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Leveraging simulation-driven ship design

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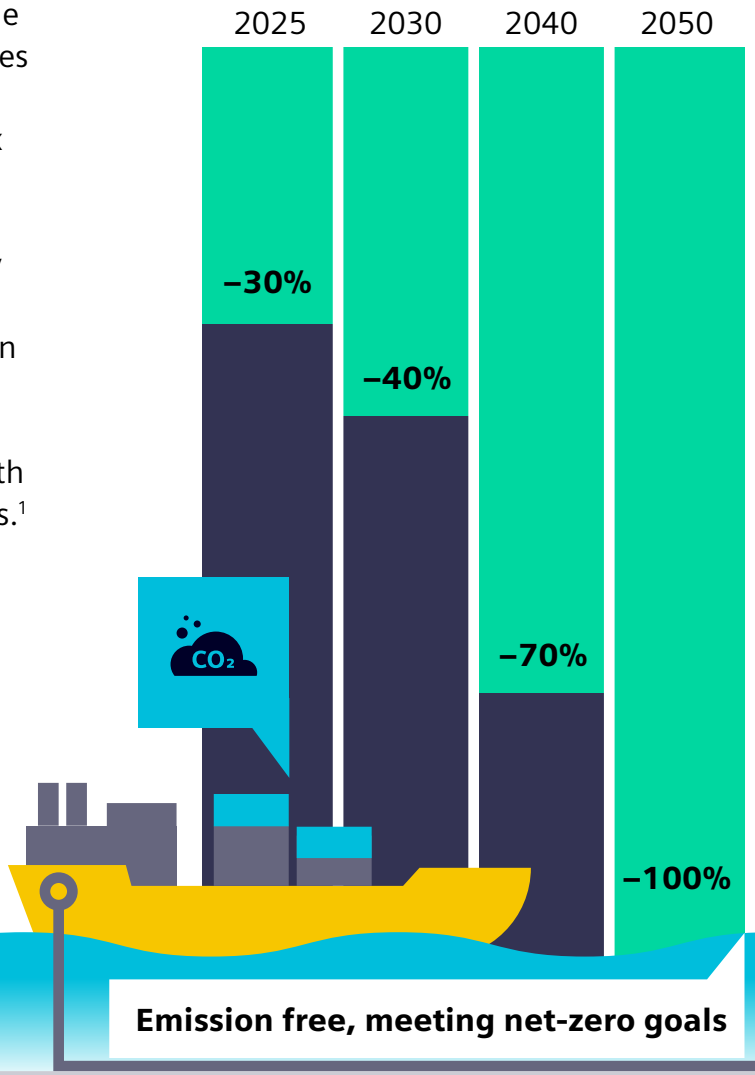
Ship design challenges

Meet net-zero goal by 2050

In the early 2000s, the International Maritime Organization (IMO) began exploring measures to enhance the energy efficiency of ships. In 2013, the Energy Efficiency Design Index (EEDI) and the Ship Energy Efficiency Management Plan (SEEMP) entered into force. Ten years later, the Energy Efficiency Existing Ship Index (EEXI) and the Carbon Intensity Indicator (CII) made their debut. In July 2023, IMO member states adopted the 2023 IMO Strategy on Reduction of Greenhouse Gas (GHG) Emissions from Ships, with enhanced targets to tackle harmful emissions.[1]

The industry will be focusing on key performance indicators (KPIs) to meet the IMO strategy to reach net-zero GHG emissions and reach favorable CII by 2050 and ensure an update of alternative zero and near-zero GHG fuels by 2030.

Reduction in CO_2 by percentage compared to 2008



Performance indicators

Existing ships

- Power limitation
- Propeller optimization
- Wind assistance
- Alternative routes
- Hull coating
- Cleaning
- Air lubrication
- Carbon capture

New ships

- Hull design/form optimization
- Waste heat recovery
- Electric consumption reduction
- Machinery efficiency
- Alternative fuels

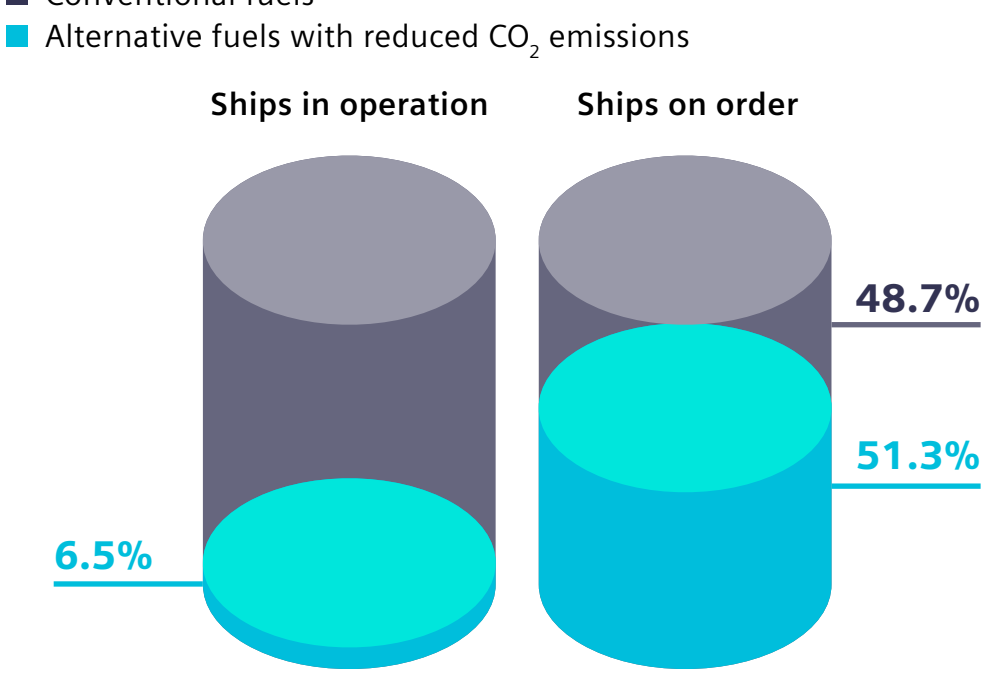
Balancing environmental sustainability, regulatory compliance and economic demands is vital for a prosperous, equitable and resilient future for maritime transport.

Rebeca Grynspan
Secretary General, UN trade and development[2]

What does this mean for ship designers and engineers?
The call for more fuel-efficient powertrains, new power sources, innovative hull designs and the use of energy-saving devices poses new design and engineering challenges.

There is a transformation going on in fuel technology as over 50 percent of ships on order in 2023 will run on alternative fuels compared to about one-third in 2022.

Alternative fuel uptake in the world fleet by gross tonnage in 2023



Lead the shift to digitalization and increase market share

Digitalization is changing industry trends and competitive advantages. In 2020, semi-digitalized shipyards were the largest industry segment. However, by 2028, fully digitalized shipyards are anticipated to be the fastest growing segment.[3]

To stay afloat in a shrinking and more competitive shipbuilding market, both large enterprises (LEs) and small and medium businesses (SMBs) must turn to full digitalization with different challenges for each segment.

To stay competitive in a newly regulated market, LEs need to use digitalization to optimize their existing fleet and manage resources and energy consumption.

SMBs struggle with cost and time. Becoming fully digitalized enhances team productivity and reduces overall product lifecycle costs, enabling them to deliver faster time-to-market.

Estimated global digital shipyard market size from 2023 to 2032 in USD billion[4]

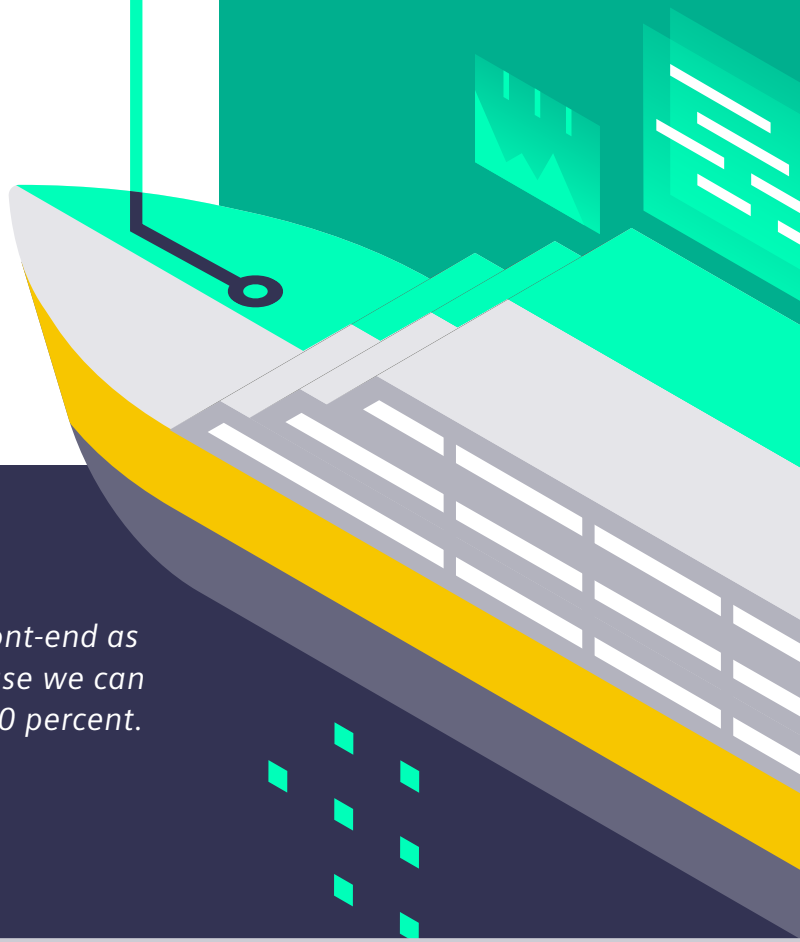
Digital transformation is key

It is essential to introduce an integrated virtual simulation toolkit to maritime engineering as it serves as a single source of truth in your digital journey, enabling the user to push the boundaries of vessel design.

A holistic digital twin can be used to support engineering efficiency when taking a conceptualization to detailed design. Digitalization can help connect the physical and virtual world, from initial to production design, maritime automation systems or engineering and consultancy services to support deployment. A multiphysics approach is key to integrating hydrodynamics, structural integrity, propulsion systems and environmental considerations.

Initial design — **Basic design** — **Detailed design** — **Production design**

Simcenter solutions integrate simulation, testing and expert services that help you reach your goals, increase your productivity, and deliver more energy-efficient vessels faster.



By adopting simulation early on the project, we significantly reduced cost and time on the front-end as we got the right design answer in the shortest possible time. It is massively important because we can get people to make the right design decision, thereby reducing development time by 50 to 80 percent.

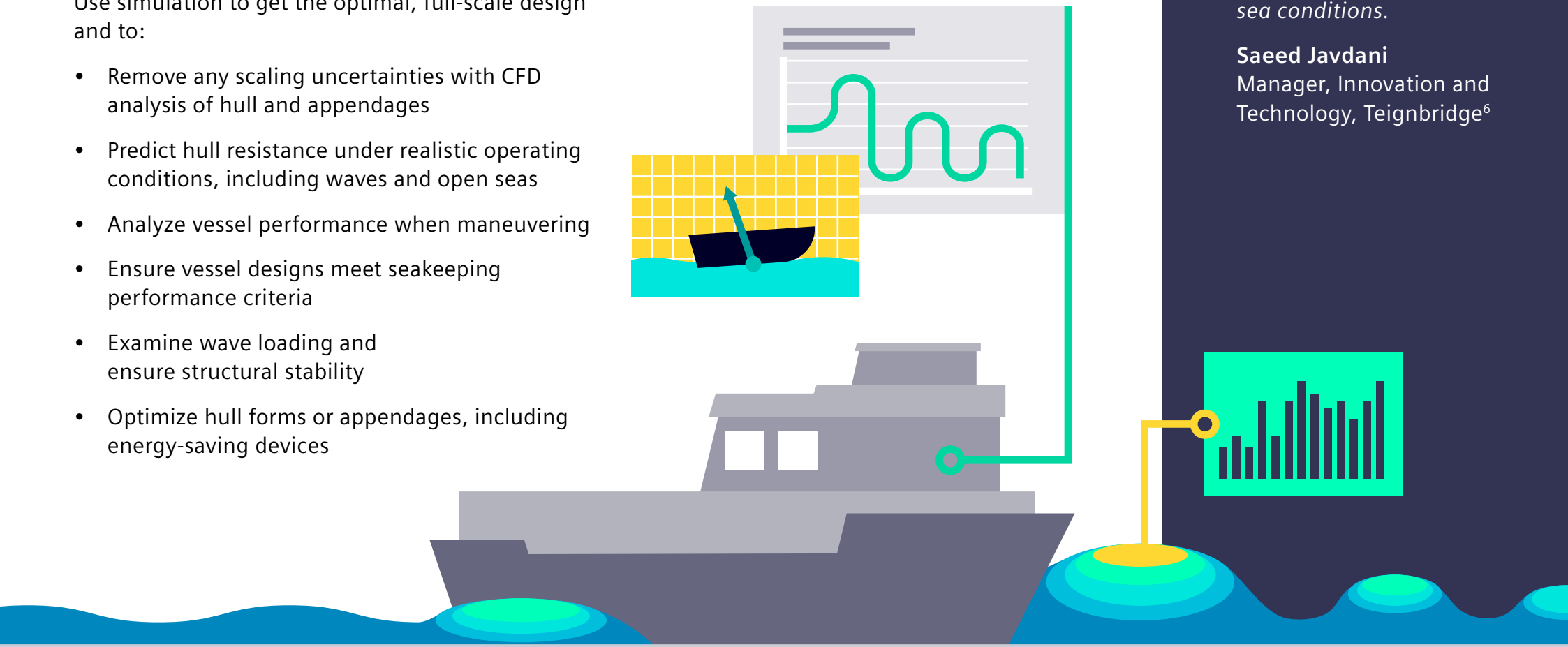
Euan Freeman
Principal Engineer, Cox Marine[5]

Hydrodynamic performance

Simulation, especially computational fluid dynamics (CFD), is commonly used for ship hull analysis in calm waters. But real-life conditions vary widely, requiring different designs for rough seas.

Use simulation to get the optimal, full-scale design and to:

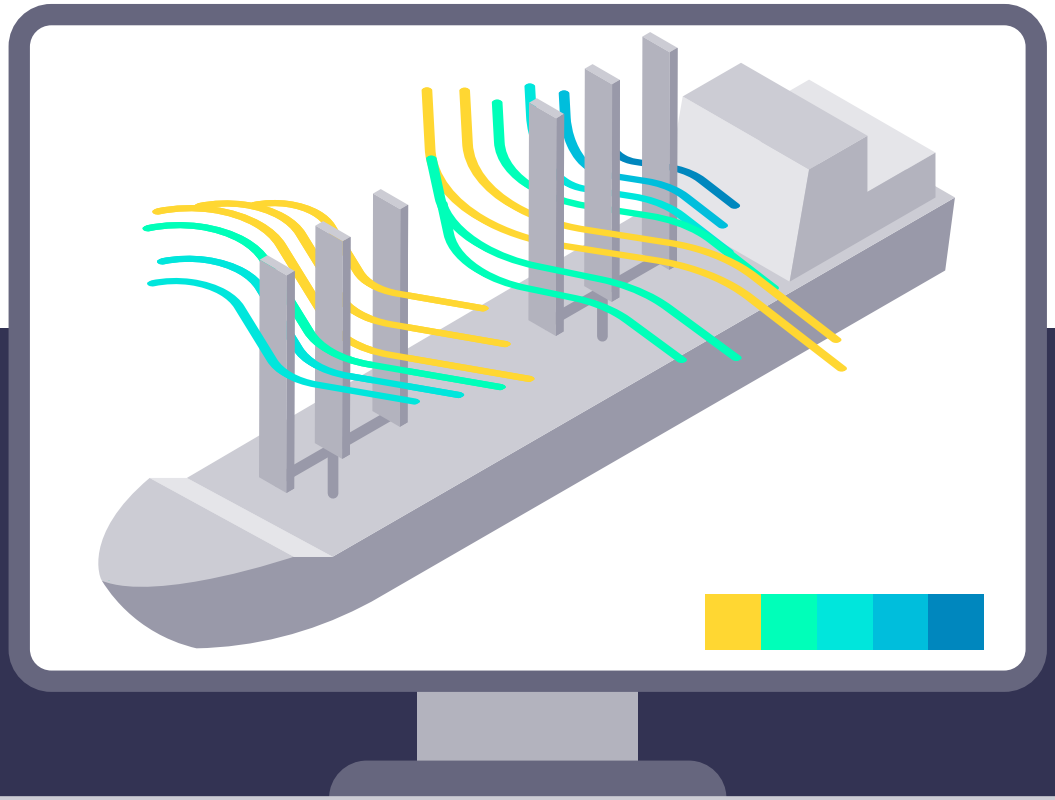
- Remove any scaling uncertainties with CFD analysis of hull and appendages
- Predict hull resistance under realistic operating conditions, including waves and open seas
- Analyze vessel performance when maneuvering
- Ensure vessel designs meet seakeeping performance criteria
- Examine wave loading and ensure structural stability
- Optimize hull forms or appendages, including energy-saving devices



> *We used to just consider one or two design points, but with Simcenter we can predict how the vessel will perform at different speeds and in different sea conditions.*
>
> **Saeed Javdani**
> Manager, Innovation and Technology, Teignbridge[6]

Aerodynamic performance

Even minor gains in energy efficiency offer cost advantages. Designing an aerodynamically efficient superstructure translates into increased fuel efficiency, passenger comfort and operational safety.



Traditional testing is time-consuming and expensive. Use a simulation-based design to:

- Rapidly optimize superstructures for real-world conditions
- Improve all aspects of vessel aerodynamic performance in a virtual wind tunnel
- Predict wind loading on vessel superstructure and confirm structural stability
- Minimize effects from exhaust gas emissions and ensure regulatory compliance
- Comply with helideck safety regulations and improve operational safety

Simcenter can clearly help ship owners make an informed decision when it comes to improving efficiency to achieve energy savings and meet EEXI regulations.

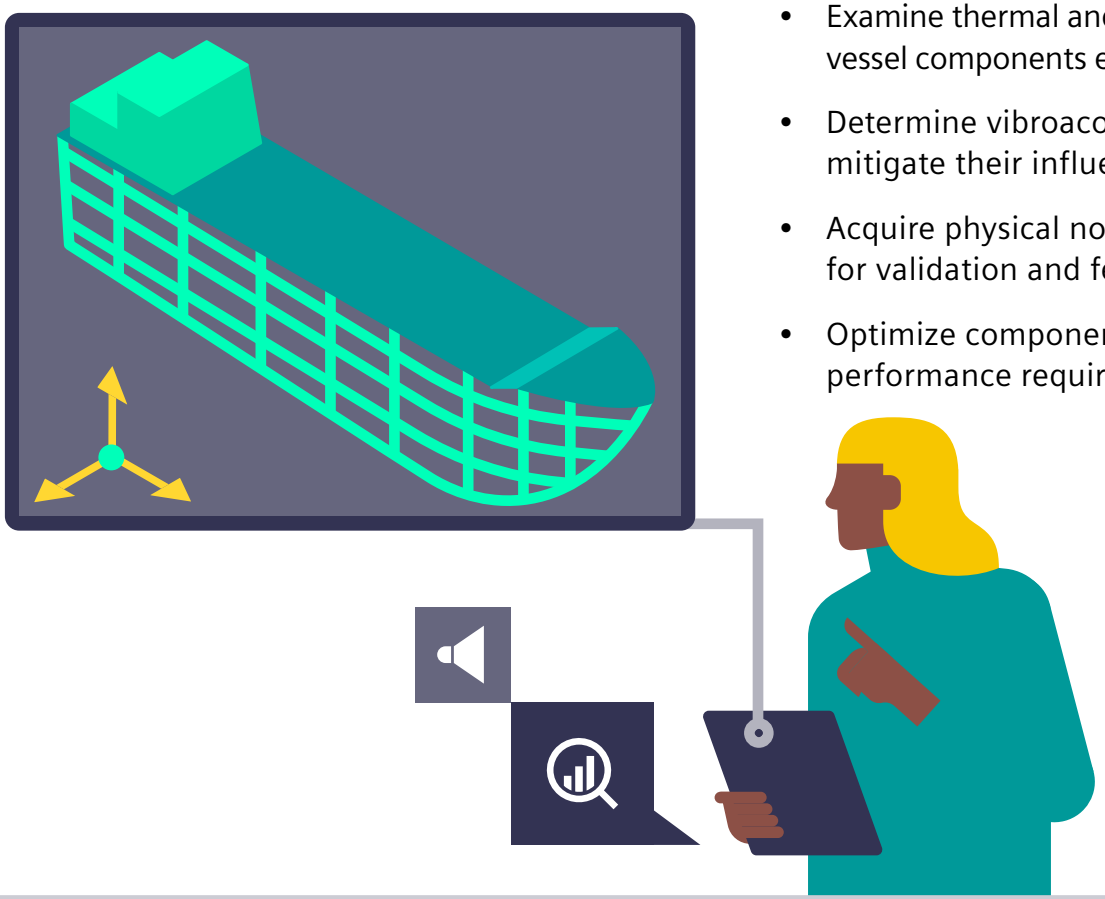
Dr.-Ing. Rodrigo Azcueta
Managing Director, Cape Horn Engineering[7]

Structural integrity and dynamics

With long vessel lifetimes and expensive maintenance, ensuring safe and reliable construction is crucial. Using simulation and testing tools helps validate structural integrity, minimize structural noise and vibration for passenger comfort and reduce environmental impact.

> *If you don't use simulation for projects like these, the only other possible approach is physically testing and troubleshooting the system. And this obviously isn't very practical. It is nice to know that we can use Simcenter simulation to make sure everything will go according to plan for the real live test.*

Andrea Gambino
Mechanical Engineer,
CETENA[8]



Use structural integrity and dynamics solutions to:

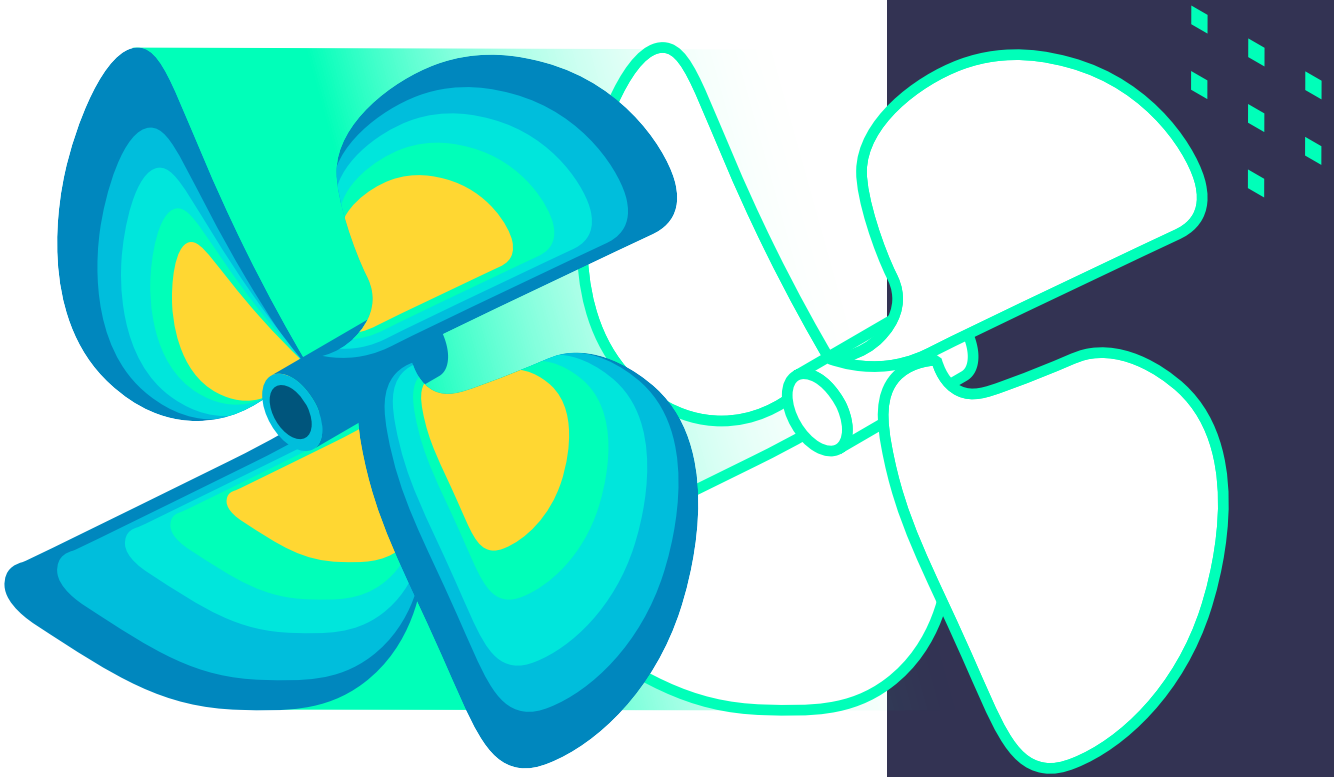
- Perform a wide range of structural analysis simulations
- Examine thermal and stress responses on vessel components early in the design cycle
- Determine vibroacoustic effects and mitigate their influence
- Acquire physical noise and vibration data for validation and feedback on designs
- Optimize components while maintaining performance requirements

Propulsion systems

Early optimization of the propulsion system ensures contractual compliance, enhances sea performance and cuts fuel consumption. Having a virtual simulation of the propeller in the initial phase enables the user to understand the propulsion effects at full scale.

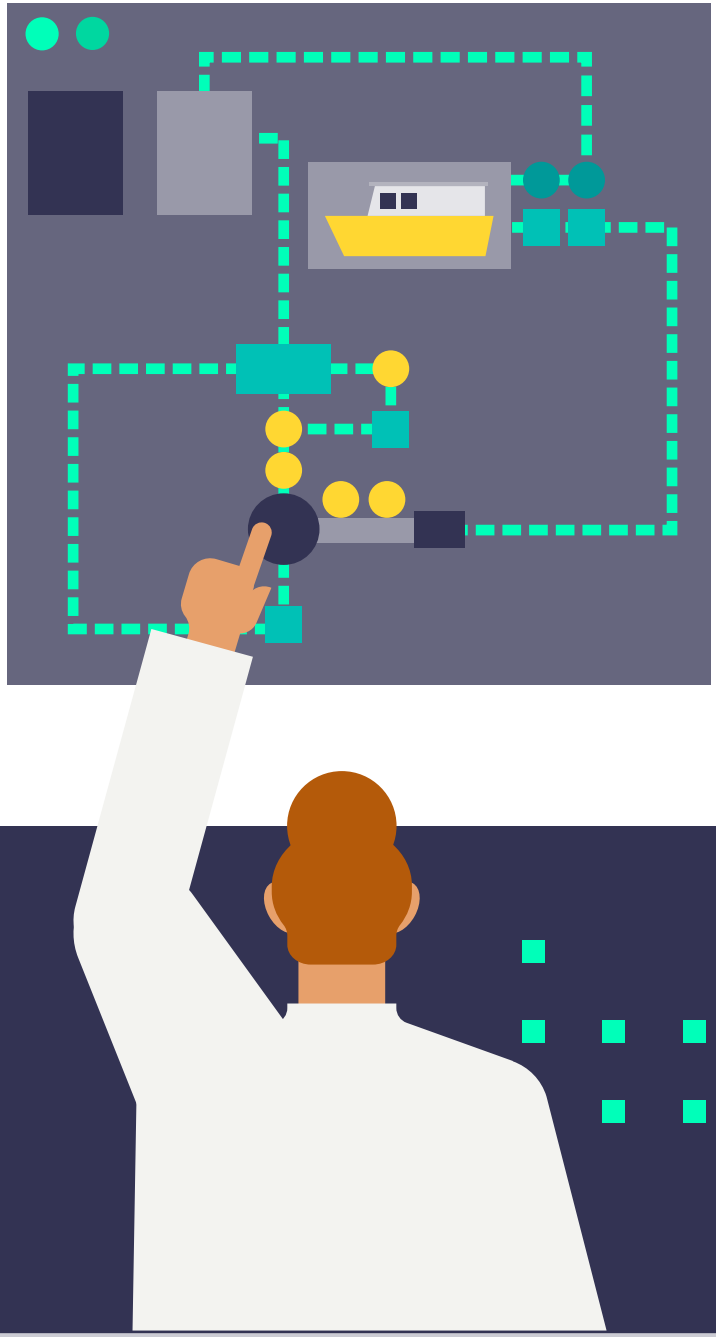
To design an optimal, cost-effective propulsion system that meets contractual and regulatory requirements, use simulation to:

- Predict propeller performance, including the effects of cavitation and erosion
- Optimize propeller designs for required operational efficiency
- Simulate self-propulsion and analyzing design-critical operating conditions
- Improve existing fleet efficiency via energy-saving devices
- Minimize vibroacoustics
- Provide accurate inputs to load calculations and system simulations



> *We achieved a reduction of up to 30 percent in fuel consumption at cruising speeds, with no impact on top speed.*
>
> **Simon Schofield**
> Chief Technology Officer,
> BAR Technologies[9]

Engines and power generation



Using simulation-based design helps companies accelerate the transition from diesel to electric propulsion, hastening time-to-market. From components to full-system levels, traditional and alternative propulsion systems should be optimized for your vessel's performance. Use simulation to:

- Assess the performance of diesel and hybrid engine systems at component and system levels
- Increase engine efficiency and reduce fuel consumption
- Weigh the virtual development and integration of electric motors and generators
- Predict the impact of modifications to existing vessels such as for scrubbers
- Develop a thermally efficient battery pack design with optimized system design

Simcenter allows us to implement modifications much faster by using its off-the-shelf components and easily changing their parameters. This allows us to significantly reduce modeling time when designing new injection systems compared to our in-house program.

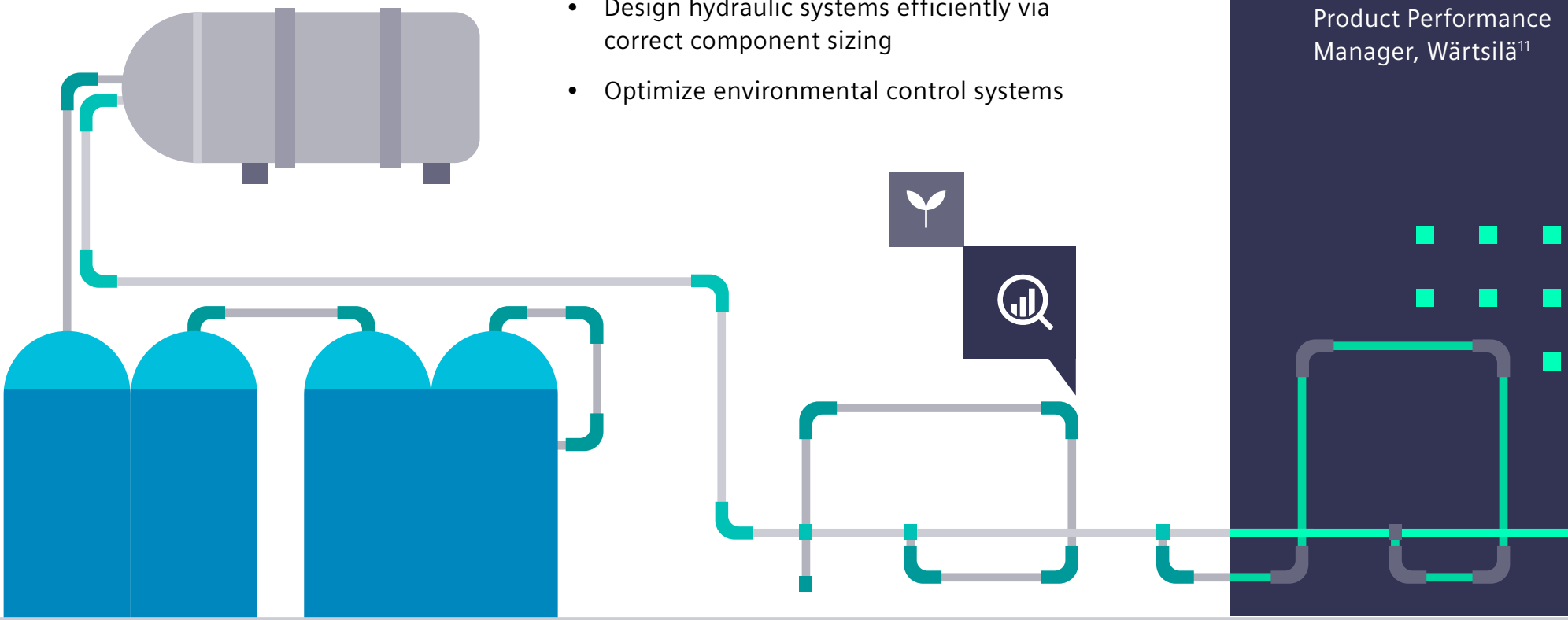
Mads Weise Ravn
Research Engineer, MAN Energy Solutions[10]

Systems performance and controls

Enhancing engine efficiency and energy recovery early in the design phase enables cutting consumption and testing costs while boosting safety and durability, providing comprehensive system analysis for optimal fuel efficiency across various scenarios.

Use this approach to:

- Evaluate and optimize all marine engine subsystems
- Improve energy management by validating the most efficient propulsion architecture over complete mission profiles
- Design hydraulic systems efficiently via correct component sizing
- Optimize environmental control systems



A holistic perspective early in the engineering process is the only way to gain real insight into vessel performance and make better, more sustainable decisions earlier in the design process.

Norbert Bulten
Product Performance Manager, Wärtsilä[11]

Why use Simcenter

Simcenter™ software, which is part of Siemens Xcelerator business platform of software, hardware and services, is a flexible, open and scalable suite of industry-leading engineering simulation and test solutions and associated services. Using Simcenter enables users to leverage artificial intelligence (AI) capabilities to make faster decisions and have an improved user experience. It also enables the user to enhance productivity by using cross-domain workflow automation as well as process and data management.

By providing detailed insights into the real-world performance of vessels, Simcenter allows engineers to increase productivity, shorten time-to-market and accelerate innovation over the entire product lifecycle.

For more information, visit our website
sie.ag/3TLiBp

Free trial: experience our marine engineering solutions
https://trials.sw.siemens.com/en-US/trials/simulation-ship-design-software?lp=1

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Explore the possibilities
Perform intelligent design space exploration, from fluid topologies to system architecture, using integrated co-simulation software.

Go faster
Leverage reduced-order modeling (ROM), workflow automation and AI to develop better designs faster through simulation and real-world data. Cut the simulation run time of even the most complex operational scenarios.

Model the complexity
Real operating conditions are complex and innovation can introduce new risks. Build a digital twin of your vessel to deliver better performance.

Stay integrated
Ensure alignment across teams and processes. Deliver performance for all attributes and guarantee traceability by integrating all simulation and testing activities within a complete digital thread for product development.

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