hot topics”
  - Changes in regulation
  - Availability of funding and facilities
  - Trust in CFD by industry
  - Industry drivers for research
  - Ability to store and post-process generated data

Closing Remarks

- Advent of HPC's has allowed use of CFD in naval architecture applications
- CFD is beginning to replace model scale experiments
- Current simulations are still limited in size, complexity and accuracy by computational capability
- Moving to exascale computing will allow much more realistic and complex simulations, with more refined meshes and fewer assumptions
- However the marine industry also needs to develop greater trust in CFD to take full advantage of future possibilities

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