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REDUCTION OF GHG EMISSION FROM SHIPS-FOCUS ON ECONOMIC ELEMENTS WITH REFERENCE TO INDUSTRY 4.0

Inclusion of AI and Digital innovations in Maritime Operation in IMO GHG emission Strategy

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SUMMARY

Executive summary:	The shipping industry accounts for nearly 3% of global greenhouse gas (GHG) emissions, necessitating urgent decarbonization strategies. This paper proposes the use of AI in ship's route optimization and Predictive maintenance in IMO Framework to improve efficiency and also to allocate the R&D fund in these technology. By leveraging machine learning, IoT sensors, and autonomous systems, the shipping sector can enhance fuel efficiency, minimize waste, and comply with stringent environmental regulations such as the IMO 2030 and 2050 targets.
Strategic direction, if applicable:	
Output:	
Action to be taken:	Paragraph 5-7
Related documents:	ISWG-GHG 18-WP1-REV 1,MEPC 83-inf.2,MEPC 83-INF.34,MEPC 82-Inf.8

Proposals for AI Adoption in Maritime Decarbonization

1. With the IMO's goal of achieving net-zero emissions by 2050, the integration of Artificial Intelligence (AI) into maritime operations represents an essential and cost-effective pathway toward decarbonization. AI technologies enable real-time data-driven decisions that optimize energy consumption, minimize waste, and improve operational efficiency — particularly for countries with limited financial and infrastructural resources. This proposal focuses on three main areas of AI application:
   1.1. **Voyage Optimization:** AI-powered route planning tools analyze real-time weather data, ocean currents, and vessel traffic to identify the most fuel-efficient paths. These systems dynamically adjust vessel speed and optimize port arrival times, reducing idle time and minimizing fuel usage. The overall effect is a measurable reduction in greenhouse gas (GHG) emissions across voyages.
   1.2. **Engine Optimization:** Using advanced sensors and AI-based monitoring systems, ships can ensure engines operate at maximum efficiency. Even small inefficiencies can lead to large emission increases; therefore, continuous AI supervision ensures optimal combustion and minimal fuel wastage.
   1.3. **Predictive Maintenance:** Through continuous analysis of sensor data, AI predicts potential equipment failures before they occur. This proactive approach reduces downtime, prevents excess fuel burn from inefficient machinery, and extends equipment life — contributing directly to emission reduction. Collectively, these proposals form a strategic framework that leverages existing shipbuilding and engine redesign capabilities to achieve significant emission reductions without requiring drastic infrastructure overhauls.

Technologies Already in Use

2. The shipping industry has already begun adopting AI tools with tangible success:
   Maersk – ECO-Voyage: An AI-based optimization platform that improves routing and speed management, achieving 0.5–1% annual fuel savings.
   DeepSea Technologies – Pythia: A performance optimization system using deep learning to adapt dynamically to operational conditions, delivering 10–12% fuel savings.
   DeepSea Technologies – Cassandra: A predictive performance monitoring system identifying hull fouling, propeller wear, and engine inefficiencies.
   NAPA Digital Twin: Deployed by NYK Line, MOL, and MSC to enhance voyage and power management through real-time simulations.
   Eniram by Wärtsilä: Used by Royal Caribbean and other operators, integrating route optimization and energy management for improved performance.

3. These technologies collectively demonstrate that AI-driven systems have moved beyond experimentation and are producing measurable operational and environmental benefits in the maritime industry.

Challenges in Implementation

4. Despite the benefits, the adoption of AI in maritime operations faces two major barriers:
   4.1 **Implementation Challenges:** Data quality inconsistencies, the lack of skilled personnel, interoperability problems, and integration difficulties with legacy systems hinder digital transformation. Additionally, restricted internet connectivity at sea limits real-time data transmission and system updates.
   4.2 **Financial Barriers**: The high initial investment for AI infrastructure, such as sensors, software, and training, discourages many small and mid-sized operators. The return on investment remains uncertain for companies hesitant to adopt digital systems on a large scale.

Proposed Solutions

5. To address these barriers, this proposal outlines five strategic measures:

   5.1. **Enhanced Connectivity:** Adoption of low Earth orbit (LEO) satellite networks like Starlink and OneWeb will enable high-speed internet at sea, supporting real-time data exchange and cloud-based AI monitoring.

5.2. **Cost-Effective AI Adoption:** Utilizing cloud-based AI platforms, shared digital ecosystems, and subsidy programs can reduce the financial burden of AI integration. Collaborative models allow multiple operators to share infrastructure and digital resources.

5.3. **Cultivating AI Talent:** Introduce AI-centric training modules in maritime academies and upskill existing crew members through industry-academic partnerships. This ensures the availability of skilled personnel to manage AI-based systems effectively.

5.4. **Standardization and Interoperability:** Global adherence to data standards (IMO, ISO) will allow seamless integration of AI technologies across ships, ports, and fleets, promoting consistent results and reducing duplication of effort.

5.5. **Phased System Upgrades:** Retrofit existing vessels with modular AI systems such as predictive maintenance sensors and route optimization software to minimize costs while progressively enhancing efficiency.

5.6. Together, these measures create a structured, scalable roadmap for AI integration within the maritime sector.

Port and Global Incentive Schemes

6. The transition to AI-driven decarbonization can be accelerated through structured incentive frameworks implemented by ports and international organizations:

6.1. **Financial Rewards and Subsidies:** Introduce an IMO-supported global incentive program offering grants, tax reductions, and carbon credits to companies demonstrating measurable GHG reductions through AI-enabled systems.

6.2. **Port Incentives:** Provide rebates, docking priority, and fee exemptions for AI-enabled vessels achieving verified emission reductions.

6.3. **International Cooperation:** Facilitate collaboration among shipowners, ports, and governments to share data, develop best practices, and establish joint innovation programs.

6.4. **Financial and Technical Support:** Offer funding and technical assistance to developing countries to implement AI retrofitting programs for older vessels.

6.5. **Level Playing Field:** Ensure fair recognition for early adopters and standardized benchmarks for AI-based emission reduction across all regions.

7. These incentive mechanisms ensure global participation and equitable distribution of benefits while fostering a competitive and innovative maritime ecosystem.

8. Conclusion: Artificial Intelligence provides a transformative yet practical solution to reduce GHG emissions in shipping. By focusing on voyage and engine optimization alongside predictive maintenance, AI enables immediate emission reductions while preparing the industry for a transition to future clean fuels. However, to realize this vision, coordinated global policies, training initiatives, and incentive programs are essential. AI-driven optimization is not merely an alternative strategy but a critical, cost-effective pathway to decarbonize the maritime sector today and ensure readiness for the fuels and technologies of tomorrow.

9. The committee is requested to consider our proposal in this document as mentioned in paragraphs 5,6 and 7.