CMA SHIPS

Ship design and optimisation With Computational Fluid Dynamics

35 years of passion

22/09/2013

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HYDROCEAN

CMA CGM

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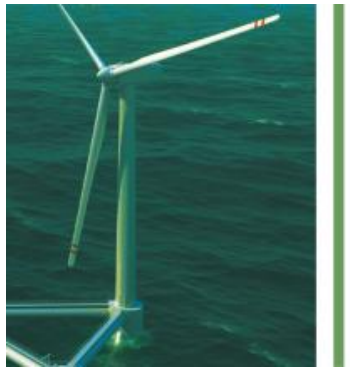
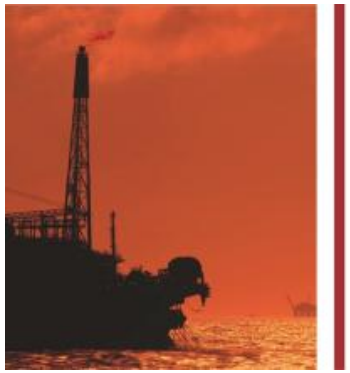
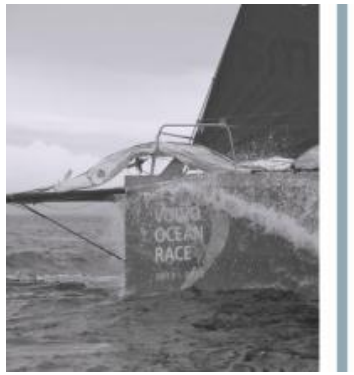
HYDROCEAN & CMA CGM OVERVIEW

HYDROCEAN

CMA CGM

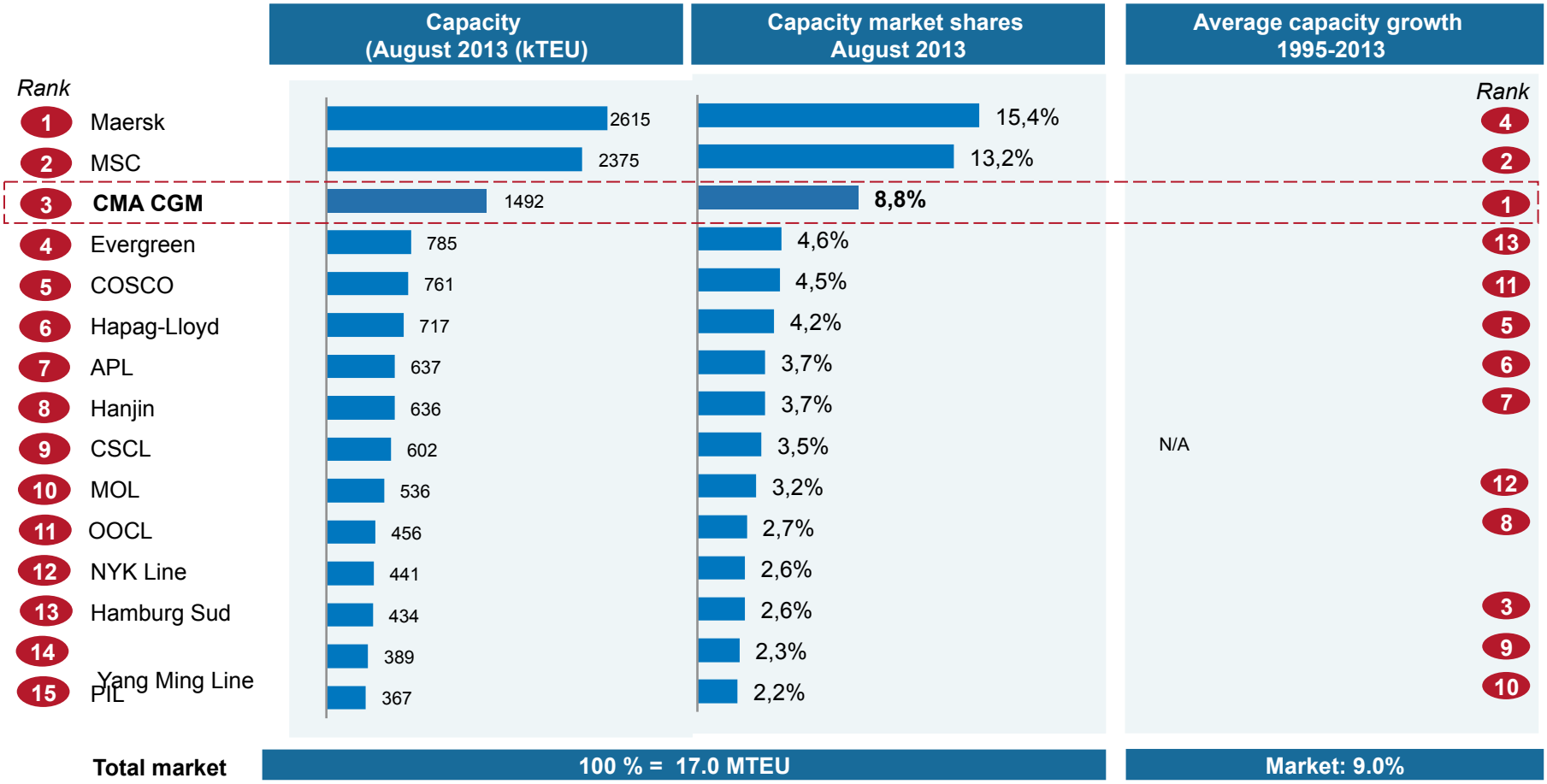
HydrOcean - CFD specialists

- **Company specialised in numerical hydrodynamics**
  - Expertise in 4 activity sectors of marine industry
- **A high qualified team of 20 engineers**
  - 20 engineers with double qualification in marine & CFD
  - Half of the team have PhDs
- **A unique numerical towing tank**
  - A unique range of numerical solvers covering most of numerical models
  - Dedicated solvers developed in partnership with Ecole Centrale Nantes Fluid Dyn. Lab.
  - Unlimited number of licenses
- **Large CPU power**
  - Use of around 200 cores for a standard CFD study
  - Access to over 2000 CPU cores

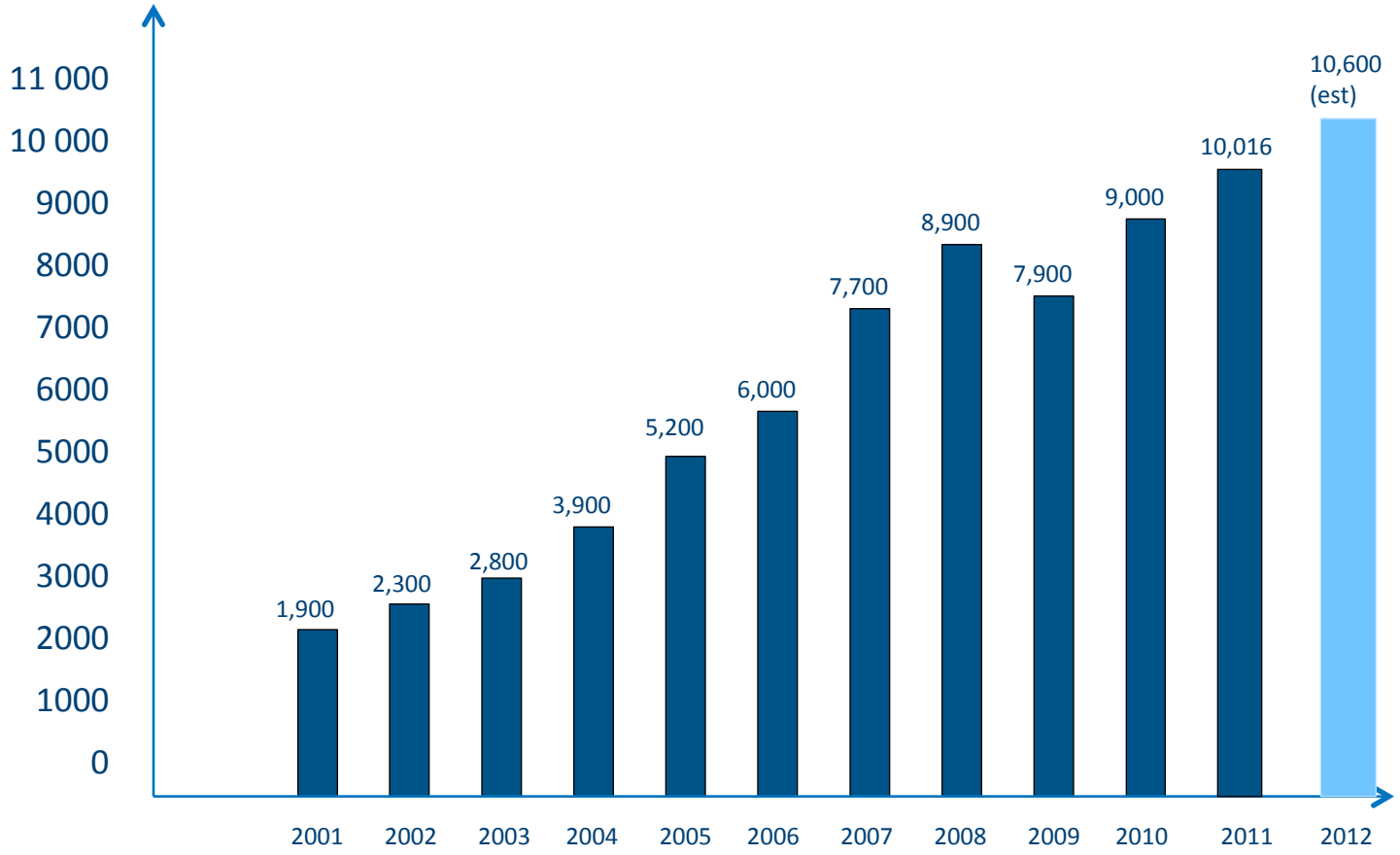
DCNS · HYUNDAI MIPO DOCKYARD CO.,LTD. · STX Europe · CMA CGM · Eni Saipem · Couach YACHTS · TOTAL · Technip · Brittany Ferries · V.Ships · CMN · corsica ferries · THALES · SBM OFFSHORE

CMA CGM : a Global Market Leader



Source: Alphaliner, CMA CGM analysis

CMA CGM: 17% Average Volume Annual Growth over 12 Year Period



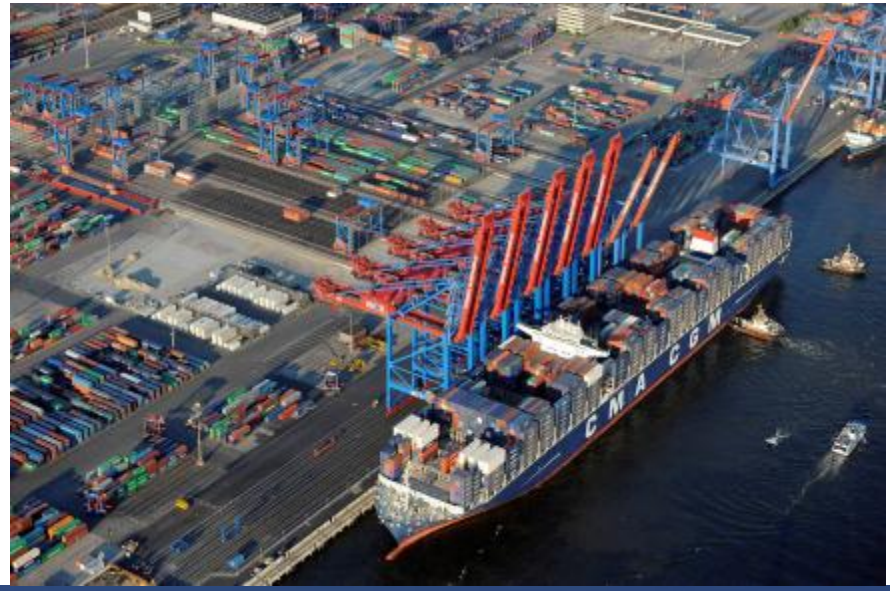
Volumes Carried in K TEU

CMA CGM, A Global Transport Group

CMA SHIPS

The Wheelhouse and the Engine Room of CMA CGM

- Managing the vessels
  - Crew & Fleet
  - DD
  - Supply of spare parts and consumables
- Supervising New Buildings
- Providing CMA CGM with any technical advise
- Fleet Center Navigation
- Energy Department



Figures

- 108 vessels
- 606 197 TEUS capacity managed
- 4 142 seafarers
- 183 employees

2.
Hull form Optimisation
Solvers & key issues

HYDROCEAN

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Numerical tools and solvers

Hull form optimisation requires : Adapted Numerical solvers

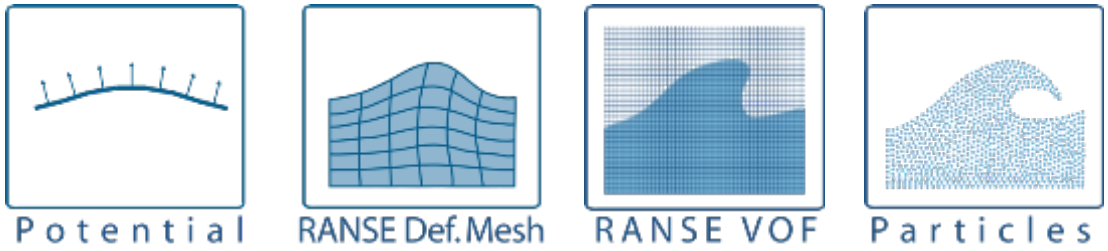
- **Potential flow solvers :**
  - Fast and low cost, but limited accuracy for ship stern area, and even for bow due to non-linear effects, not able to compute appendages, ship power, maneuvering or added resistance …
- **Navier-Stokes with free surface flow solvers :**
  - Much more accurate results however very high CPU time and license costs are expensive. Complex automatic meshing for 3D volume meshes
- **Exemple : Hull form optimisation for 10 operational conditions, 50 hull forms**
  - Total of 500 CFD computations
  - 1 CFD calculation needs 1 license for 32 cores, 10 h on 32 cores
  - Total of 10 x 32 x 500 = 160 000 CPU hours

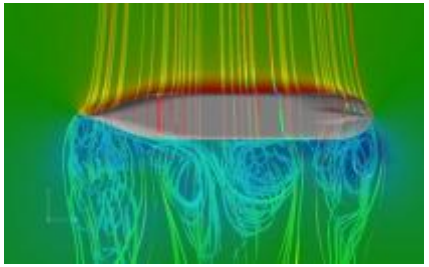
	Potential	CFD		
Nb of licence / CPU	1 licence 1 core	1 licences 32 cores	10 licences 320 cores	20 licences 640 cores
Study duration	24 hours	208 days	20 days	10 days

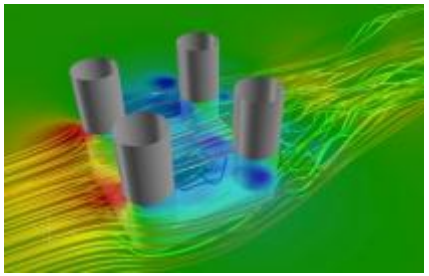
Numerical tools and solvers

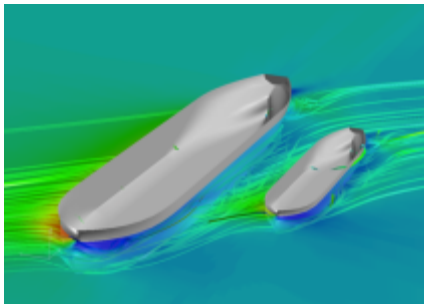
Our vision

1 - The accurate simulation of complex phenomena needs the use of adapted solvers.









2 - The use of commercial CFD solver is cost and time consuming. HydrOcean has access to unlimited license of in-house solvers dedicated to marine applications and large CPU clusters.

3 - HydrOcean works in partnership with ECN Fluid Dyn. Lab. In the development of unique solvers adapted to marine applications : propeller model, incoming irregular waves …

3.
Energy efficiency services

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Hydrodynamic performance 0ptimisation

Description

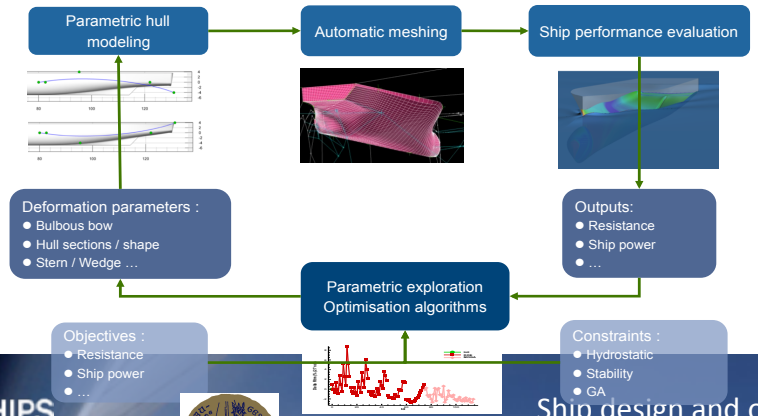
Hull form and appendage optimisation to increase ship's efficiency and reduce fuel oil consumption

- New build or refit of existing vessels

Solution

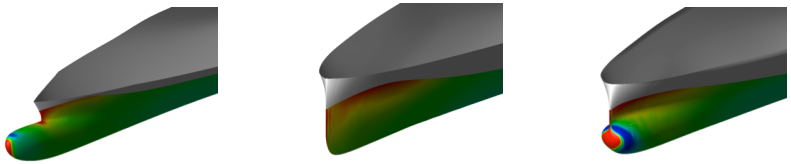
Automated optimisation loop including :

- Parametric hull modeling software (OPTNAV)
- Automatic meshing
- Optimisation of ship's hydrodynamic performances with an unlimited number of RANSE-CFD solvers in terms of :
  - ★ **Resistance in calm water**
  - ★ **Propulsive power**
  - ★ **Resistance in waves**
  - ★ **Seakeeping behaviour**
- Automatic post-processing of the results for efficient analysis

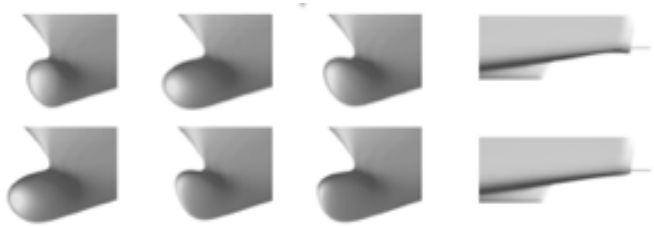


Approach

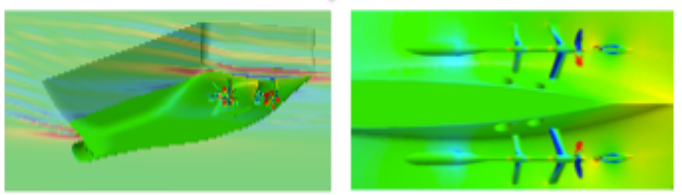
1 - Design Diagnostic



2 - Parametric optimisation



3 - Final evaluation



ESD evaluation and optimisation

Description

- ESDs are more and more used in order to reduce ship consumption. Evaluation at model scale is complex due to important scale effects, and ESDs must be adapted to the hull and operational conditions.

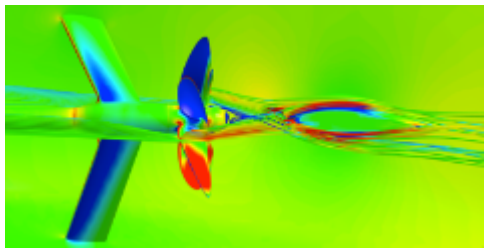
Solution

Self-propulsion based on two complementary models to be used depending on ESD and required accuracy

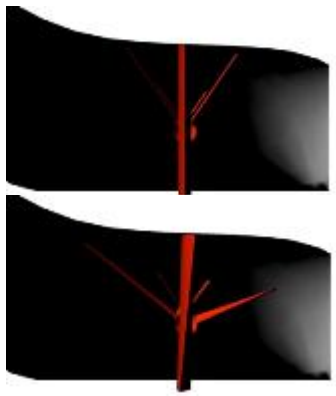
- Actuator disk model
- Rotating propeller

Application examples :

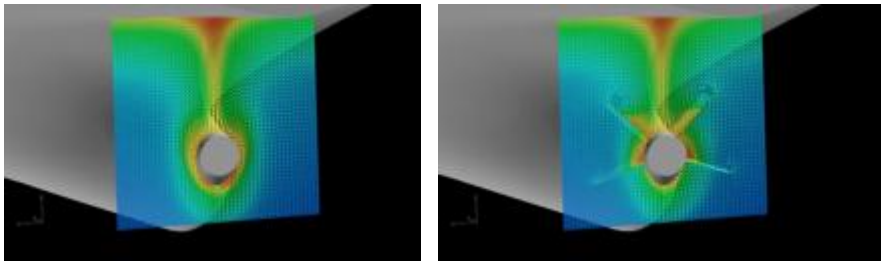
- Optimisation of twisted rudder
  - **Twist of rudder adapted to rotated flow of propeller**
  - **Increase of propulsive efficiency**
  - **Simulations performed with rotating propeller**



CFD image illustrating interaction between appendages and propeller (Velocity streamlines and pressure fields)



- Adaptation of pre-swirl stator
  - Stators adapted to flow
  - Increase of propulsive efficiency
  - Simulations performed with rotating propeller or actuator disk



Effective wake calculated on a LNG hull without and with pre swirl stator

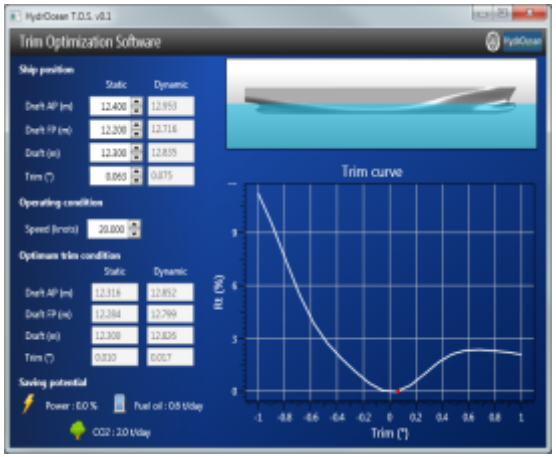
Trim Optimisation

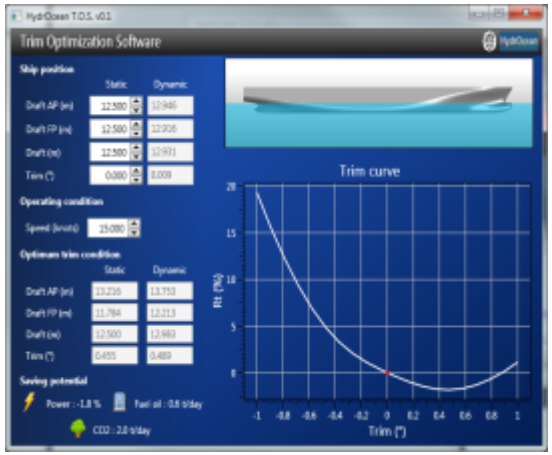
Description

- Optimisation of operation of ships from an hydrodynamic point of view

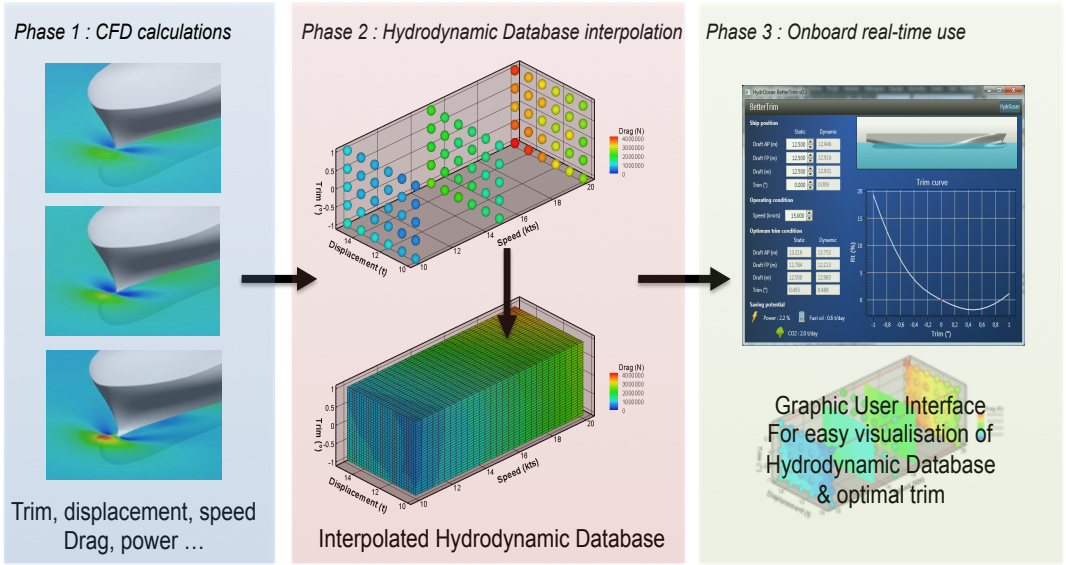
Solution : On board software

- **Dedicated software based on RANSE-CFD computations**
- Identification of optimal static trim for a given speed and displacement
- Use most advanced CFD solvers, and generation of an accurate and detailed hydrodynamic database in few days
- No ship modification required : pay back period less than a few months !





Approach



4.
CMA CGM TOSCA, 8500 TEUs
Bulb Optimisation

HYDROCEAN

CMA CGM

CMA CGM

Advanced Shipping, Environment Minded

CMA CGM's commitment for environmental protection and a sustainable development relies on 4 Major Commitments :

- Fight Climate Change
- Preserve the Marine Environment
- Develop Eco-friendly Solutions
- Promote an Environmental Culture

Lloyd's List Awards Global | 2011 Winner Company of the Year

> Acquisition of new ships
→ A modern fleet incorporating the latest technologies to protect the environment.

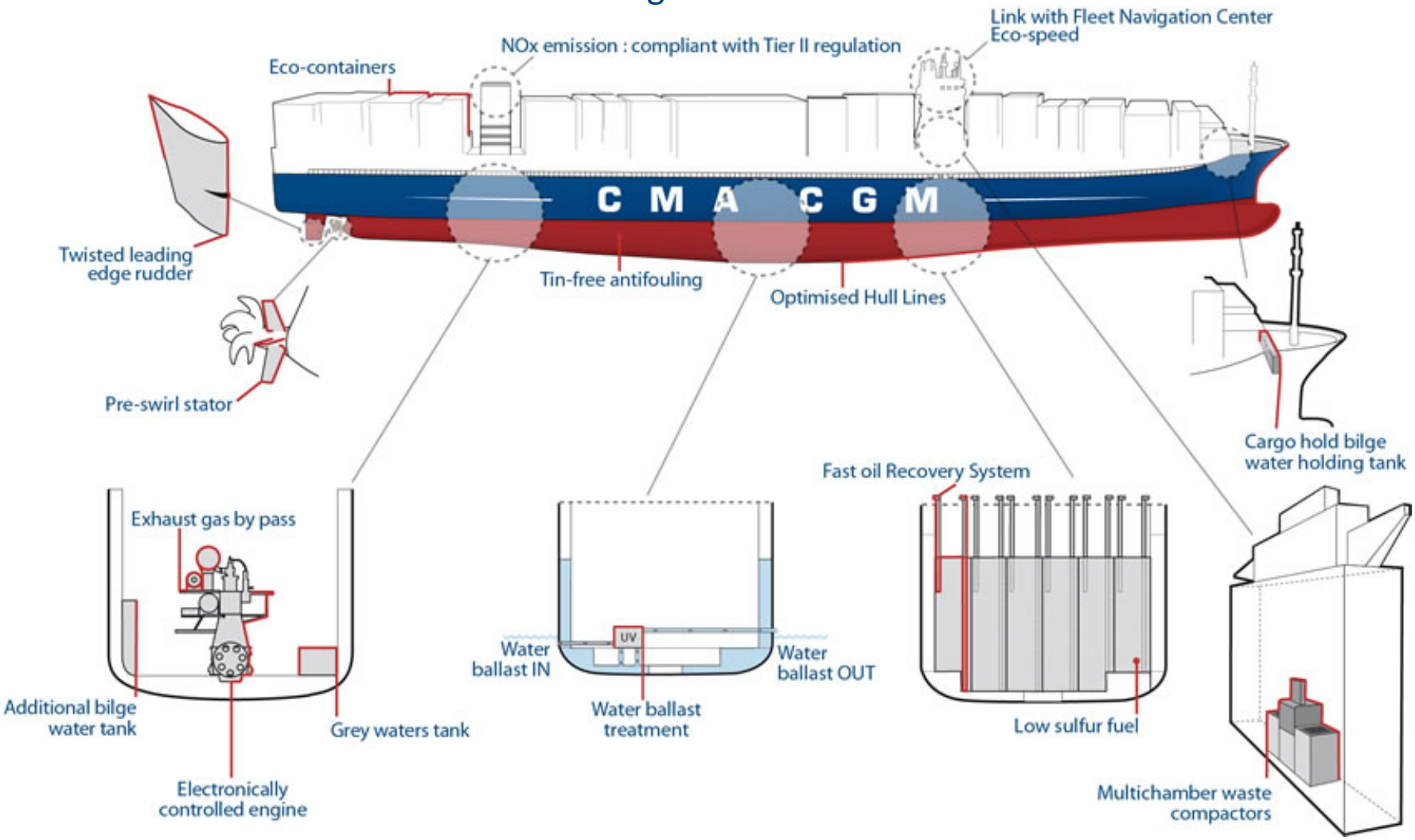
> Program to reduce the speed of the vessels: the **Eco-speed**.
→Reduction of fuel consumption.

The CMA CGM MARCO POLO (16000 TEU) rejects only 36g of CO2/km-teu

CMA CGM: Environment and Sustainability

Green Ship Class Concept

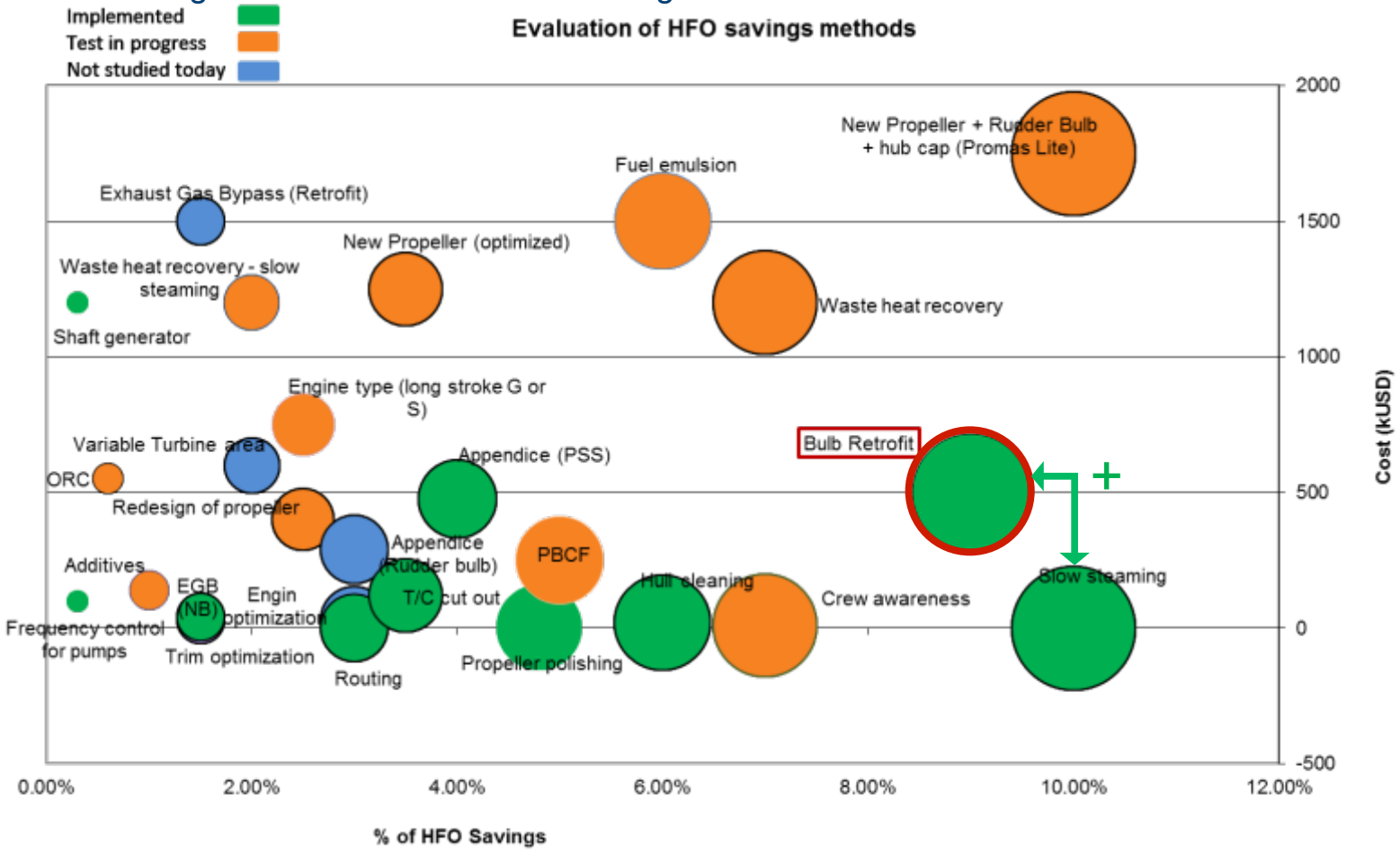
Modern Fleet with the Latest Eco-technologies



Cost savings: action and technologies review

Objective :

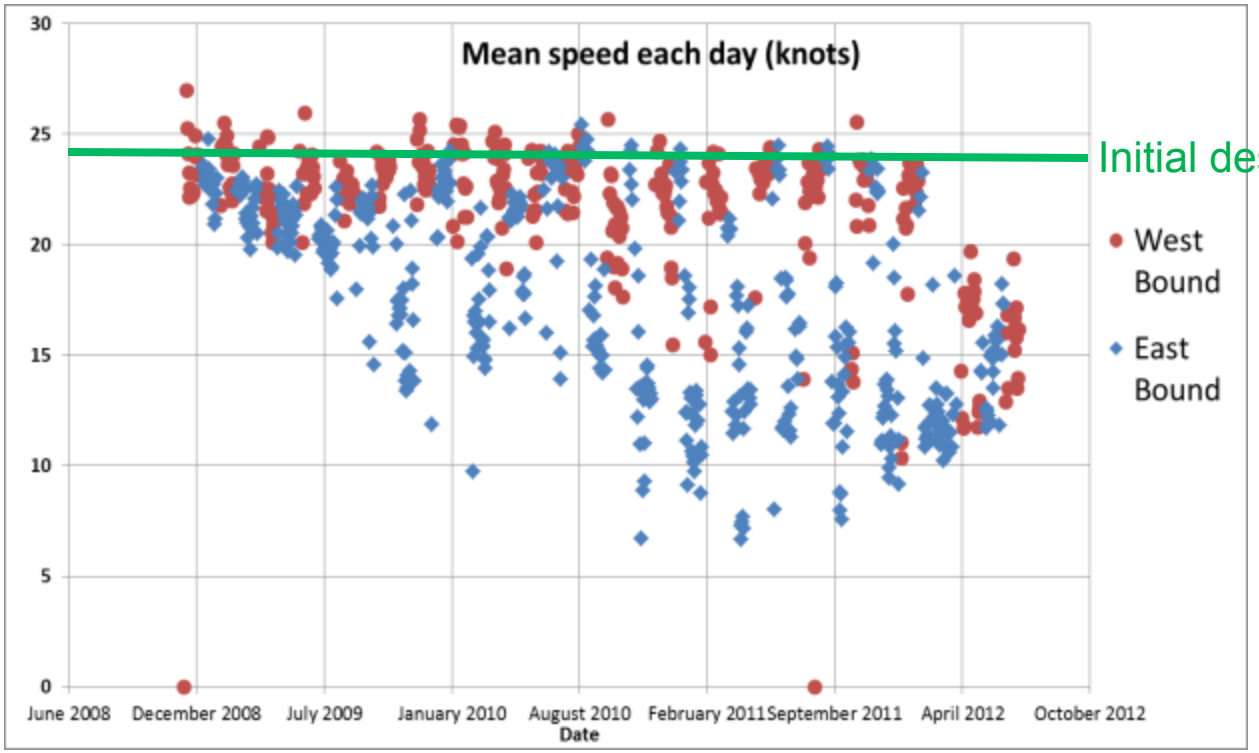
- Optimisation of bulbous bow during retrofit could be quite efficient if savings are proven
- Gains are higher if the vessels sails off-design conditions



Slow steaming for containerships

Analyse :

- Daily mean speed evolution on a typical Asia to Europe trade since 2009
  - Decrease from 24 knots down to a range of 12-18 knots



- Vessel initially optimized for 24.5 knots, 14m Draft

Bulbous bow optimisation for operational profile

Objective :

Optimisation of bulb for an operational profile of 17 conditions

Constraints :

- Conservation of max speed
- Limitation of modifications so that box thruster section not modified
- Conservation of LOA / LPP
- Study performed at iso displacement and trim
- Hull to be optimised for Operational profile (17 conditions)

Approach : parametric evaluation : 50 hull forms

Direct deformations

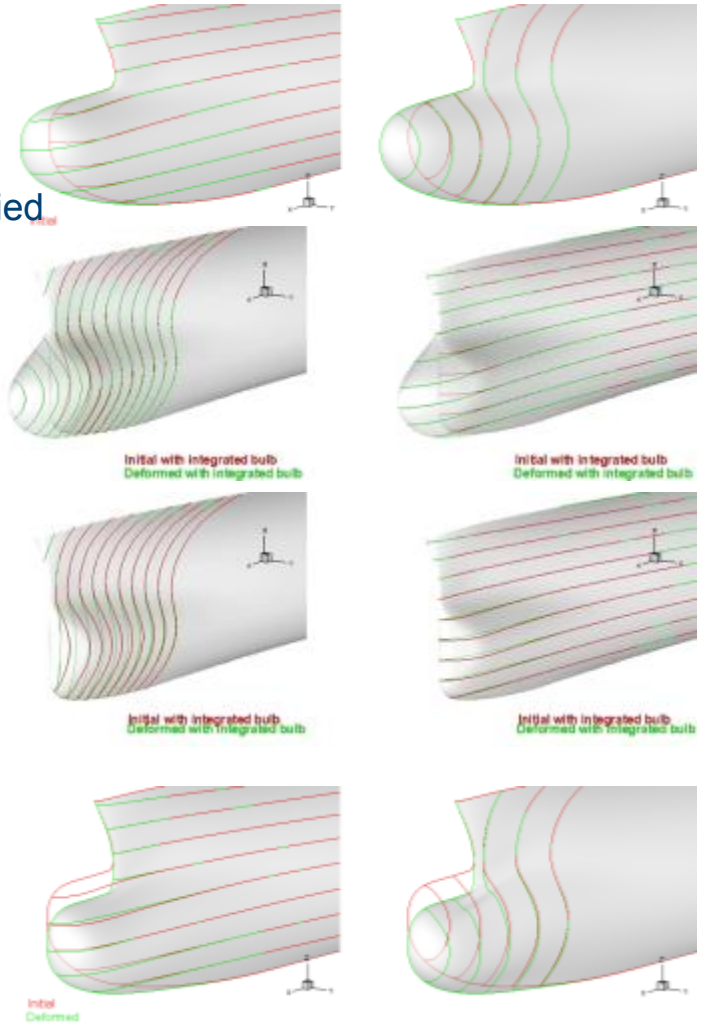
- Length
- Width
- Height

Coupled deformations based on

- Width / height
- Length height

		Speed (knots)			
		12	**15**	**18**	**21**
Draft (m)	**9.5**	3.0%	12.0%	10.5%	4.5%
	12	2.5%	10.0%	8.8%	3.8%
	13	3.0%	12.0%	10.5%	4.5%
	14	1.5%	6.0%	5.3%	2.3%

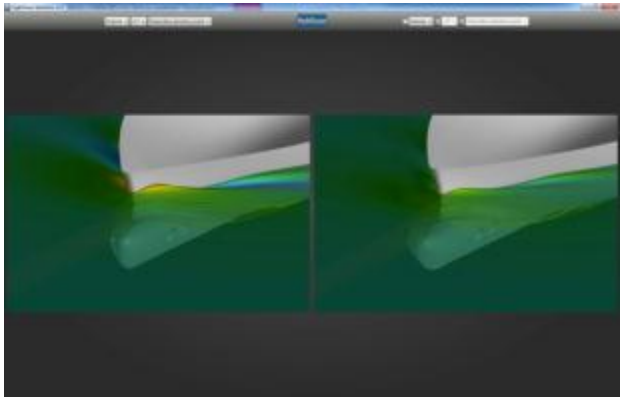
➡ **850 RANSE-CFD computations**

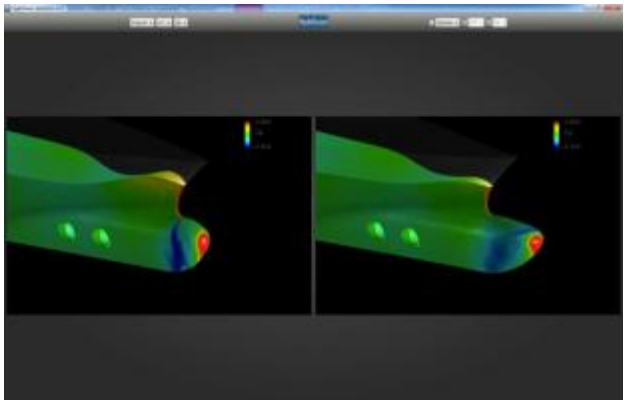


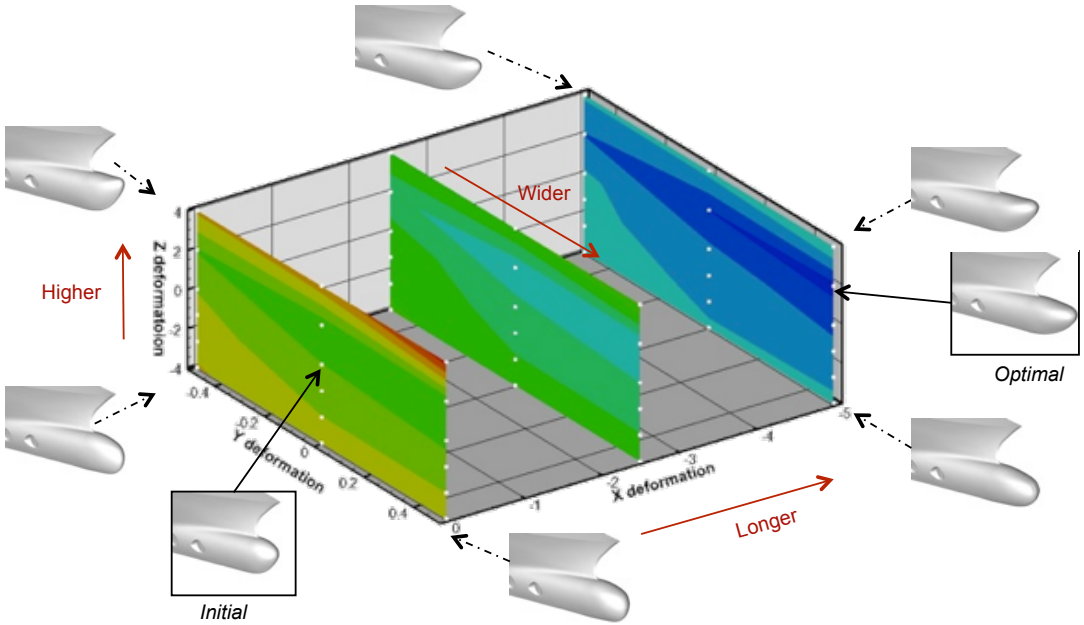
Bulbous bow optimisation for operational profile

Analysis:

- Evaluation of all parameters
  - Length, Height, Width
- Specific and dedicated analysis tools for huge amount of data
  - Subvison for image comparison
  - Visual analysis
  - Specific developed routines



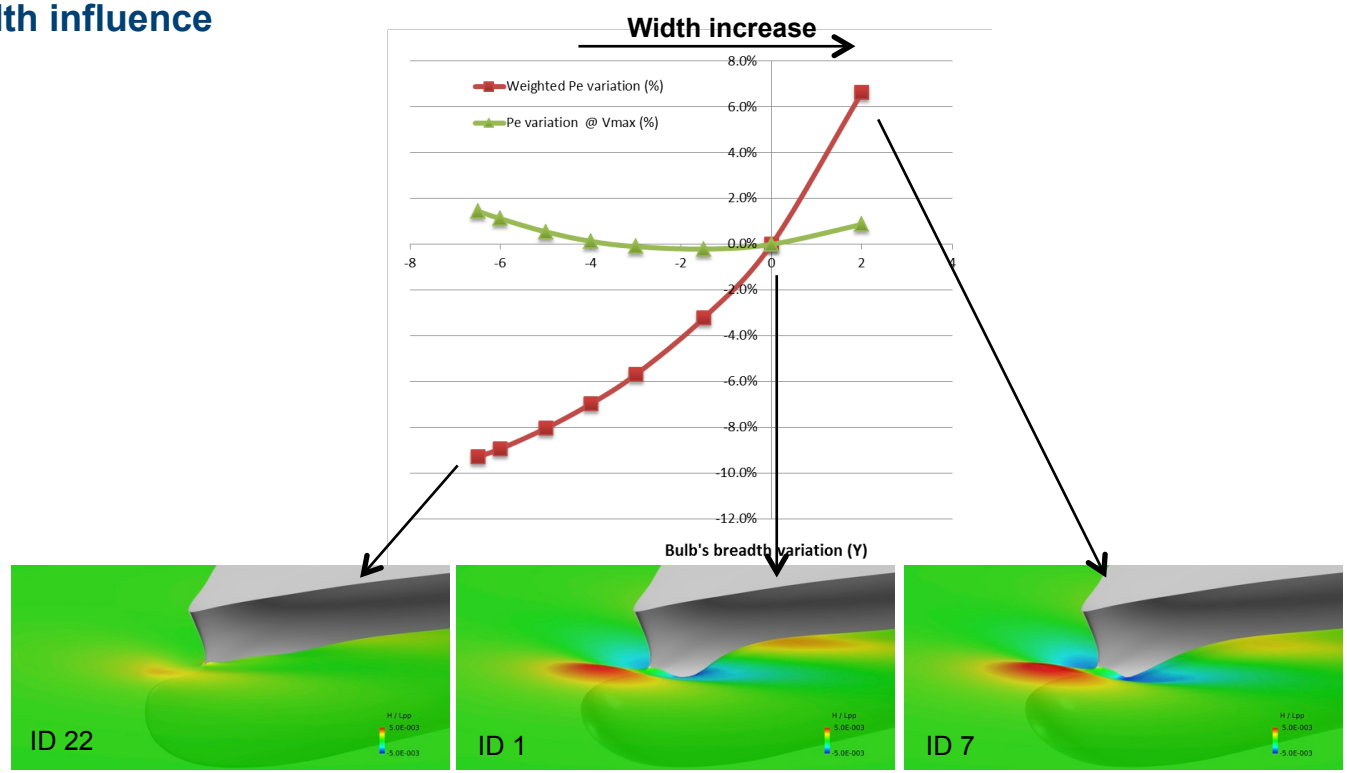




Bulbous bow optimisation for operational profile

Analysis example:

- **Bulb width influence**

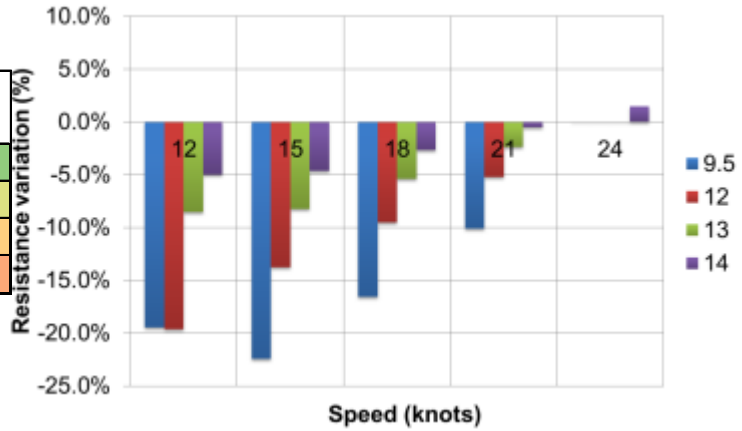


- The bulb's width deformation has a strong influence on weighted Pe variation and a small influence on Pe at Vmax
- The thicker bulb offers 9.3% of gains on weighted Pe and 1.5% of loss on Pe at Vmax.

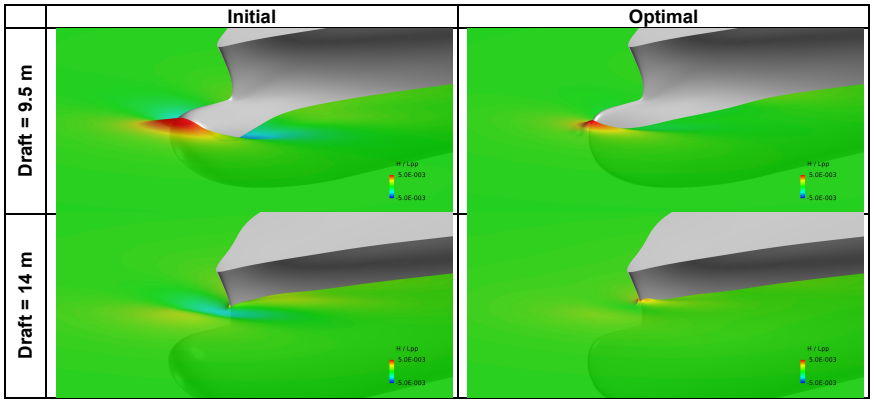
Bulbous bow optimisation for operational profile

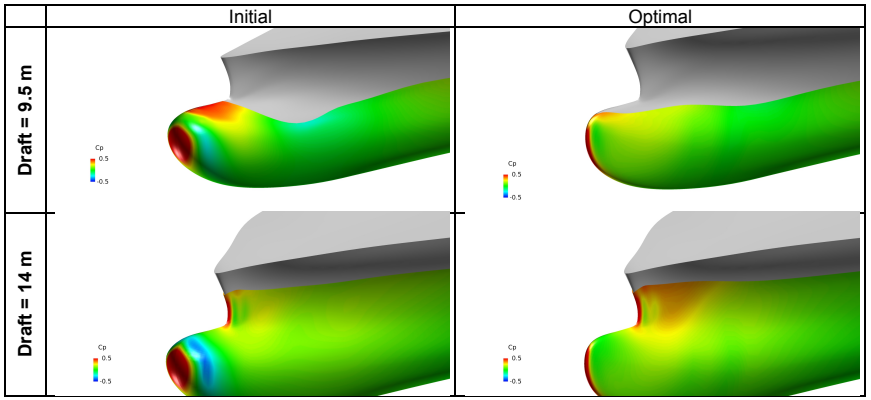
Results :

		Speeds (knots)					
ID	48	12	15	18	21	24	Weighted Pe variation (%)
Draft (m)	9.5	-19.4%	-22.4%	-16.6%	-10.1%	/	-18%
	12	-19.7%	-13.7%	-9.5%	-5.2%	/	-12%
	13	-8.6%	-8.3%	-5.4%	-2.4%	/	-6%
	14	-5.0%	-4.6%	-2.6%	-0.5%	1.5%	-3%
Weighted Pe variation (%)		-14.1%	-13.3%	-9.4%	-5.1%		



- **9.4% gains on weighted Pe for a 1.5% loss on Pe at Vmax**

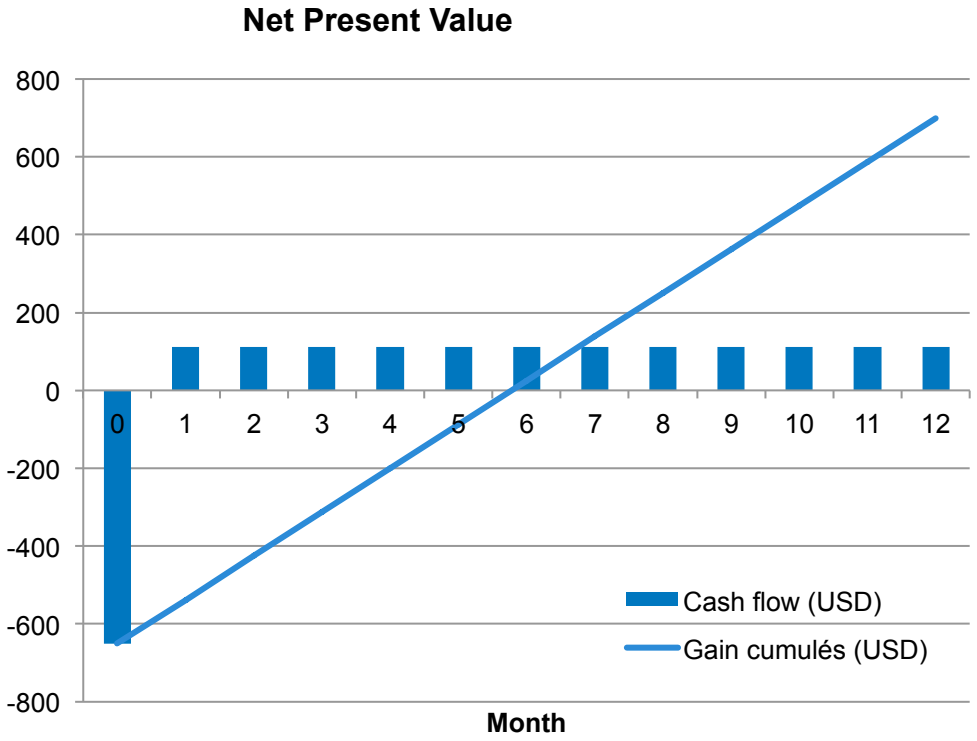




Business Case

- Mean Consumption: 25,000 T/Year/vessel
- Optimized Bulb: -9% in mean HFO Consumption
- Savings : 2,250 T/Year/vessel (1,350,000 USD/Year/vessel)
- Retrofit Cost
  - 600,000 USD
- ROI: 5-6 months

GO

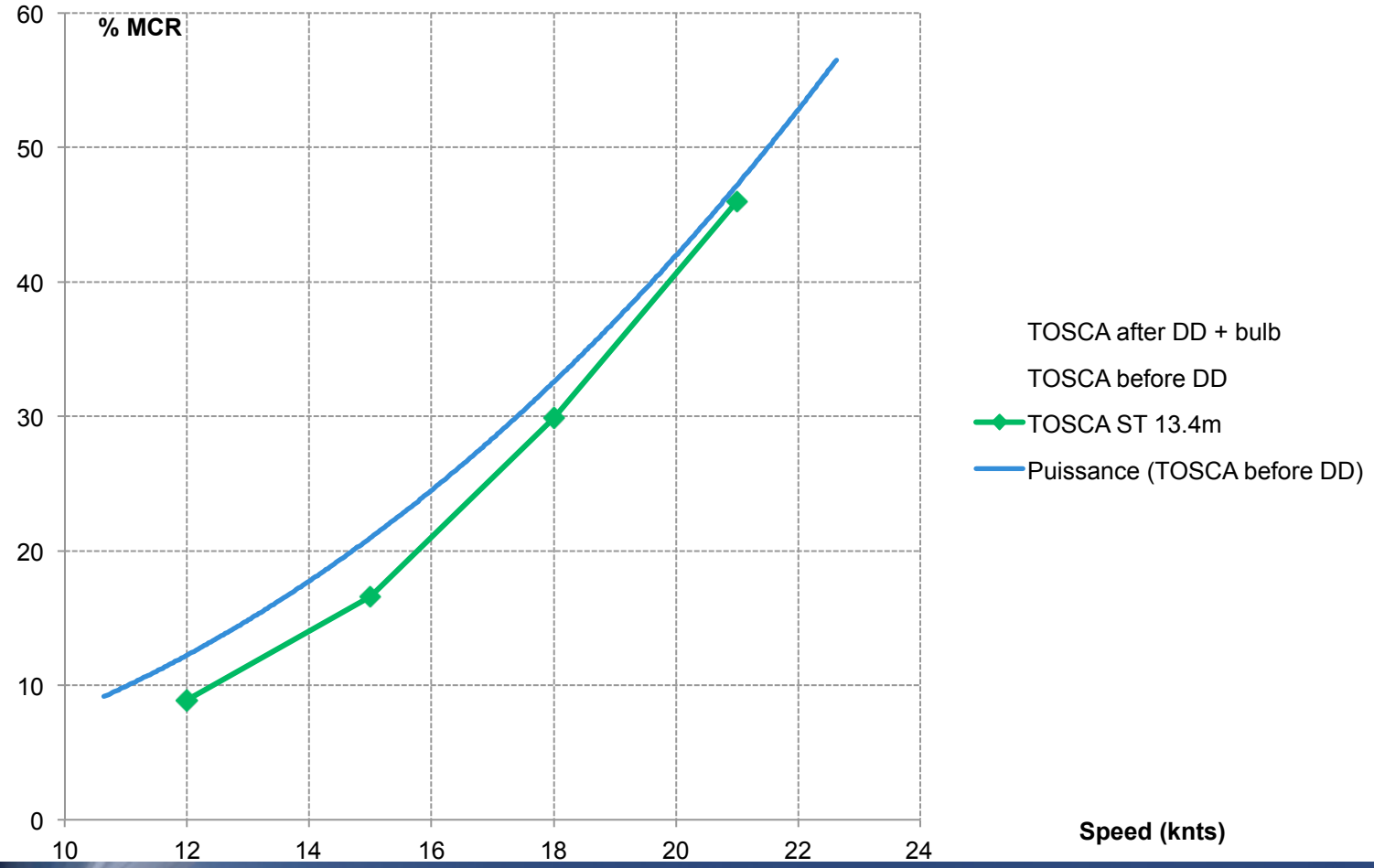


CMA CGM TOSCA

- Work done during Dry Dock:
  - Propeller Boss Cap Fin
  - New Paint
  - Main Engine Overhauls
  - **New Bulbous Bow**

CMA CGM TOSCA

- Sea trial after dry docks:
  - High savings for lower speeds



CMA CGM TOSCA

- Results from sea trial @13,4m

		Vitesses (nds)				
ID	48	12	15	18	21	24
T (m)	9.5	-19.4%	-22.4%	-16.6%	-10.1%	/
	12	-19.7%	-13.7%	-9.5%	-5.2%	/
	13	-8.6%	-8.3%	-5.4%	-2.4%	/
	14	-5.0%	-4.6%	-2.6%	-0.5%	1.5%

Speed (knts)	12	15	18	21	Average
Hydrodynamic gains (PBCF + paint + Bulb)	27,3%	20,8%	8,1%	2,5%	**14,7%**

CMA CGM LA TRAVIATA

- Sister vessel same age, same Dry Dock, without bulb retrofit
- Results from sea trial @13m

Speed (knts)	12	15	18	21	Average
Hydrodynamic gains (PBCF + paint)	4,3%	8,7%	6,5%	8,3%	**6,9%**

CONCLUSION

- Full scale sea trial accuracy : more than 2%
- Hard to isolate single effect
- Good agreement with computations

CONCLUSIONS

- Original Bulbous bow was optimized for design conditions:
  - 24.5 knots / 14m draft
- Post crisis environment: need for flexibility and lower speeds

- High savings expected from bulbous bow retrofitting

- Computations done with accurate CFD codes
- Parametric study to cover the whole range of deformations
- Multi-criteria to cover the whole operating profile of the vessel
- 5 weeks study

- Results confirmed by sea trials and first voyage of the vessel

- Short time for return on investment
- High cash flow generation

- Following bulb retrofit a trim optimization study has been performed by HydrOcean to update CMA CGM tables.

Thanks for your attention

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