NAVIGATING THE FUTURE: AI AND CO-SIMULATION FOR GREEN SHIPPING



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Over 90 per cent of international trade depends on maritime transportation, which is crucial to the global economy since it provides a reliable and affordable alternative to other modes of transportation. However, shipping alone contributes to nearly 3 per cent of the world's greenhouse gas (GHG) emissions. This prompted the International Maritime Organization (IMO) and private enterprises to launch campaigns to promote green shipping and make environmental sustainability a priority.

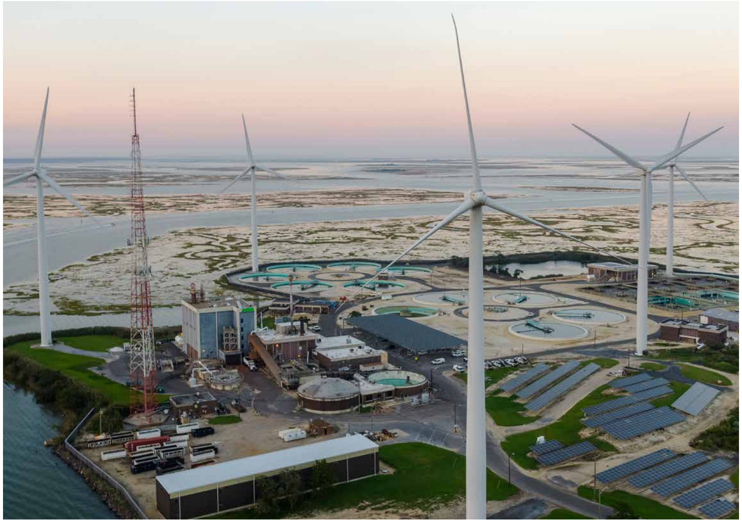
Growing concerns regarding the environmental impact of shipping in recent decades led also to the inclusion of green shipping into global transportation policies. The intricate nature of every maritime ecosystem though makes it challenging to implement these regulations in local maritime contexts. IMO revealed its aspirations to reduce carbon emissions from international shipping by at least 70 per cent by 2050 and by 40 per cent by 2030. Also, more demanding requirements were set on sulphur and nitrogen oxides (SOx, NOx) for commercial vessels, giving rise to Emission Control Areas (ECAs) such as in the Baltic and North Seas.

In this context, sustainable practices come at the forefront of development to create cutting-edge solutions for maritime operations that benefit the economy and environment alike. Embracing such practices not only benefits the environment as such but reinforces the cost reduction and promotes the profitability of the industry in the long run. Several measures can contribute to fostering innovation while minimising environmental impact: improving energy efficiency, cutting down on waste products and ballast water pollution, more advanced engines less harmful to the environment, complying with governmental regulations to avoid penalties, anticipating, and reducing environmental risks, etc.

LEVERAGING THE POWER OF AI – A JOURNEY TOWARDS DECARBONISATION

In an effort to mitigate environmental impact and reach the ambitious targets set by the IMO with the support of the maritime community, companies initiated different strategies: vessel retrofitting, investigating alternative fuels, and even reevaluating vessel design.

"SUSTAINABLE PRACTICES COME AT THE FOREFRONT OF DEVELOPMENT TO CREATE CUTTING-EDGE SOLUTIONS FOR MARITIME OPERATIONS THAT BENEFIT THE ECONOMY AND ENVIRONMENT ALIKE."



Complementing all these, is artificial intelligence (AI) ultimately the holy grail of green shipping? To promote the sustainable development of the maritime sector, the strategies mentioned above evoque three key areas which proved to be notably relevant: ship design, operational efficiency, and voyage planning, which we will briefly discuss below.

OPERATIONAL PERFORMANCE: BETWEEN AI AND CO-SIMULATION

The operational efficiency of a vessel can be characterised through computational models involving relevant variables like operational velocity, weather conditions, vessel maintenance status, etc. These models rely on extensive empirical data from real-life, but also simulated scenarios. AI can help generate these simulated scenarios and complete automatic performance testing on them, revealing potential shortcomings in operational efficiency.

Contemporary maritime vessels integrate highly interconnected subsystems that function autonomously at different levels of resolution. These subsystems may execute specialised tasks or oversee essential day-to-day ship operations. Together, they play a crucial role in maritime decision making by exchanging information. Creating efficient maritime systems that facilitate interdependent modules and ensure their seamless operation is a complex undertaking. It involves modelling the interactions among software modules across diverse timeframes and scales, considering a variety of accuracy requirements.

Simulation environments thus play a crucial role in deploying and expanding maritime software systems, being integral to both the architectural setup and the software development lifecycle. However, maritime systems are notably diverse, requiring the integration of modules from various domains often developed within specialised software frameworks.

Typically, such modules are built by multiple suppliers that deliver components, sensors, and software that shall work coordinated, where simulation models are considered an important part of the continuously updated virtual documentation which follows a vessel from the design phase and into sea trials and finally into operation (digital twin).

To address this challenge, co-simulation emerges as a solution, enabling the system-level simulation of different subsystems together in a distributed manner. These subsystems, functioning as software artefacts, act as black boxes, receiving inputs (e.g., from other software artefacts), progressing forward in time using built-in routines and providing outputs that can become inputs for other similar subsystems. Time synchronisation among subsystems occurs through discrete communication points, serving as the sole interaction between them. Aside from these communication points, these subsystems operate independently.

Co-simulation enables, thus, dynamic modelling of various systems for cooperative use in software, hardware, and human-in-the-loop simulations. Its benefits range from versatile use and performance enhancement through shared computational resources to the flexibility of changing the full-system architecture dynamically, facilitating continuous integration of different modules. Moreover, each subsystem can be implemented as a black box, allowing companies to cooperate and share models without revealing proprietary information.

SHIP DESIGN: DAWN OF A NEW ERA

Beyond its role in reducing emissions in maritime operations, one aspect has taken shipbuilding by storm: the electrification of ships.

Electrification possesses significant potential to revolutionise ship design, construction, and vessel operation itself. It essentially streamlines design

"ELECTRIFICATION POSSESSES SIGNIFICANT POTENTIAL TO REVOLUTIONISE SHIP DESIGN, CONSTRUCTION, AND VESSEL OPERATION ITSELF."

and enables more adaptable use of space, fundamentally altering the process of equipment installation on ships. Substantial opportunities exist for establishing dominant designs in this context, akin to those made for electric vehicles in the automotive industry through car platforms. Additionally, integrating a similar type of platform in shipping could confer a competitive edge by enabling revenue generation throughout the vessel's lifespan.

Essentially, we are witnessing a technological transition that offers considerable potential for gaining a competitive advantage by reimagining how ships are conceived, constructed, operated, and maintained, thus capitalising on productivity enhancements and the new business prospects that it presents. Consequently, we are witnessing the replacement of one technological paradigm with another within the realm of shipbuilding and shipping itself, involving stakeholders who directly influence and are impacted by this transformation.

Electrification and digitalisation are intertwined in facilitating this transition, prompting to draw upon interdisciplinary expertise to comprehend the business and policy implications of this evolution.

VOYAGE, VOYAGE: VOYAGE PLANNING FOR A BETTER TOMORROW

By streamlining routes and enabling vessels to select the most fuel-efficient ways, AI-driven optimisation techniques help cut down on emissions and fuel usage. Also, an important aspect is emissions at the port side associated with port calls, involving different resources and maritime actors. Port calls need to be optimised to reduce port waiting time. Furthermore, real-time data analysis helps with proactive maintenance to increase fuel economy by supporting ongoing vessel performance monitoring. Predictive maintenance driven by AI is becoming increasingly popular to ensure that engines and other equipment operate at their best, reducing emissions and downtime.

The power of AI-based systems can help increase the operational efficiency of vessels by making use of IoT sensor data from the ship, weather reports, and historical travel data. By utilising AI technologies,

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there is a full potential for the integration of renewable sources where there is the requirement, and the usage of fuel cells alternative to Internal Combustion Engine (ICE) to significantly drop the emissions of GHG.

The adoption of automated route planning is witnessing a steady growth facilitated by the deployment of expert weather routing and radar systems. Its effects are a decrease in the number of maritime accidents and enhanced energy efficiency of vessels. This technique considers various environmental variables such as wave movement, wind and current direction, air and water temperature and density. For safety assurance, radar systems are also used to detect other vessels and maritime objects.

Moreover, cutting-edge AI-powered surveillance solutions improve vessel tracking in real-time, guaranteeing legal compliance and reducing hazards. By identifying possible risks and operational bottlenecks, predictive analytics enables prompt interventions and accident avoidance.

SHIPPING INTO THE FUTURE… SUSTAINABLY

AI is the driving force behind the shipping and maritime industry revolution. The journey towards sustainability, efficiency, and resilience is paved by the integration of AI, from decarbonisation projects to workforce empowerment and improved safety. These sectors are navigating the waters of growth and leading the way towards a more technologically advanced, environmentally conscious, and optimistic future as they capitalise on AI.

Long-term sustainability is a critical consideration, especially when it comes to the maritime industry. As we explore alternative fuels, renewable energy sources, and AI, we must ensure that these advancements align with broader sustainability objectives.

Moving from traditional fossil fuels to cleaner alternatives (such as biofuels, hydrogen, or electricity) can drastically reduce GHG emissions. However, we must assess their impact on maritime ecosystems and ensure they do not harm biodiversity.

Using wind, solar, and wave energy can power vessels more sustainably. Yet, we should carefully evaluate the environmental effects of installing and maintaining renewable energy infrastructure in marine environments.

AI technology, as mentioned before, can highly impact the maritime environment, but in the end, we must strike a balance between technological advancement and ecological preservation.

ABOUT THE AUTHORS:

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ABOUT THE UNIVERSITY:

Åbo Akademi University is a Swedish-language multidisciplinary academic university in Finland. The institution aims to contribute to society through general learning, education and new scientific knowledge. The Faculty of Science and Engineering at Åbo Akademi University develops solutions and processes that slow down climate change and promote a cleaner environment. The faculty's ultimate goal is for people to prosper in a sustainable society.