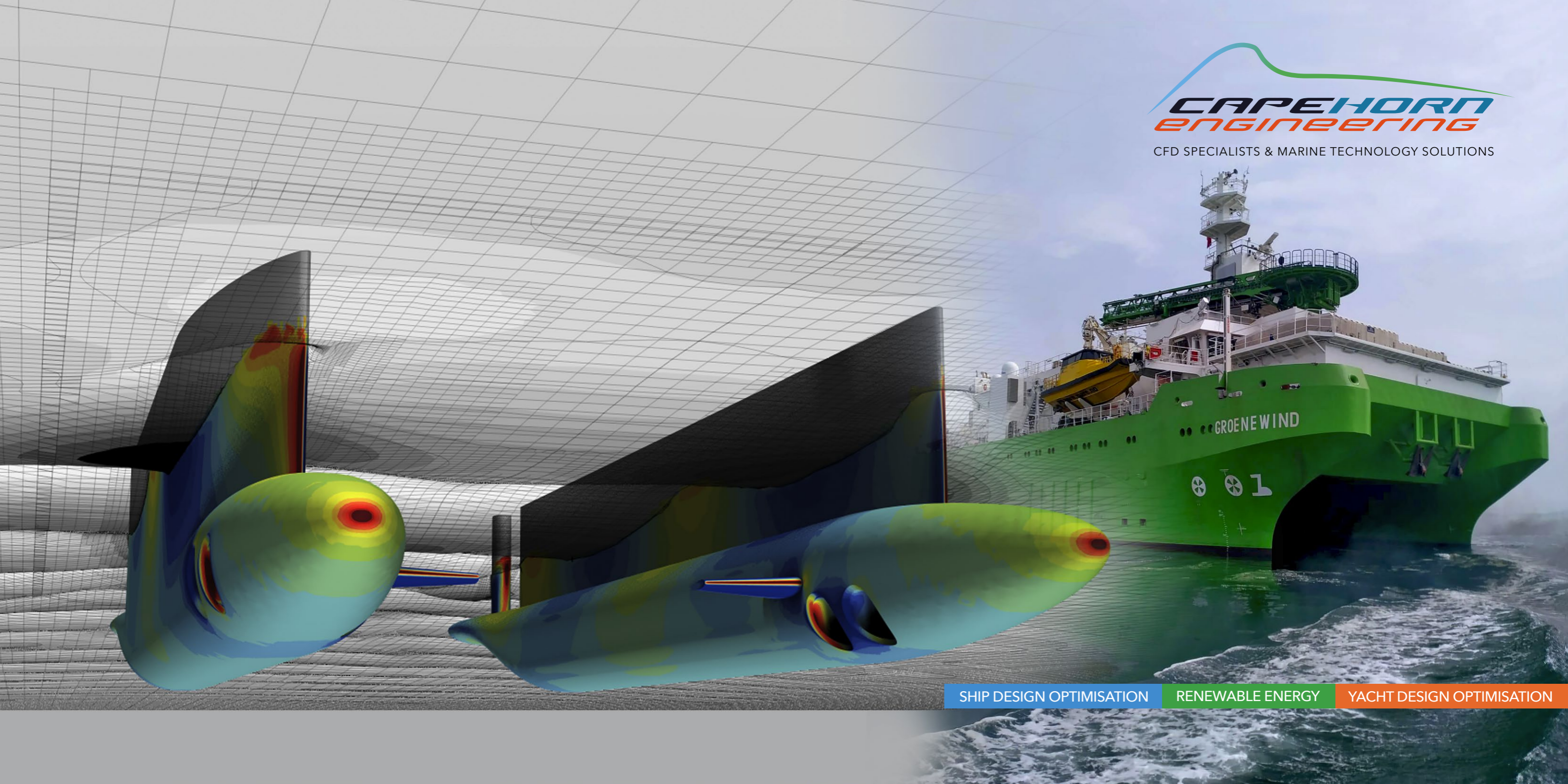




CFD SPECIALISTS & MARINE TECHNOLOGY SOLUTIONS



SHIP DESIGN OPTIMISATION

RENEWABLE ENERGY

YACHT DESIGN OPTIMISATION





## Welcome to Cape Horn Engineering

Cape Horn Engineering is a UK based company, providing best-in-class independent CFD (Computational Fluid Dynamics) consultancy with clients all over the world. As industry leaders in numerical modelling and marine technology solutions, we specialise in hydrodynamic and aerodynamic analysis, full-scale performance prediction and design optimisation.

Cape Horn Engineering was founded in 2007 by Dr.-Ing. Rodrigo Azcueta with the vision of providing world-class expertise in marine CFD to support the design of racing yachts. We have since led the numerical analysis in four America's Cup campaigns and dominated the design space for the Volvo Ocean Race for almost a decade, with yachts designed using our technology winning the circumnavigation consecutively for three editions.

Working for the America's Cup requires rigorous testing and validation to remain competitive at the highest level with access to large resources and benefiting from other disciplines. R&D and validation has always remained a corner stone in the development of our methodologies and experience, ensuring the best possible solutions are offered.

Our technology and experience, grown in this performance led environment, has since been refined for application to the wider marine sector. Our flow analyses are continuously proven in a wide variety of other marine applications including superyachts, production yachts, power boats, fully foiling and foil assisted high speed vessels, advanced and unconventional vessels, commercial cargo ships, wind assisted ship propulsion, offshore platforms and work boats for the renewable energy industry.



[SEE CASE STUDY](#)

America's Cup design optimisation

SHIP DESIGN OPTIMISATION

RENEWABLE ENERGY

YACHT DESIGN OPTIMISATION



### Delivering best-in-class service

- \* Years of verification and validation with towing tank data, tank testing programmes, wind tunnel tests and most recently with full scale sea trials
- \* No compromise on software quality, we use the best CFD package on the market, STAR-CCM+ from Siemens Digital Industries
- \* Our work flow is highly automated, allowing us to run hundreds of simulations per day
- \* We have access to powerful High Performance Computing clusters and large amounts of software licenses
- \* We communicate clearly with our clients, ensuring their needs are met, while presenting results on time and to the highest standards
- \* We use advanced visualisation techniques to investigate the flow features, sharing that knowledge with clients
- \* We pride ourselves on an unrivalled level of commitment, client confidentiality and strong customer relations. The continued relationship with our customers demonstrates our ability to provide the best service

### Main features of our simulations

- \* Our simulations are run at full scale including all appendages and details, removing the need for extrapolation from model scale
- \* Hydrodynamic simulations include the free surface deformation and the dynamic sailing attitude of the vessel
- \* Propulsion simulations can be modelled with different levels of fidelity, from virtual discs to rotating propellers
- \* Simulations can include complex physical phenomena when present, like cavitation, transition from laminar to turbulent flow, ventilation, sprays, etc.
- \* We perform manoeuvring simulations according to ITTC procedures
- \* We assess ship responses in regular waves and irregular sea states
- \* Fluid Structure Interaction for hydrofoils and other structures
- \* Aerodynamic simulations in steady state or transient flow, coupled to structural models for deformation of sails
- \* Slamming loads, sloshing, water entry, wave piercing, water on deck and any associated dynamic phenomena
- \* Multi degree-of-freedom simulations allows complex dynamic behaviours like surfing, rolling, capsizing, etc.



SEE CASE STUDY

Superyacht design optimisation

SHIP DESIGN OPTIMISATION

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YACHT DESIGN OPTIMISATION



### Using CFD technology

CFD technology offers a huge benefit for naval architects when optimising any vessel. Historically, designers have used more traditional technology, such as towing tank tests to ensure their final designs meet their client's requirements. However, the force similarities between the model at scale and the real ship cannot be achieved in a towing tank, which makes testing complex, relying upon on assumptions and empirical formulations.

Today, using CFD eliminates this problem, since it allows the vessel to be modelled at full size and directly captures the stern wake and boundary layer effects. Moreover, CFD offers a greater insight into the details of the flow through images, video animations and interactive visualisation files. Even virtual and augmented reality is starting to make an impact today. CFD also offers substantial reductions in time and costs in comparison to physical models.

We use advanced visualisation techniques to understand the flow features and to share that knowledge with clients. We post-process the simulations in a way that provides designers with load cases, internal forces and moments for dimensioning the appendages of their designs. We carry out Fluid Structure Interaction for appendages and sails. We assess cavitation of the appendages of all high speed craft. We have developed foil section optimisation loops that take into account transition and cavitation. For extensive design campaigns we enhance hull and appendage shapes using modern optimisation techniques like neural networks and genetic optimisation algorithms.

### Machine Learning and Artificial Intelligence models

Cape Horn Engineering has pushed the boundaries of numerical modelling since its inception. We continue to push technology to its limits, developing ground-breaking techniques and methodologies to ensure we remain at the forefront of the industry. Through collaborations with industry leaders and universities, our latest research aims to harness the potential offered by Machine Learning and Artificial Intelligence Modelling, reducing analysis times from hours to seconds, and facilitating real time analysis to changing input conditions. These new technologies could be the future of numerical analysis, and the opportunities it facilitates are exciting and monumental.



### Advantages of CFD compared to tank testing

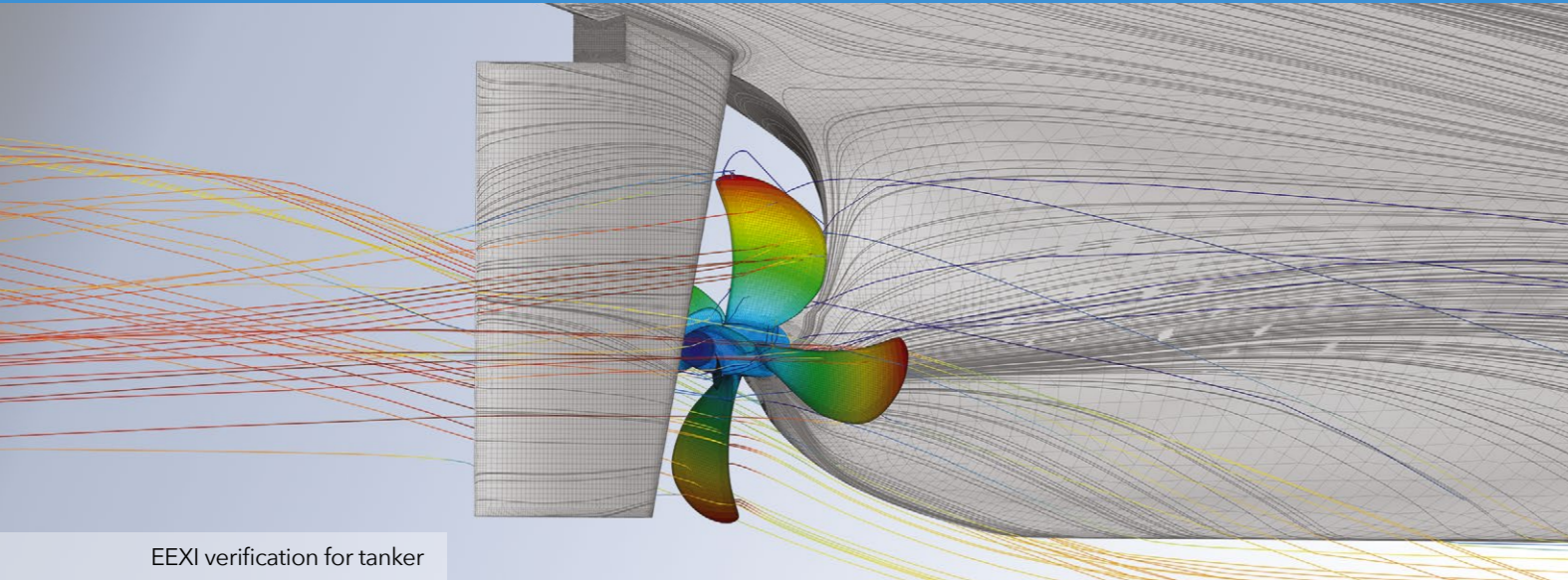
- \* All simulations are at full scale
- \* Simulations use realistic inertias and centres of gravity (something not easily achievable in tank testing)
- \* Oblique incident waves coming from any direction can be simulated, tank testing is usually limited to head waves
- \* Decomposition of individual forces and moments for the hull and each appendage and by physical origin, like friction and pressure
- \* Precise analysis of motion velocities, accelerations and trajectories of the body
- \* Flow visualisation and animation to gain insight and understanding about differences between designs
- \* Simulations are 100% reproducible
- \* Hull or appendage shapes can be easily changed without building new models
- \* Easy to test many design configurations eg. to swap appendages
- \* Time and cost reduction



SEE CASE STUDY

Racing yacht technology, Malcolm McKeon, Baltic Yacht 112m LIARA





EEXI verification for tanker

Cape Horn Engineering is proud to provide a range of services to clients across the shipping industry. In addition to standard performance analysis, design optimisation and seakeeping analysis, Cape Horn offers a range of services that can be tailored to your specific needs. In recent years the increased demand of the industry has led to us gaining extensive experience in:

- \* EEXI calculations
- \* Analysis of ESD's
- \* Comparison and development of WASP Devices

### Energy Efficiency Existing Ship Index (EEXI)

Global efforts to reduce the environmental impact of the shipping industry have accelerated rapidly in recent years, with new measures, such as the Energy Efficiency Existing Ship Index (EEXI) set to come into force in January 2023.

CFD offers a cost effective and fast solution to develop speed-power curves for vessels lacking data that meets the strict conditional requirements of the regulations. Cape Horn Engineering is experienced in calculating the reference speed of a vessel for EEXI, having developed an efficient workflow in conjunction with a leading classification society.

Employing CFD ensures the calculated reference speed accounts for the physical flow around the vessel, considering any modifications or ESD's that have been installed, while avoiding the time and expense of model testing. It is considerably more accurate than the conservative empirical formulae supplied by the IMO and the higher fidelity calculation may help ensure compliance for marginal vessels.

[SEE CASE STUDIES](#)

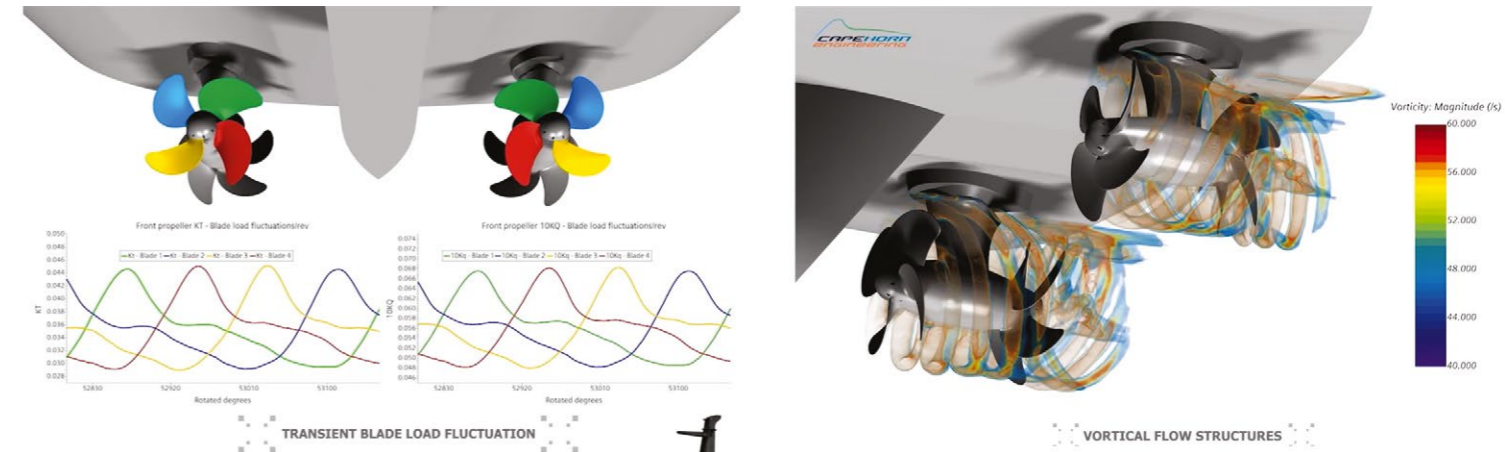
### Validation & Verification (V&V)

Cape Horn Engineering have simulation workflows and analysis tools to efficiently perform verification and validation (V&V) of a simulation set up, in accordance with ITTC Quality Control Procedures. The process of V&V is integral to producing reliable and accurate CFD results and is something that we have always taken very seriously. These V&V procedures ensure that our CFD results meet the strict requirements of the IMO when performing EEXI simulations.

### Energy Saving Devices (ESD)

Energy Saving Devices offer great potential to improve the efficiency of a ship, helping to reduce the emissions and the operational expenses. They may also be employed to help a vessel meet the EEXI requirements.

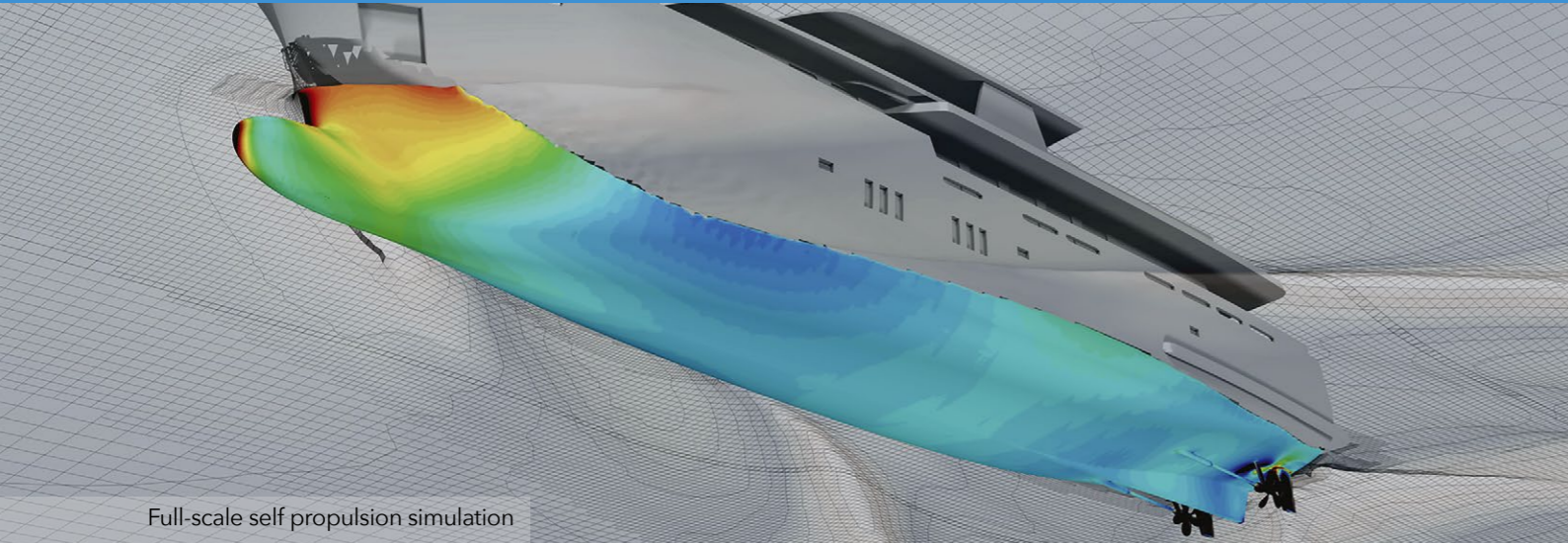
CFD offers the perfect test environment in which to model ESD's, in full scale, as applied to the physical ship geometry. We are experienced in complex simulation set ups in which propulsion is modelled with a rotating, meshed propeller geometry as opposed to relying upon common simplifications to ensure the highest degree of accuracy. This analysis confirms that the ESD will perform as expected, and the maximum increase in efficiency is achieved prior to the costs of installation.



[WATCH PROPULSION SIMULATION](#)

Full-scale propulsion tests





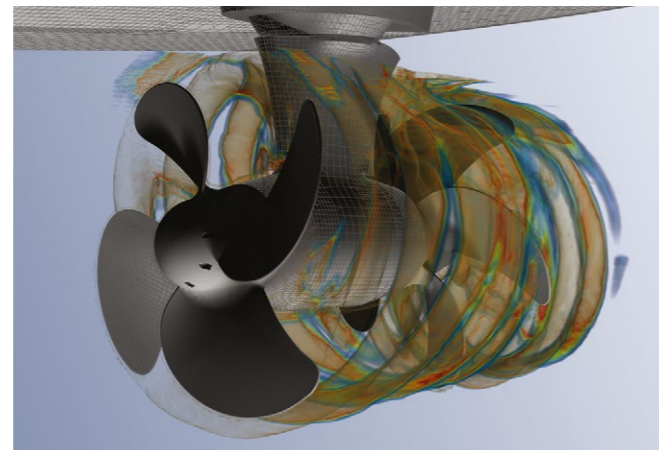
Full-scale self propulsion simulation

### CFD Technology for Seakeeping

Seakeeping simulations have traditionally been extremely computationally expensive to run, due to the stringent spatial and temporal discretisation requirements. Recent developments in the CFD solver we use, combined with our custom setup, allow us to efficiently compute a vessels motions in incident waves from any direction, including the most challenging condition of following waves. Several useful characteristics can be obtained, ranging from the amplitude of the motions and accelerations in specified locations, to the occurrence of green water on deck.

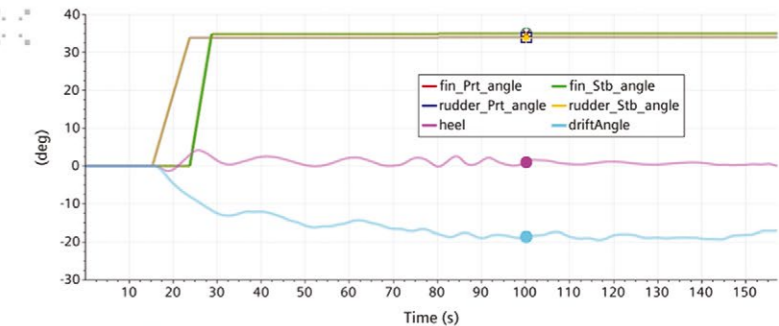
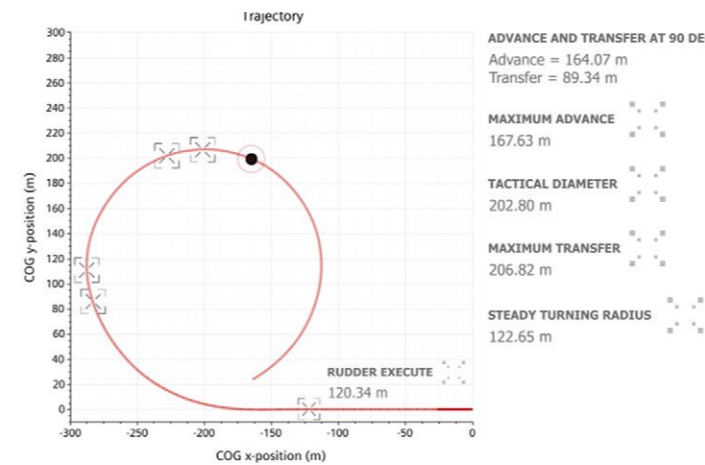
At Cape Horn Engineering we have developed statistical models to characterise a vessels motion in response to an irregular sea state, allowing long term operability analysis of a vessel operating in a particular location. By using carefully selected regular wave simulations, we calculate a vessels Response Amplitude Operator (RAO). Once fed through our custom modelling software, response characteristics for an irregular sea state can be obtained, including the motion response spectrum, added resistance, RMS motions, Motion Sickness Incidence (MSI), and probabilities of exceeding operational criteria such as vertical acceleration.

[WATCH SEAKEEPING SIMULATION](#)



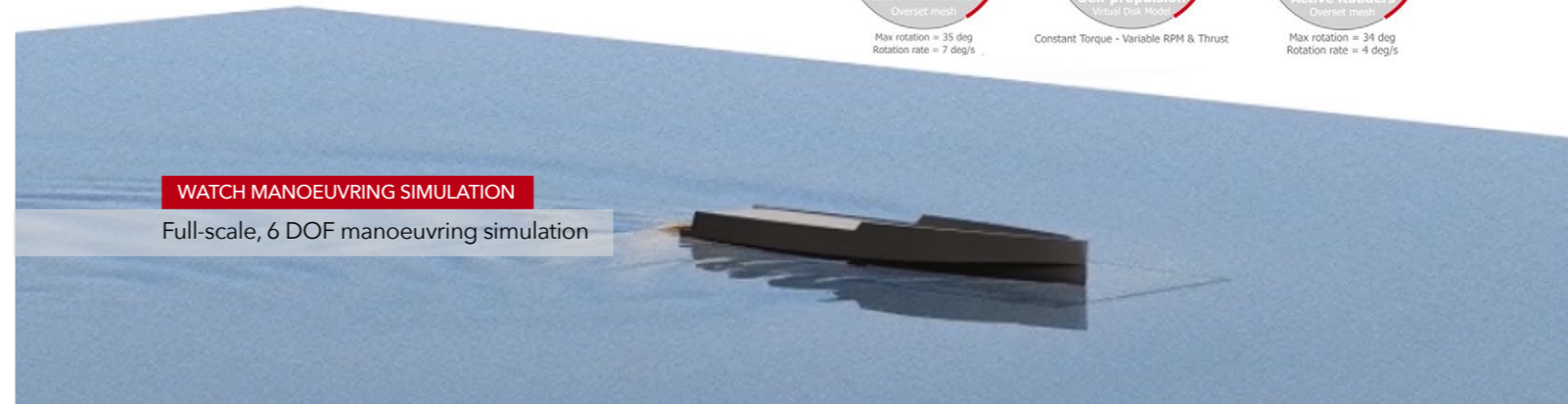
### Areas where we can help...

- \* Energy Efficiency Existing ship Index (EEXI)
- \* Energy Efficiency Design Index (EEDI)
- \* Performance of Energy Saving Devices (ESD)
- \* Performance of Wind Assisted Ship Propulsion Devices (WASP)
- \* Hull and appendages performance and optimisation
- \* Propulsion, propeller selection, fuel consumption and delivered power
- \* Propeller cavitation analysis
- \* Manoeuvring coefficients according to ITTC procedures
- \* Appendage torque and bending moments
- \* Seakeeping analysis, added resistance, motions and accelerations
- \* Roll damping, performance of fin stabilisers
- \* Slamming loads, water on deck and sloshing
- \* Performance analysis of high-speed vessels
- \* Effects of steps, trim tabs and interceptors
- \* Fully foiling and foil assisted vessels
- \* Cavitation on hydrofoils and 2D foil section optimisation
- \* Fluid Structure Interaction (FSI) of appendages
- \* Occupant safety and comfort including local wind effects and exhaust gas
- \* Windage and structural wind loads on superstructures
- \* Engine room and cargo hold and cabin ventilation
- \* Ship Helicopter Operating Limits (SHOL)
- \* Damage stability, ship launching and lifeboat launching

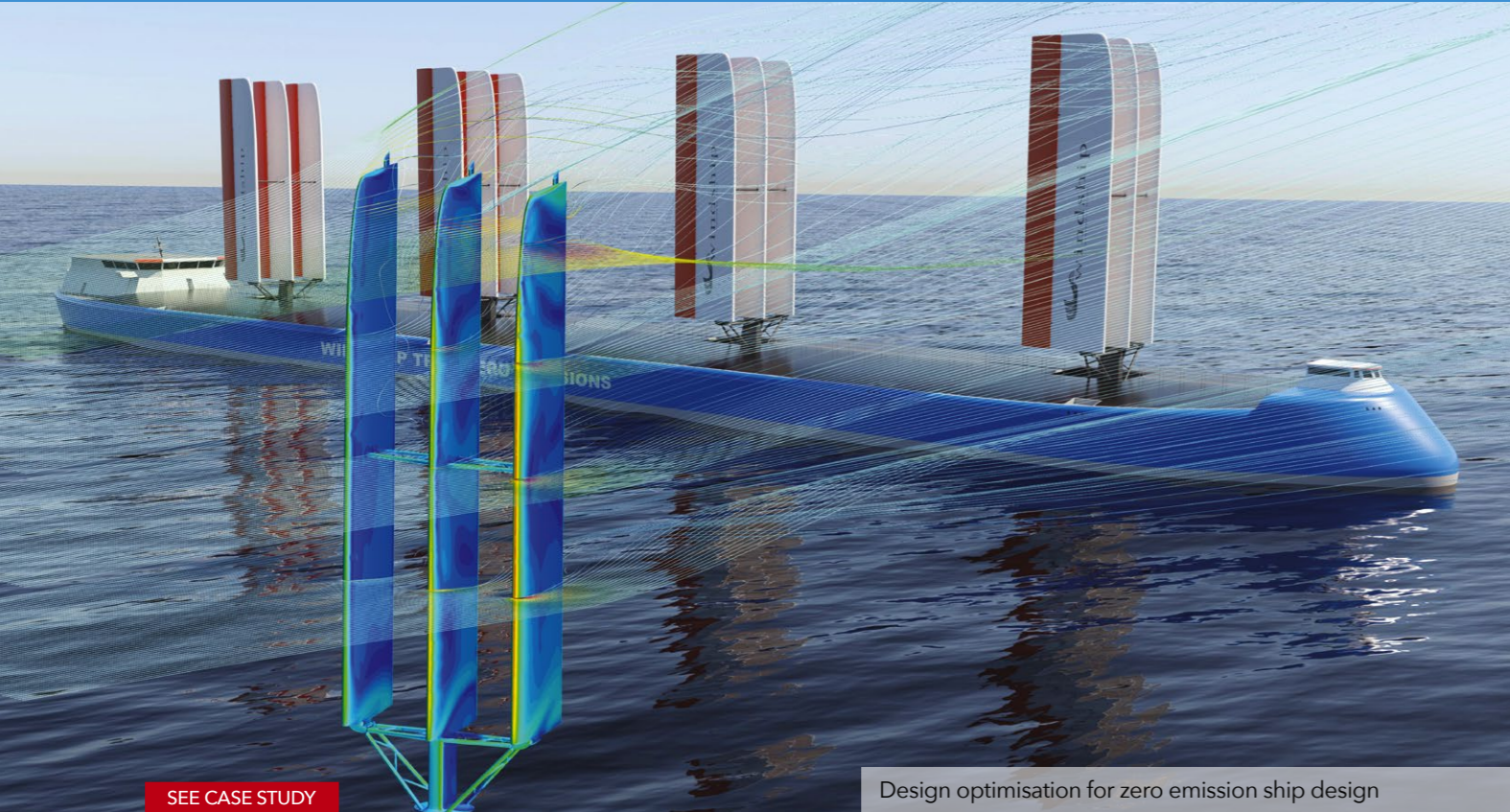


[WATCH MANOEUVRING SIMULATION](#)

Full-scale, 6 DOF manoeuvring simulation







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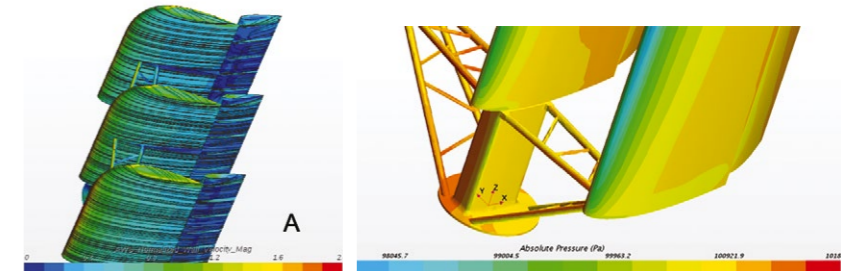
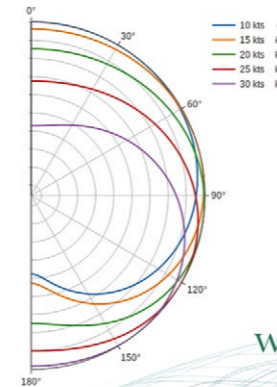
Design optimisation for zero emission ship design

Environmental concerns are influencing a greater need for renewable and sustainable energy across the world, with specialist technologies being at the forefront of new designs and solutions. As maritime industries begin to tackle climate change issues, ports and shipping companies are looking for carbon-free alternatives by testing potential solutions for vessels.

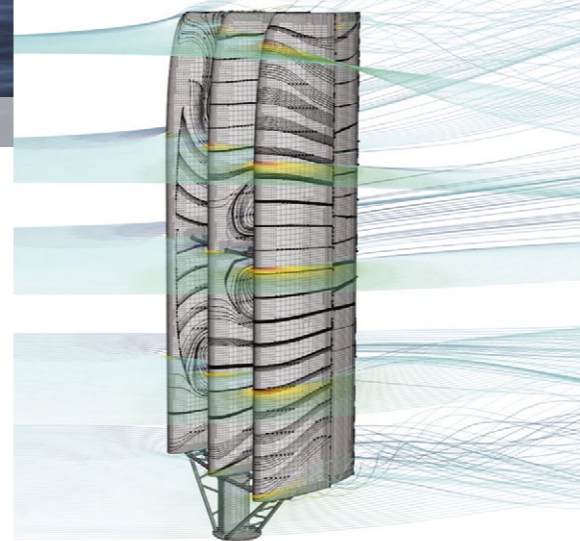
### Wind-Assisted Ship Propulsion (WASP)

One innovative technology being applied is Wind Assisted Ship Propulsion (WASP), using devices such as wing sails, suction sails, Flettner rotors, or any other wind-powered devices. These systems can offer fuel savings of 10 to 30% when retrofitted to existing vessels. Due to our renowned experience and specialist technology, we are working for several technology developers to help optimise their products, either by running systematic shape and condition variations to be used in Velocity Prediction Programs or by running bespoke six-degrees-of-freedom (6DoF) to validate the final products. For this, we have developed a simulation workflow to directly compare the efficiency of WASP devices and to determine the potential power saving. These are highly complex simulations that model both

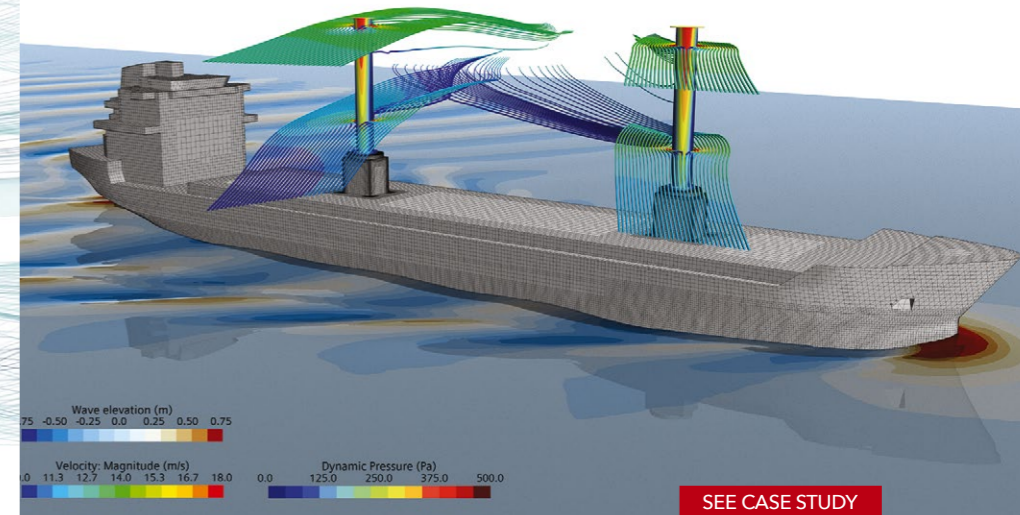
the hydrodynamic and aerodynamic effects simultaneously in a single simulation. To further increase the accuracy, the wind conditions above the water surface are modelled with a realistic wind profile considering the atmospheric boundary layer wind gradient. The vessel is sailing at constant speed, with either an actuator disk or a rotating propeller geometry modelling the propulsion. This calculates the propeller torque and RPM, and thus the delivered power. The simulation further considers the waves generated by the vessel, the dynamic sinkage and trim, the drift or leeway angle, the heel angle, and the rudder angle to keep a constant course. This offers a direct measure by which the fuel (and emissions) saving potential can be assessed. In order for the shipping industry to adopt these new technologies, the accurate CFD analysis of potential savings and performance results provide crucial information.



Extensive CFD testing to further improve the design of the solid wings



WATCH AERODYNAMIC SIMULATION



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Aero and Hydro simulation for accurate performance prediction



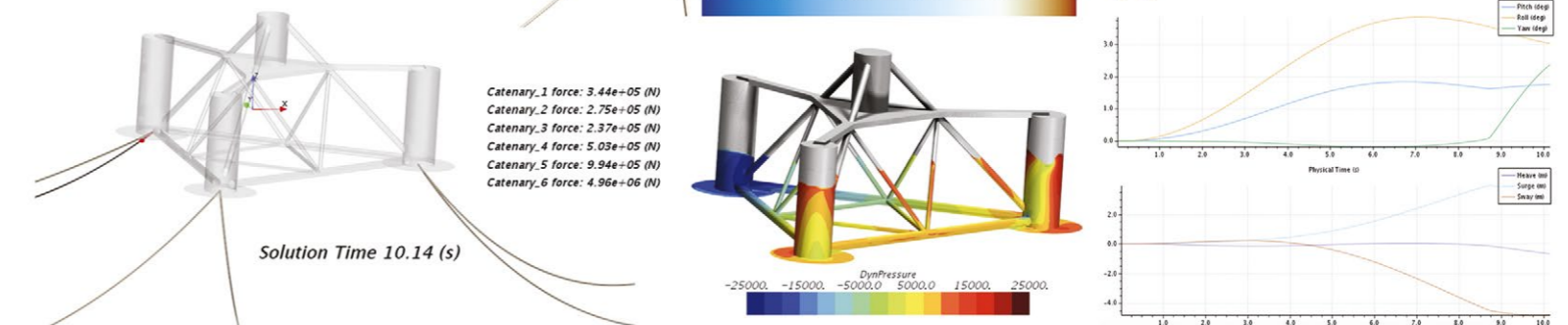
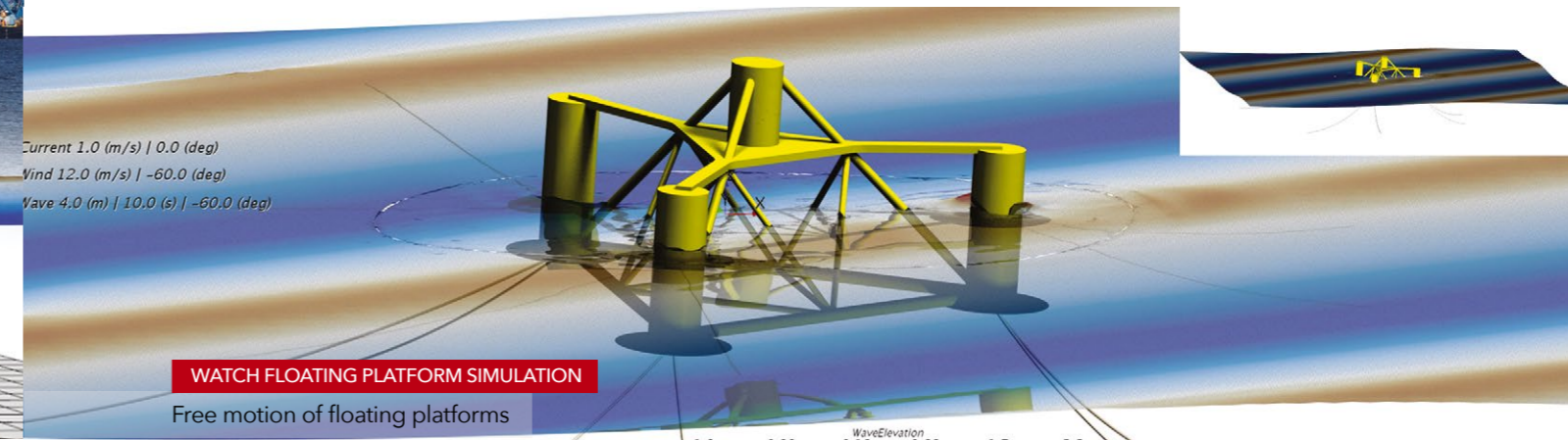


### We can support your project

- \* Improve rotor blade performance including section profile
- \* Motions and extreme loads of offshore floating platforms
- \* Investigate mooring systems
- \* Investigate wave energy devices
- \* Investigate tidal turbine devices
- \* Reduce noise emissions and vibrations
- \* Reduce high fatigue loads
- \* Meet stringent safety standards
- \* High fidelity, CFD-based wind and tidal forecast embedded in global models

### Floating Platforms

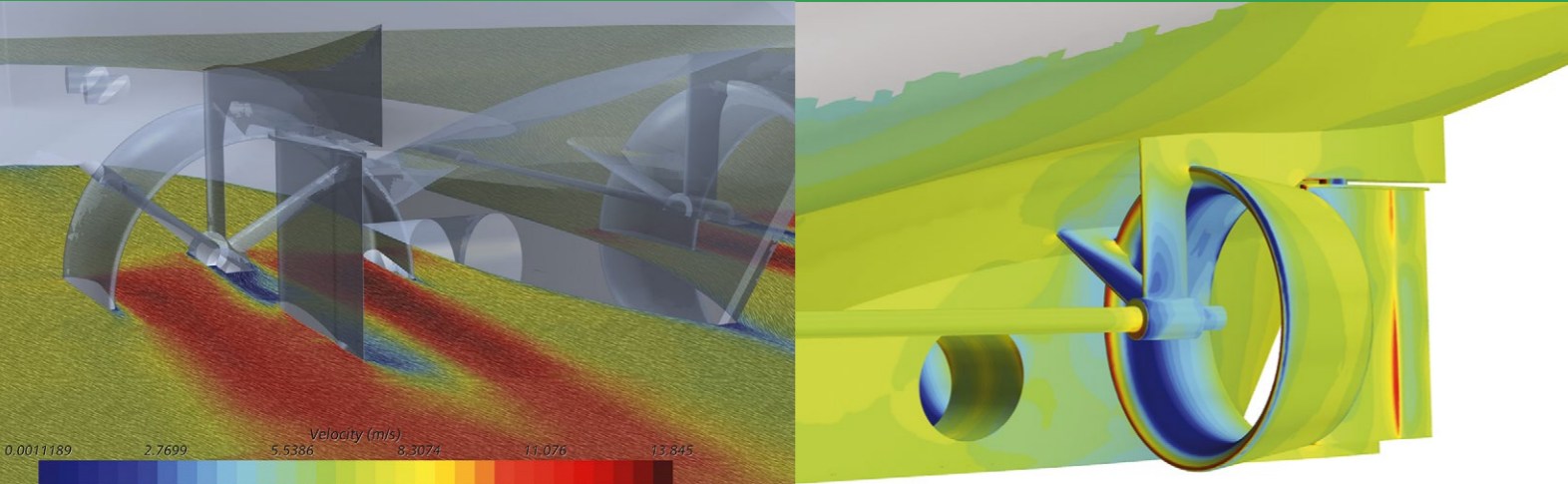
With our expertise in aerodynamics and hydrodynamics we can assess and compare the performance of different types of renewable energy structures. We have experience in high-fidelity modelling of Offshore Wind Platform motions under the effect of waves, current and wind to investigate high fatigue load cases, extreme load events, meeting stringent reliability and safety standards.



We care passionately about the environment and firmly believe the world needs to concentrate its efforts in developing efficient solutions for producing renewable energy. We have a strong desire to apply our skills and technology to contribute to this development and improve the performance of wind or ocean energy structures for renewables. We are interested in partnering in regional or global R&D efforts for developing novel solutions and improving renewable energy structures to reduce the cost of energy and increase safety and reliability. Our simulations can be applied to any type of offshore platform, including different mooring systems, for offshore wind, ocean waves and tidal energy.

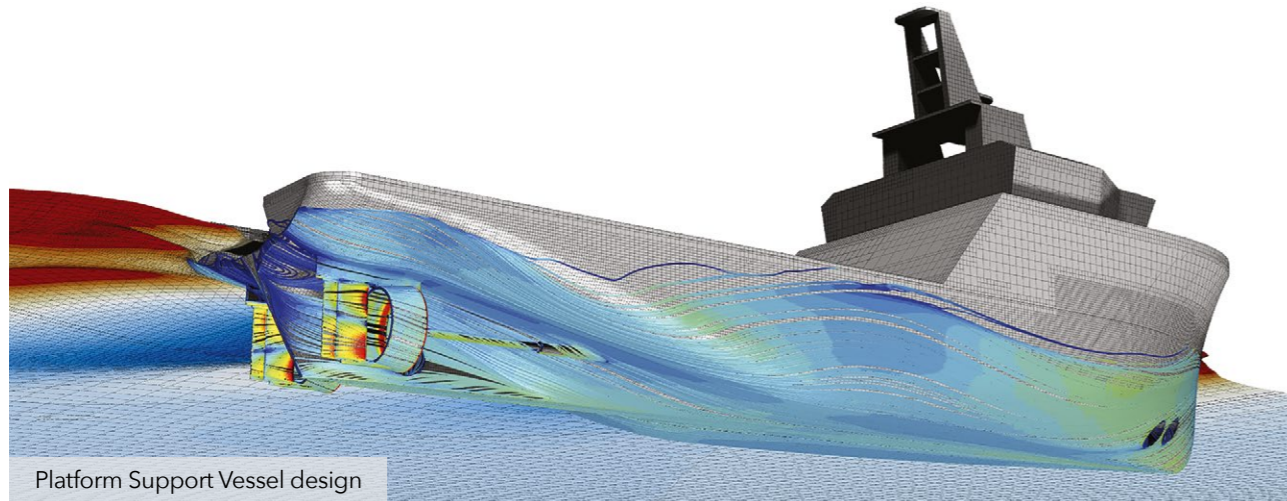
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### Service Operation Vessels (SOV), Crew Transfer Vessels (CTV)

In addition to helping to improve the performance of wind or ocean energy structures we also apply our technology and expertise to the Service Operation Vessels (SOV), Crew Transfer Vessels (CTV) and other work boats that are required to operate offshore, sometimes in hazardous weather and extreme sea states. At Cape Horn Engineering we have developed statistical models to characterise a vessels motion in response to an irregular sea state, allowing long term operability analysis of a vessel operating in a particular location. We can assist in significantly improving safety, comfort and workability for wind farm technicians, even in the roughest sea conditions.



Platform Support Vessel design



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Platform Support Vessel ride stability

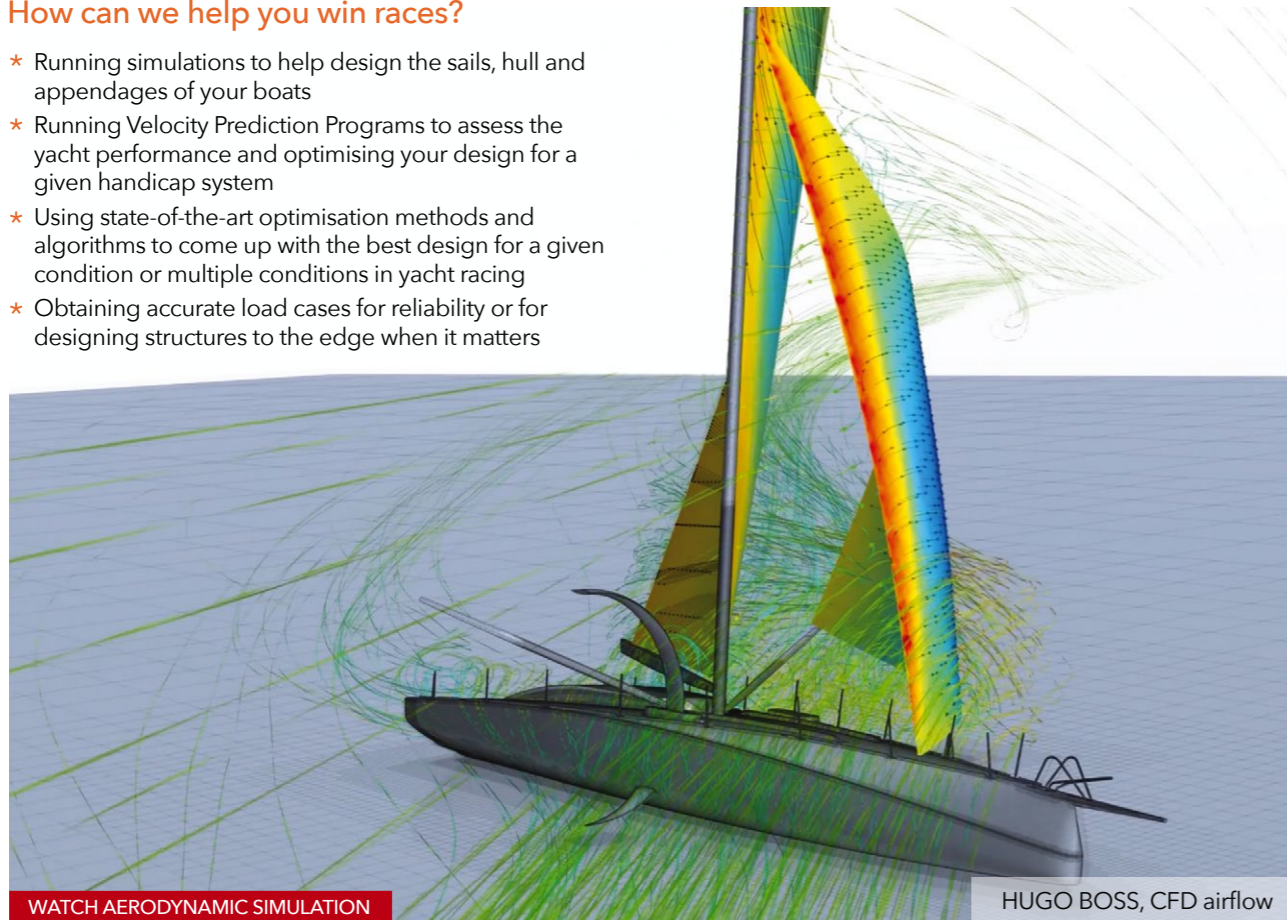


Dr.-Ing. Rodrigo Azcueta has been at the core of simulation based America's Cup and Volvo Ocean Race design campaigns for 15 years, always pushing the boundaries. Our designs and engineering solutions have helped three sailing teams win the famous Around-the-World Volvo Ocean Race: ABN Amro in 2005/06, Ericsson Racing Team in 2008/09 and Groupama Sailing Team in 2011/12. We have been involved in 4 America's Cup Campaigns: the 32nd with BMW Oracle Racing, the 33rd with Team Origin, the 34th with Artemis Racing, the 35th with Land Rover BAR.

After our successful involvement in the design of the foils of the previous HUGO BOSS, without doubt the fastest boat in the fleet during Vendee Globe 2016-2017, we were proudly commissioned again by Alex Thomson Racing to assist in the design of the new foil system for the recently launched, next generation IMOCA Open60 HUGO BOSS.

### How can we help you win races?

- \* Running simulations to help design the sails, hull and appendages of your boats
- \* Running Velocity Prediction Programs to assess the yacht performance and optimising your design for a given handicap system
- \* Using state-of-the-art optimisation methods and algorithms to come up with the best design for a given condition or multiple conditions in yacht racing
- \* Obtaining accurate load cases for reliability or for designing structures to the edge when it matters



WATCH AERODYNAMIC SIMULATION

HUGO BOSS, CFD airflow



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HUGO BOSS, designed for Vendee Globe 2021



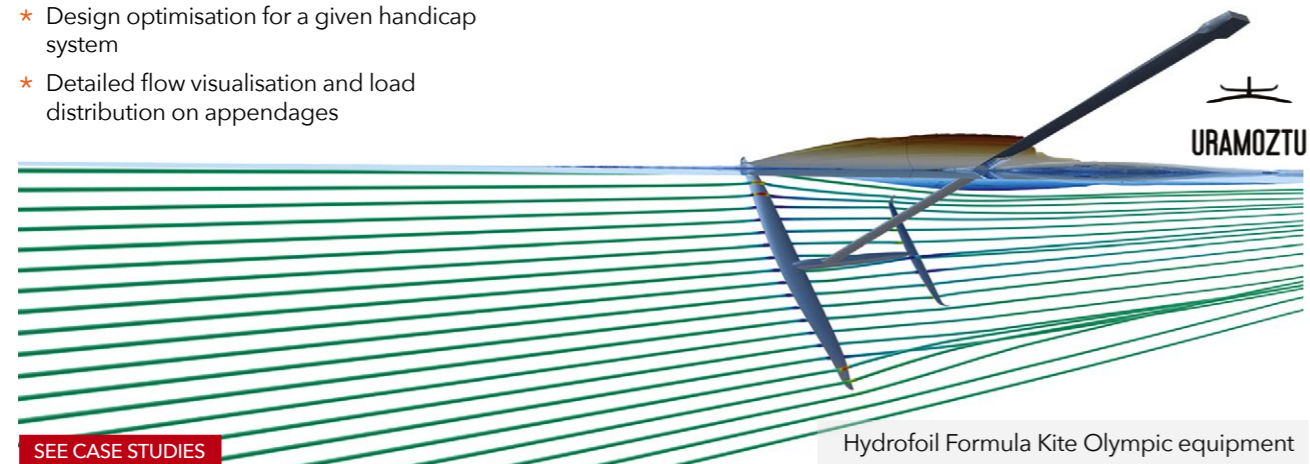
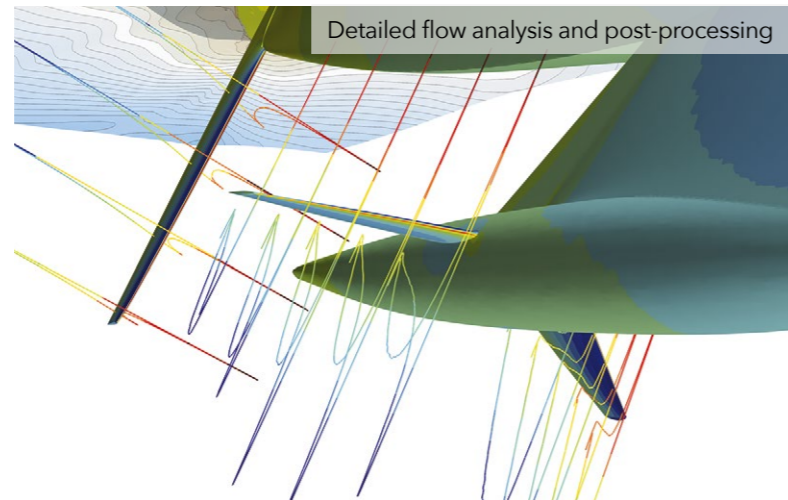
## Making a difference...

Cape Horn Engineering's methodologies have been developed and rigorously tested in a highly competitive environment, where the slimmest of margins can make the difference between winning and losing a race.

Besides America's Cup, VOR70 and Open60 we have helped design winning yachts for ORC, IRC, Superyacht class, 12 and 6mR, Olympic classes including Formula Kite hydrofoils, TP52s, Mini Maxis, classic yachts, production boats, the list is endless.

## Areas where we can help...

- \* VPP and Polar curves
- \* Hull and appendages performance and optimisation
- \* Yaw balance, appendage torques and bending moments, load cases
- \* Seakeeping, added drag, motions and accelerations, slamming loads
- \* Sail design and sail coefficients
- \* Windage of hull, deck and rigging
- \* Cavitation on hydrofoils
- \* 2D foil section optimisation, laminar sections free of cavitation
- \* Fluid Structure Interaction of foils and sails
- \* Design optimisation for a given handicap system
- \* Detailed flow visualisation and load distribution on appendages







Online sail design service - for sail makers, naval architects and yacht designers

The AeroSim Portal offers a very cost-effective solution for a complex task. It has been designed and engineered to offer a cloud-based sail design tool to boost sailing yacht performance.

The service is developed with technology originating from Volvo Ocean Race and America's Cup campaigns and is truly state-of-the-art. Applied simulation methodologies are rigorously examined and validated. Accurate results of your sail geometries plus efficient visualisation of the sail loads are available in just less than 1 hour. With this service you will be able to efficiently analyse and evaluate the performance of single or multiple sail configurations in different weather and race course conditions.

Increase your sail performance...

- \* Submit a single sail design to multiple geometries
- \* Specify weather conditions / racecourse conditions
- \* Purchase tokens through a secure payment system
- \* Run simulations in just less than 1 hour

See the results...

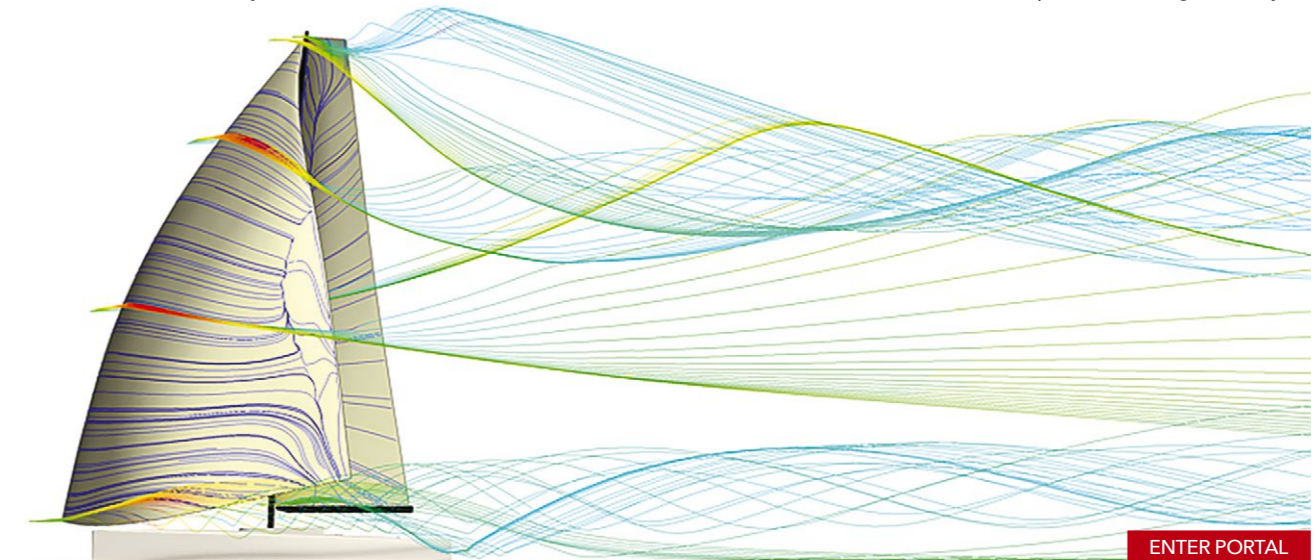
- \* High fidelity simulations
- \* Evaluates the performance of the sails
- \* Efficient visualisation of the sail loads
- \* Accurate results of the best possible sail geometry



Design optimisation for 53ft sailing yacht

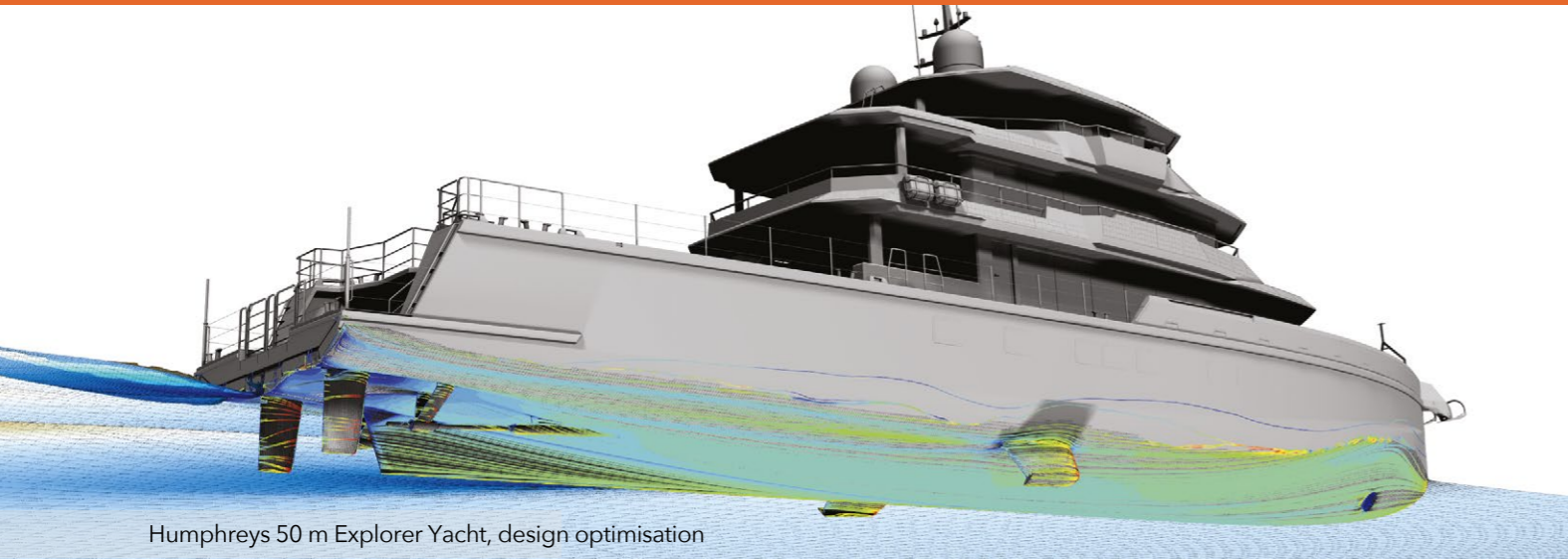
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CFD analysis is increasingly being used to optimise the design of production yachts. Our involvement with international yacht designer, Roberto Biscontini to optimise the design of the new Beneteau First 53 has proved to be a winner for Europe's largest boat builder. Rigorous testing with Computational Fluid Dynamics (CFD) was carried out on 25 different hull designs, plus keel bulb, rudder and displacement investigations in a very wide range of wind and sea conditions. Extensive work on weight analysis, precisely positioning the boat's centre of gravity, centre of effort and centre of buoyancy helped to achieve the desired result... a well balanced, powerful hull with high speed potential but also a good level of sailing comfort.



[ENTER PORTAL](#)

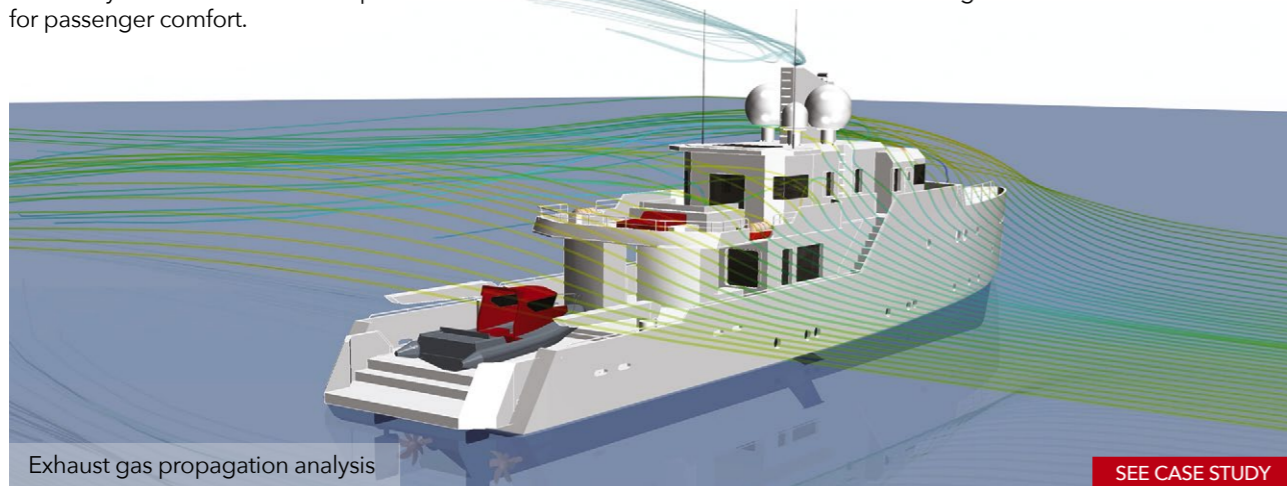




Humphreys 50 m Explorer Yacht, design optimisation

### Improving comfort, efficiency and performance

A good design process involves investigating the hull with its appendages and propellers simultaneously, as there is no isolated engineering component without an effect on the whole system. CFD allows us to perform calculations on the system as a whole, so the design process can be steered for fuel efficiency, comfort and safety. CFD technology can also be used for aerodynamic simulations to capture wind effects around exhaust vents in order to investigate where the smoke will travel for passenger comfort.



Exhaust gas propagation analysis

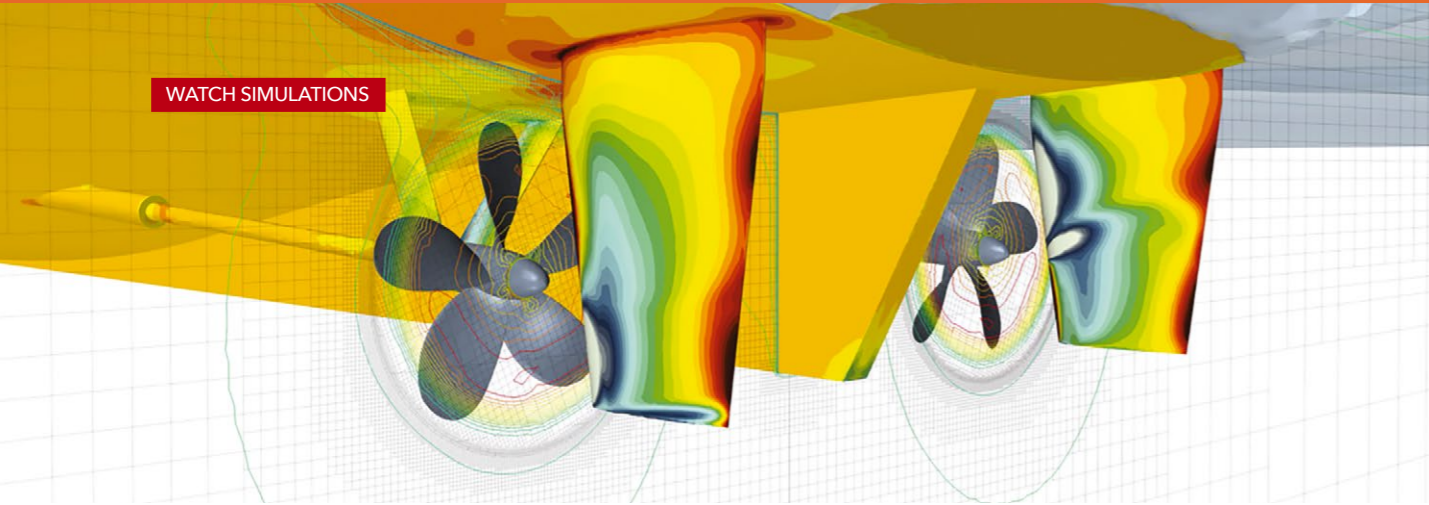
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CFD validation for 58ft motor yacht

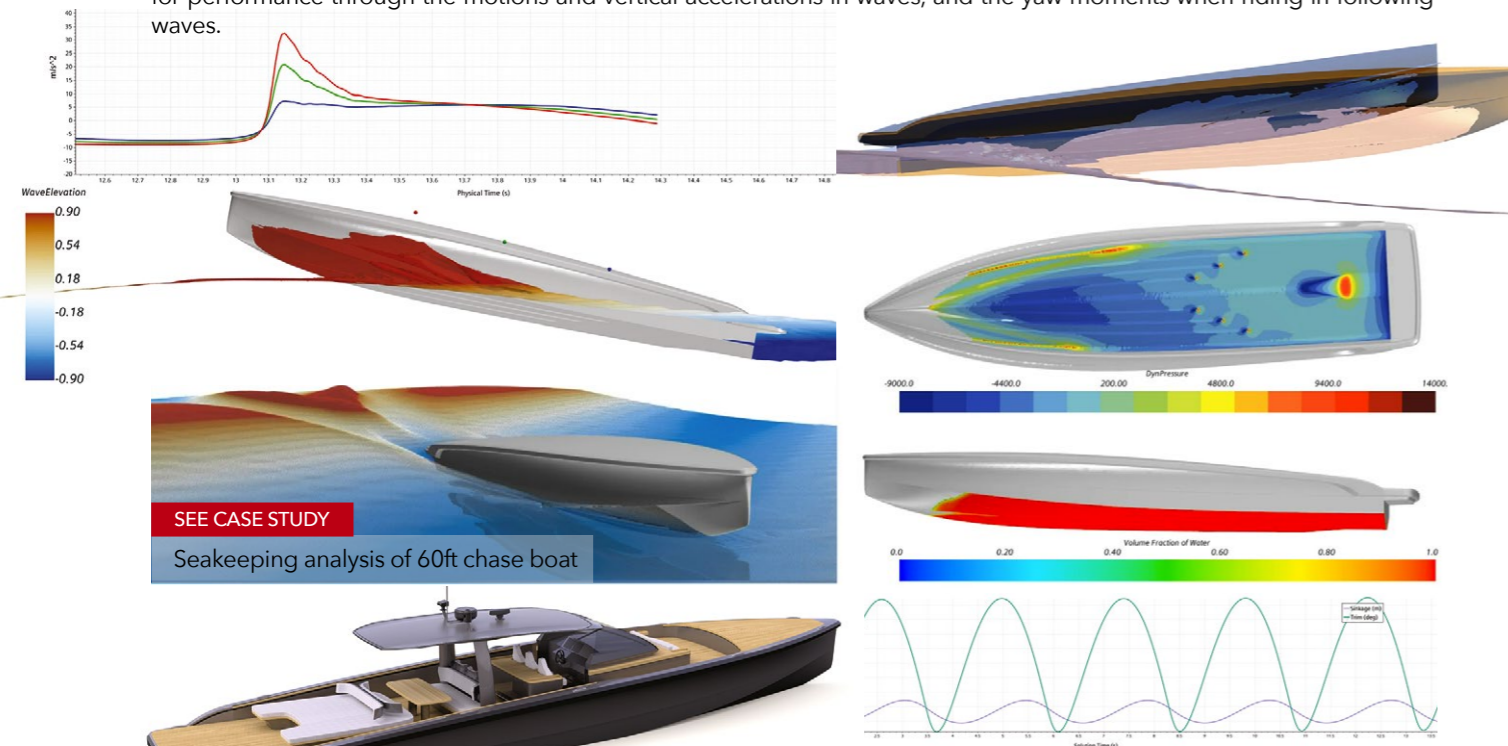
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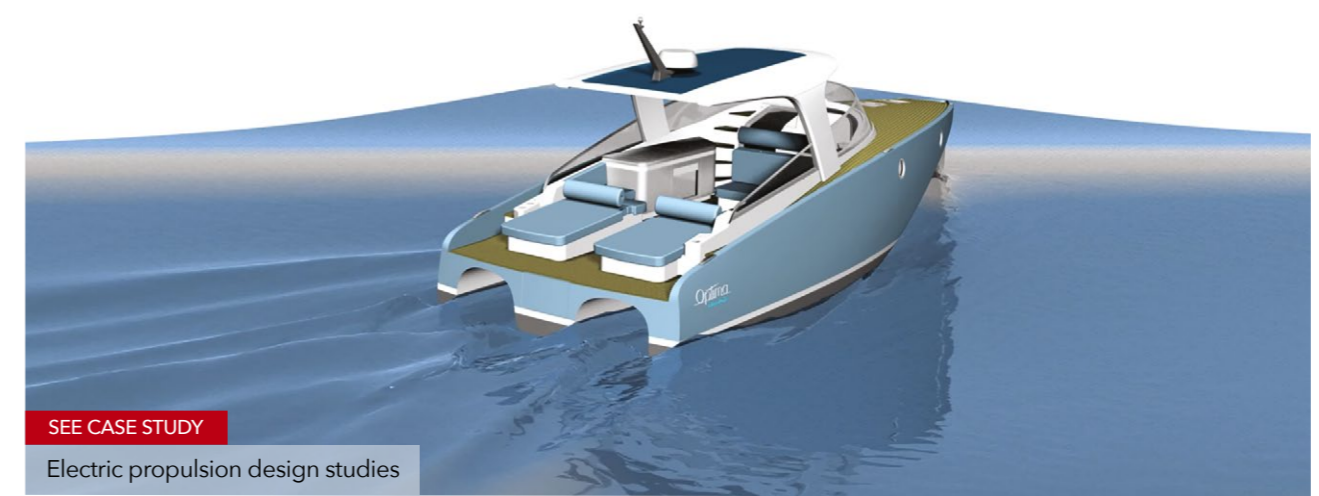




Innovative and highly efficient hull forms are analysed for performance, comfort, stability and safety. Designs are investigated for performance through the motions and vertical accelerations in waves, and the yaw moments when riding in following waves.



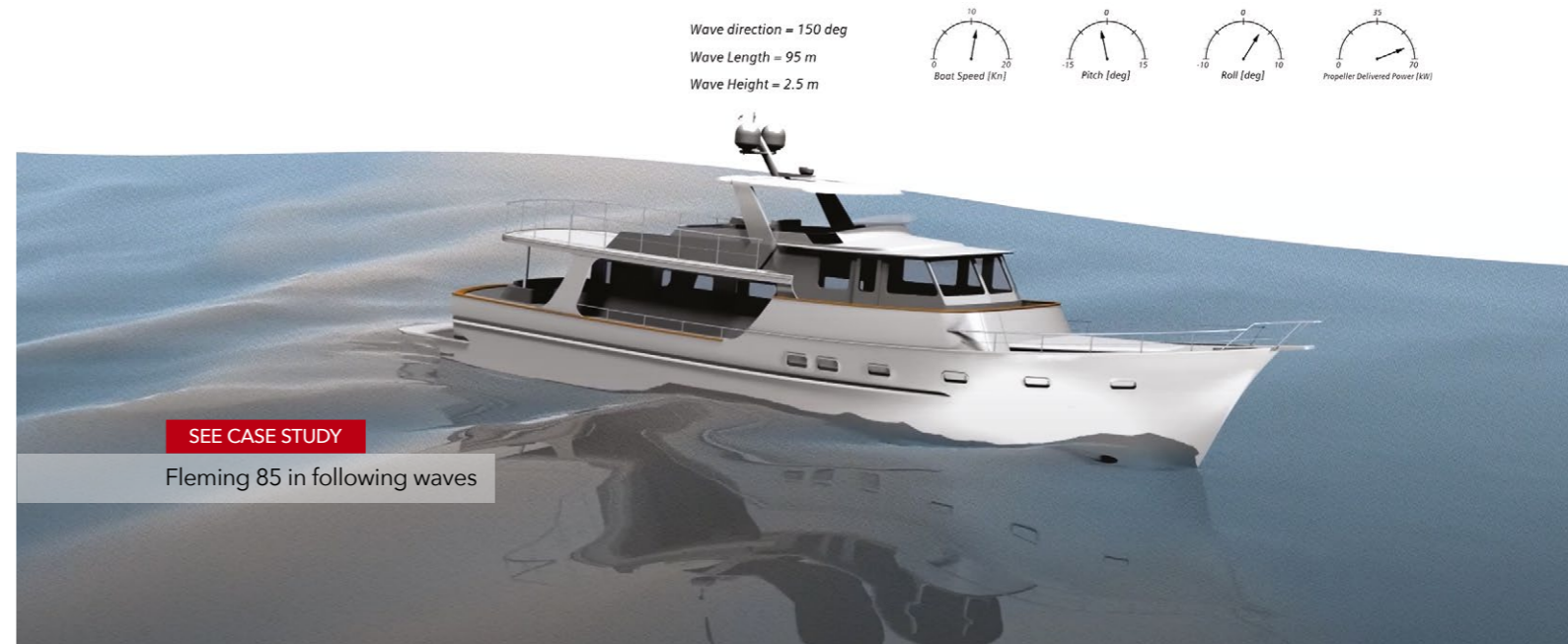
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Seakeeping analysis of 60ft chase boat



SEE CASE STUDY  
Electric propulsion design studies

Innovative and highly efficient hull forms were analysed for performance, comfort, stability and safety. Propulsion from high-performance electric drives provides a sustainable alternative to conventional motor yachts using fossil fuels.

Multi Degree-of-Freedom simulation in waves are performed to assess confort and safety. The full scale Fleming 85 yacht, fully appended with rudders, propeller shafts and brackets, anti-roll fins, bow and stern thrusters, and stern platform is free to heave, pitch, roll and surge in following waves.



SEE CASE STUDY  
Fleming 85 in following waves



### Why outsource CFD?

Many naval architects and racing teams invest in their own in-house CFD capabilities but when performance is crucial, it pays to outsource to specialists. If you're serious about winning or achieving the highest performance and keen to avoid expensive mistakes, you need the best CFD team for the best results.

In-house CFD can be very costly in the longer term. Software vendors will present potential clients with an optimistic view of what is achievable, which may lead to disappointment. Resources and software licenses may not get used efficiently or effectively, adding unnecessary overhead. CFD experts within the industry are rarely available for hiring. Resorting to less experienced juniors may lead to poor quality results and delayed delivery. A specialist dedicated CFD company will have relevant expertise and larger resources, allowing them to deliver the highest quality results in a shorter time frame, at a reduced cost.

### Choosing a CFD provider

Today, there are many new so-called CFD experts who claim to predict performance within 1% precision. The main concern with choosing a CFD provider is that it has now become very easy to produce some sort of results and nice flow visualisations, which can look impressive. The CFD provider should have the relevant expertise, disciplines, experience and software to run simulations and analysis to the exacting standards required. For this reason and to ensure you receive the best results, it is crucial to choose a CFD provider carefully, based on resources and expertise.

### Why choose Cape Horn Engineering?

With new guidelines and regulations to reduce emissions and improve air pollution, the demand for yacht and ship optimisation is rapidly increasing and becoming a key requirement with yacht designers and naval architects. We are specialists within the marine industry and leaders in flow analysis with an expertise in aerodynamic and hydrodynamic performance. Our CFD analysis will support designs to improve efficiency and performance, including aerodynamic simulations for innovative solutions such as wind propulsion technology. We use the best CFD package on the market, STAR-CCM+ from Siemens Digital Industries and we are renowned for providing best in class services to many international clients around the world.



SEE CASE STUDY

Around-the-World Volvo Ocean Race



## SUPPORTING CLIENTS AROUND THE WORLD

We are proud to assist some of the best companies within our industries.



We are also members of the following associations.







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