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Circular Business Models & Technologies for a circular transition of containership companies

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Introduction

Shipping is considered the most energy-efficient and environmentally friendly conventional (fossil fuel-fired) transport modality, with emission rates lower than for aviation, rail, and car transport. However, it still adversely impacts the climate and the environment (European Environment Agency, 2019). The cargo shipping industry includes three main segments: bulk, tankers, and containerships. The containership industry is at the heart of global trade flows. It has the most diverse customers and cargo base of any sector, differing by tradeline and requiring greater coordination and overhead. Perspectives on the trade market indicate that the number of goods transported by shipping may triple by 2050, leading to a corresponding increase in fuel consumption and a high increase in crude oil demand and emissions in high-traffic density areas (Di Natale and Carotenuto, 2015).

Maritime industry challenges

The challenges the containership industry faces are reducing fuel consumption against volatile fuel prices and greenhouse gas (GHG) emissions (Besikçi et al., 2016). Also, voyage planning and execution from berth to berth must meet the objectives of the safety of life at sea (crew safety), safety and efficiency of navigation, and protection of the marine environment (IMO, 1999). Maintaining the useful life of physical assets in vessels is also necessary. Finally, traditional maintenance techniques based on run-to-failure in breakdown situations or periodic preventive maintenance, regardless of the health status of a physical component, have become a significant expense for many companies.

Cargo shipping companies need accurate and reliable, real-time information about their fleet navigational performance, fuel oil consumption, etc. Meteorological and oceanographic factors and weather routing advice are essential for safe and effective passage. However, the final decision of the ship's navigation remains the responsibility of the master (IMO, 1983). There is a worldwide increase in maritime companies with forward-

thinking managerial teams eager to adopt value-adding smart IT systems. Nowadays, they recognize the necessity of installing and operating Ship Performance Monitoring systems. They have acknowledged that the only way to be competitive is to be technologically ahead, Methis Whitepaper (2018). Furthermore, 80% of containership customers/end-users started to consider, or will consider in the future, sustainability factors in their selection processes (Reinhardt et al., 2012). In an era of dwindling resources, no maritime application can be considered complete without addressing sustainability.

Circular economy & new technologies implementation in the maritime sector

The Circular Economy (CE) has gained recognition as a guiding principle for business model innovation. Circular Business Models are innovative business models that define the rationale of how an organisation creates, delivers, and captures value to close, narrow, slow, and generate material loops (Antikainen and Valkokari, 2016, Bocken et al., 2016) supported by new technologies (inform strategy) (Konietzko et al., 2020). The pairing of CE and new technologies for maritime fleet management provides a fertile ground for circular business innovation and value creation, paving the way to explore novel ways this interaction can drastically change the nature of products, services, business models, and ecosystems. CE and new technologies can unlock synergies to generate direct value for customers/end-users and increase resource productivity across the industry by forming unique ecosystems that eliminate negative externalities and the need for considerable resources turning CE into a practical reality. Still, the potential role and opportunity space in the containership industry has hardly been analysed. CE principles are not well established, and the concept is not yet well understood by all stakeholders (Okumus et al., 2023).

In the maritime sector, routing advice techniques adjust to weather updates and actual deviation from the initial route baseline driven by the master navigation decisions along the voyage. The criteria for suggesting an option revolve around (but are not limited to) fuel consumption minimization (Fagerholt et al., 2015). Moreover, condition-based (predictive) maintenance (CBM) allows for monitoring an asset's condition and deciding the needed interventions (e.g., maintenance, etc.) when specific indicators show signs of decreasing performance or before the failure or exhausting of parts occurs (Jardine et al., 2006). CBM allows the maritime domain's contribution- and integration into a circular-by-design economy.

Methodology and Data Collection

This study will explore existing circular business models and technologies in the maritime industry to reduce fuel consumption and GHG emissions through resource efficiency and to maintain, reuse, refurbish, and remanufacture vessels' assets and identify the most suitable circular business models for the case scenarios developed in SmartShip, i) weather routing optimization and monitoring, ii) route monitoring, and iii) condition based (predictive) maintenance. SmartShip aims to provide a platform for alternative routing options to the vessels and optimum routing advice to the master in near real-time, considering the vessel's location,

destination, conditions, and weather forecast. The solution also includes developing an *alerting system* that notifies the user when a vessel deviates from its predefined route objectives due to current voyage conditions and master decisions along the vessel's course execution. The central concept behind route monitoring and route deviation is to generate warnings to the master for possible voyage under-performance based on analysis of both own fleet's and other vessel's historical data with similar weather conditions.

The model can help better estimate a voyage's distance (port-to-port), fuel consumption, and voyage performance based on predefined common routes vessels follow. Data acquisition components capturing real-time data from engine/propulsion monitoring sensors (primary engine data, auxiliary engines data, generator engine data, etc.), measurement instruments (e.g., flowmeters), navigational equipment (positioning systems, weather monitoring systems), and other gauges on board enable implementing CBM strategies for vessels, reducing the time and cost of intervention and prolonging the life span of the components.

This study will use SmartShip project outcomes and include data collection under circular business models and ICT technologies. In-depth interviews with members of the DANAOS company's research and innovation, operations, and technical departments, as well as navigation officers, technical managers, financial managers, fleet managers, procurement managers, and other project stakeholders, will be recorded. The guiding questions of this study are i) What is the impact of new technologies on incorporating circular economy principles and creating value for shipping companies? ii) What CE attributes enable circular business models for sustainable vessel management? iii) How does applying circular business models and strategies improve the performance of existing tools for vessel monitoring?

Results and preliminary discussion

Interviews will help recognize improved environmental performance in shipping operations by assessing results in voyage performance regarding fuel consumption and emission control compliance due to SmartShip routing advice. Moreover, engine fatigue assessment and performance monitoring will retain value by extending the lifetime of vessels' physical assets. The assessment will include evaluating the Smartship solution's value-added proposition to existing tools by looking at the improvement in results of the existing vessel performance monitoring tool and the user-friendliness and experience.

The analyzed elements will allow identifying circular business models and technologies to reduce fuel consumption and optimize assets' life spam through engine fatigue monitoring. Identifying the improvements to the current business model will allow the evaluation of the enhancement and uptake of the CE. The main results will enable exploring circular business models and strategies in the maritime industry that can help slow resource flow by applying condition-based maintenance to maintain, reuse, refurbish, and remanufacture vessels' assets. Also, reducing energy consumption and GHG emissions will narrow resource flows through resource efficiency and support the transition of the maritime sector to a circular economy.

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