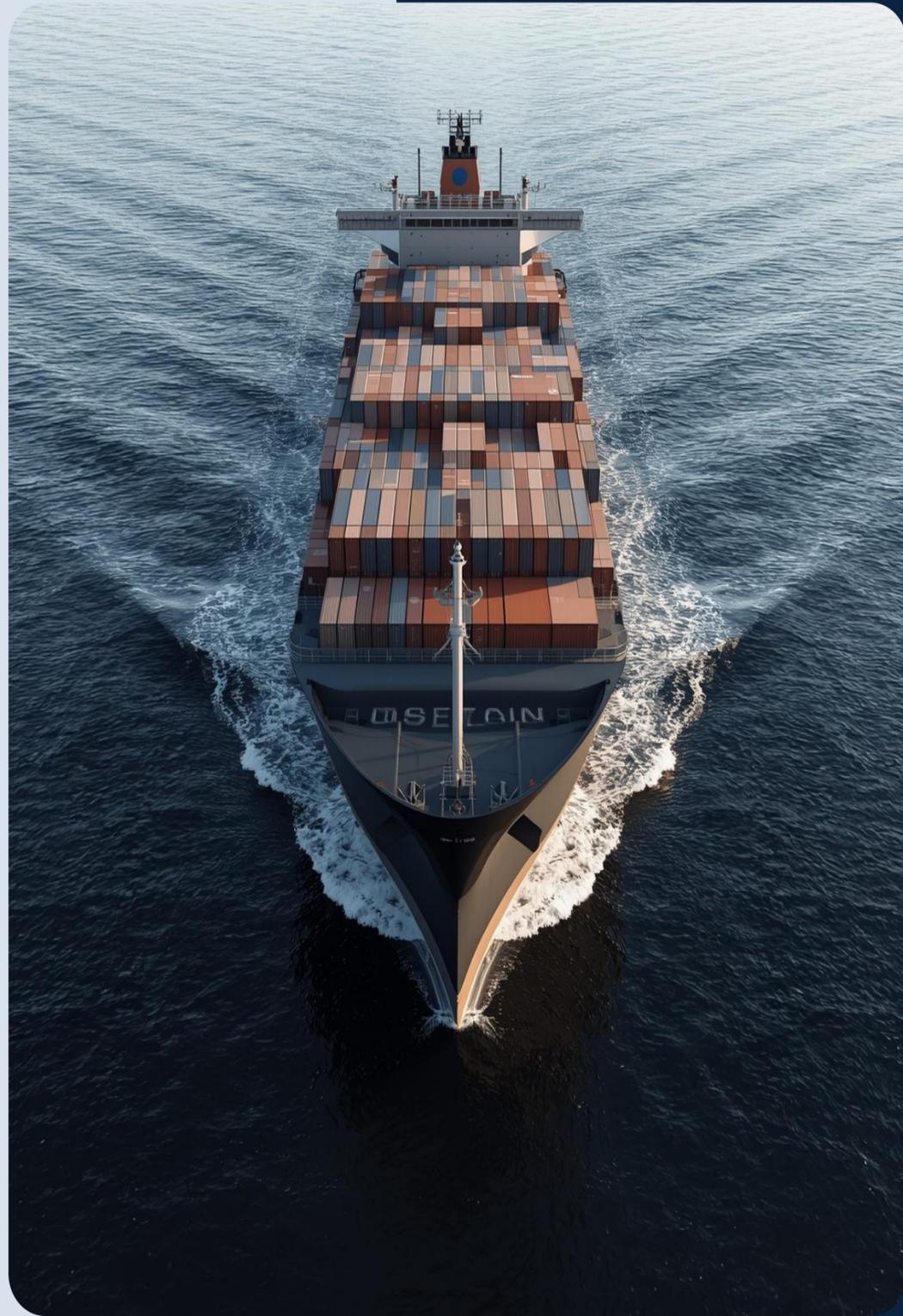


Blue Economy and Partnership for  
Sustainable Development of Ukraine's  
Maritime Sector

## **AI-Based Smart Ship Routing for Energy Efficiency and Emission Reduction at the Black Sea**

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# Global Maritime Emissions Challenges

## Importance of Emission Reduction

Maritime transport plays a key role in global trade, moving over 90% of all cargo. Increasing environmental pressures and stricter regulations require the industry to cut emissions and improve energy efficiency.

The International Maritime Organization (IMO) aims to achieve near-zero greenhouse gas emissions by mid-century.

Despite progress in certain areas, overall advancement along this path remains insufficient, which underlines the need for wide-scale deployment of innovative technologies and advanced engineering solutions.



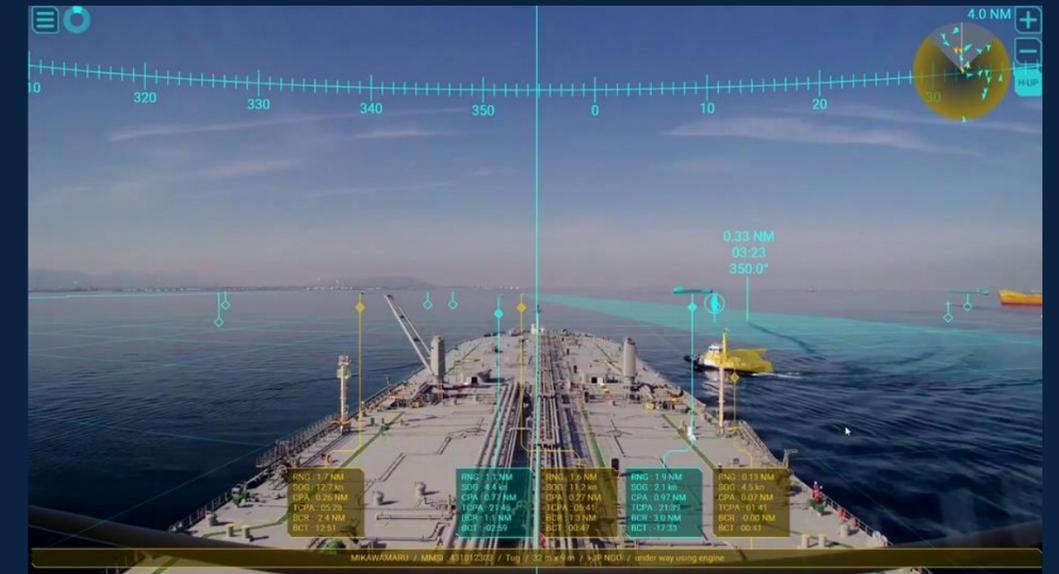
# Comprehensive approach to reducing ship emissions

Alternative fuels with a low carbon impact (LNG, methanol, ammonia, hydrogen, biofuel)

Improvement of ship power plants (dual-fuel engines, fuel cells, hybrid systems)

Use of renewable energy sources on board (solar panels, wind turbines)

AI-based intelligent navigation systems for route optimisation



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# AI Optimization Techniques

- **Intelligent methods for predicting fuel consumption**
- **Adaptive algorithms for route optimization**



## Neural Network Model

Predicting the fuel consumption of seagoing vessels is one of the key tasks in optimizing fleet operations, as it is directly related to the management of operating costs and environmental performance.



## Navigation Interface

Modern deep-learning algorithms with elements of reinforcement learning are becoming the basis of an innovative approach to adaptive control of a vessel's route.



## Efficient Shipping

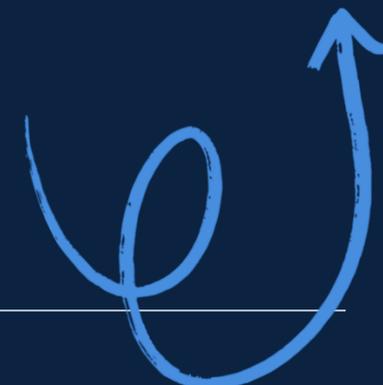
The main advantage of this approach lies in the ability of the algorithm to learn from accumulated experience and historical data, while taking into account numerous factors: the vessel's current position, remaining route length, expected weather changes and the structure of marine currents.

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# Adaptive Routing

## Efficient Navigation Strategies for the Black Sea

This is particularly important in the Black Sea region, where atmospheric and hydrological parameters are highly variable.

In winter, the algorithm can automatically avoid areas with strong north-eastern winds and adverse sea conditions by adjusting the vessel's course towards less turbulent zones. In summer, by contrast, the system can take advantage of more stable conditions, allowing the average speed to be increased without raising fuel consumption.



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# Practical implementation and development prospects

Integrating intelligent routing with energy efficiency measures can greatly reduce a ship's fuel consumption. Since fuel makes up over half of operating costs, even minor efficiency gains provide significant economic benefits.

Lower fuel use also cuts emissions and helps meet stricter environmental standards. A distributed information network combining data from ships in the Black Sea could support optimal routing based on real conditions. In the long term, integrating intelligent navigation with on-board control systems will enable fully adaptive, energy-efficient 'smart' ships.

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# Conclusion

Reducing emissions in maritime transport requires cleaner fuels, renewable energy, and optimized routes. Artificial intelligence enables intelligent routing that improves fuel efficiency and reduces environmental impact. Key tasks include:

- integrating precise environmental data;
- accounting for regional sea conditions;
- applying optimization methods that balance safety and efficiency;
- using adaptive algorithms for real-time decisions.

AI-based routing supports sustainable and low-carbon shipping.



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