A data analytics, decision support and circular economy – based multi-layer optimization platform towards a holistic energy efficiency, fuel consumption and emissions management of vessels

Navigation Optimization through DDS - Advances and State of the Art
Warsaw, 04.07.2023

Beneficiary: CERC

Presenter: Isabel von Gemmingen-Hornberg

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Overview

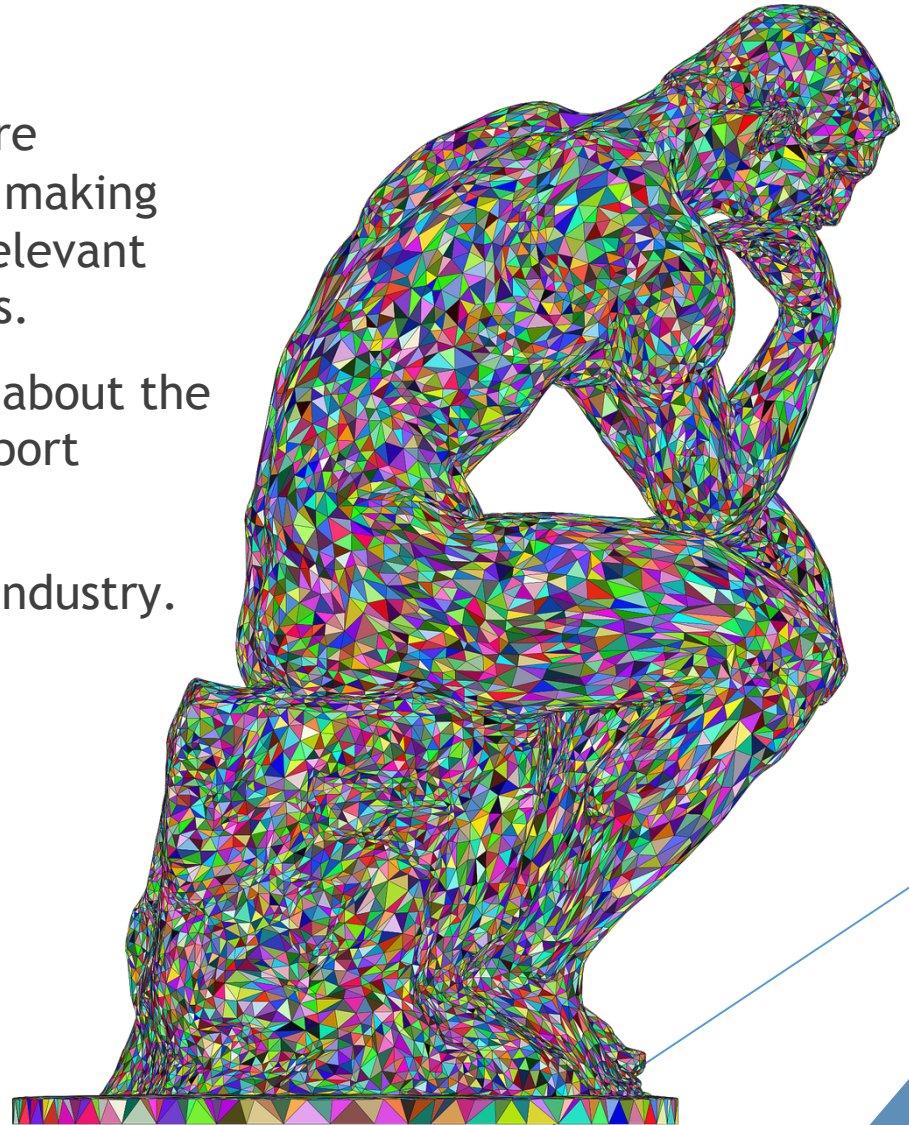
- Introduction
- Decision Support Systems
- Navigation Optimization
- State of the Art Technologies
- Literature
- Future Trends and Challenges
- Conclusions

Introduction

- In this presentation, we put the main objective of the Smartship project in context of history and scientific literature.
- We explore the advances and state of the art in decision support systems for the maritime industry, focusing on navigation optimization through DDS towards a circular transition.

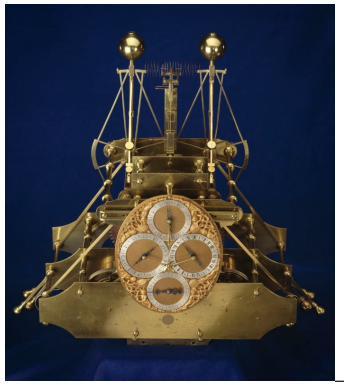
Thinking about Decision Support Systems

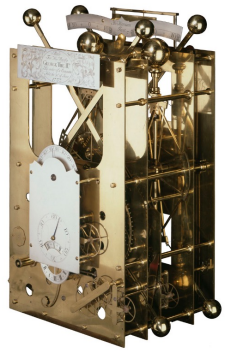
- Decision support systems (DDS) are computer-based tools that aid in making complex decisions by providing relevant information, models, and analysis.
- Let's stop for a moment to think about the function and role of decision support systems in general.
- And specifically in the maritime industry.

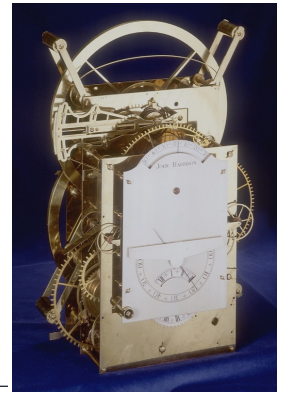


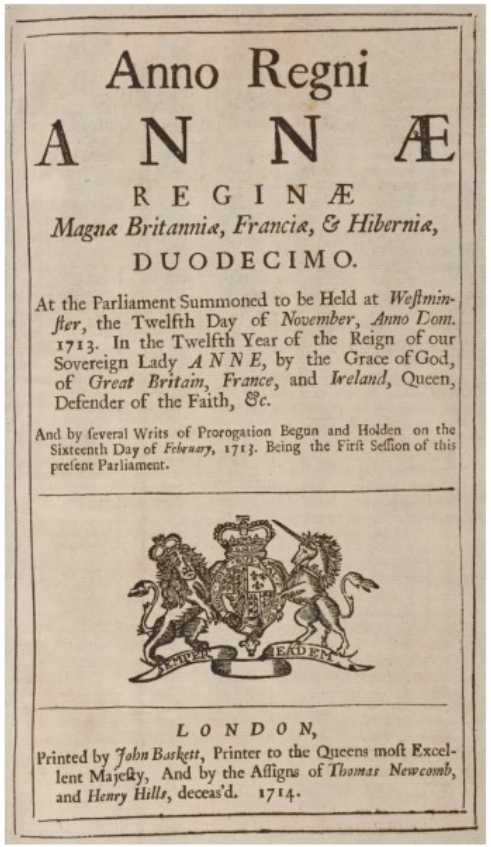
The Long Tradition of Navigation Optimization

- Innovation-Driven Navigation Optimization has a long tradition. The challenges have led to Century long quests for technological improvement to meet the most crucial challenges of the time.
- One example in this long tradition was the search for the ‘true-time’ at sea. In 1714, the British Crown offered £20 000 Pounds to the person that solves the longitude Problem. The quest was only officially solved in 1773 by the clockmakerJohn Harrison.









Anno Regni

A N N Æ

REGINÆ

Magnæ Britanniæ, Franciæ, & Hiberniæ,

DUODECIMO.

At the Parliament Summoned to be Held at *Weſtminſter*, the Twelfth Day of *November*, *Anno Dom.* 1713. In the Twelfth Year of the Reign of our Sovereign Lady *ANNE*, by the Grace of God, of *Great Britain*, *France*, and *Ireland*, Queen, Defender of the Faith, *&c.*

And by ſeveral Writs of Prorogation Begun and Holden on the Sixteenth Day of *February*, 1713. Being the Firſt Seſſion of this preſent Parliament.

LONDON,

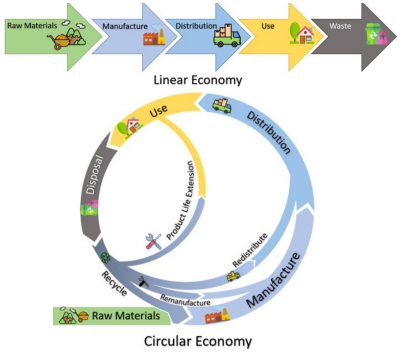
Printed by *John Baskett*, Printer to the Queens moſt Excellent Majeſty, And by the Aſſigns of *Thomas Newcomb*, and *Henry Hills*, deceas'd. 1714.

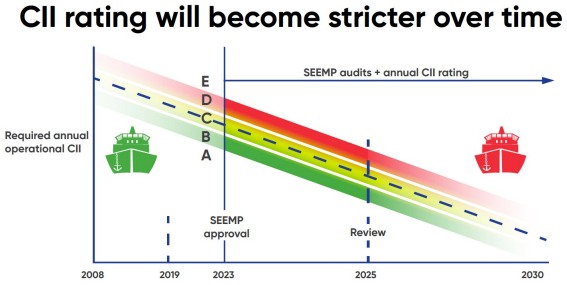
Longitude Act, 1714, (C) Cambridge University Library

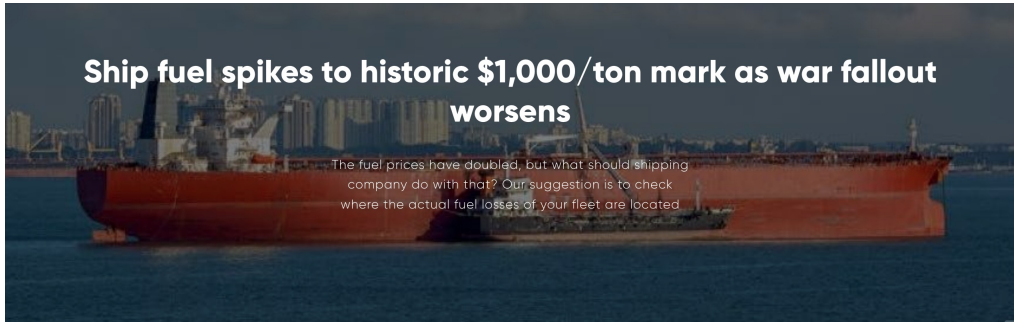
Navigation Optimization Today

- Emissions are projected to boom from approximately 90% of 2008 emissions in 2018 to 90-130% of 2008 emissions by 2050
- Navigation optimization plays a crucial role in improving operational efficiency, reducing fuel consumption, and minimizing environmental impact in the maritime industry.
- Fuel Efficiency must be optimizer under different scenarios: Route, scheduling, collision avoidance, etc.
- Several Factors: Multi-factor optimization problems
- Constraints are expected to grow over time: Cost, regulations, competition, etc.

Navigation Optimization Today







State of the Art Technologies

- Efficiency gains within the maritime industry have been achieved over time through technological advances, the improvement of data availability and quality, as well as the integration of these into decision support systems.

- Several cutting-edge technologies are being employed in DDS for navigation optimization, including artificial intelligence, machine learning, and big data analytics.

- Optimization Algorithms can profit from the vast availability and quality of data and technology.

State of the Art Technologies

Route Optimization System

Real-time route management can play a major role in improving the journey duration and efficiency. Considering the varying ocean conditions, it is important that real-time data is available for ship operators to use. The software monitors vessels and data in real-time to continuously identify optimal routes and alert operators when action is needed based on data inputs about weather patterns, piracy alerts, port traffic, and other variable parameters. Route optimization is bound to have a positive impact on the environment and commerciality, without compromising safety.

Vessel Fuel Optimization System

A new-age digital technology based on a collection of real-time data of various external parameters affecting fuel consumption by a vessel like an engine condition, hull condition, vessel speed, trim, draft, etc. which is further processed and interpreted by a machine learning module. The interpretation of data suggests changes in route, vessel speed, or other indicators to keep fuel consumption under check.

Vessel Performance Monitoring

The fundamental idea of implementing data analytics at the core is about monitoring vessel performance. Using sensor data to gather and analyze data about engine conditions and properties of exhaust gas will reveal the effectiveness of abatement methods like DWI, IAH, SCR, AND EGR or the efficacy of water injecting devices and scrubbers.

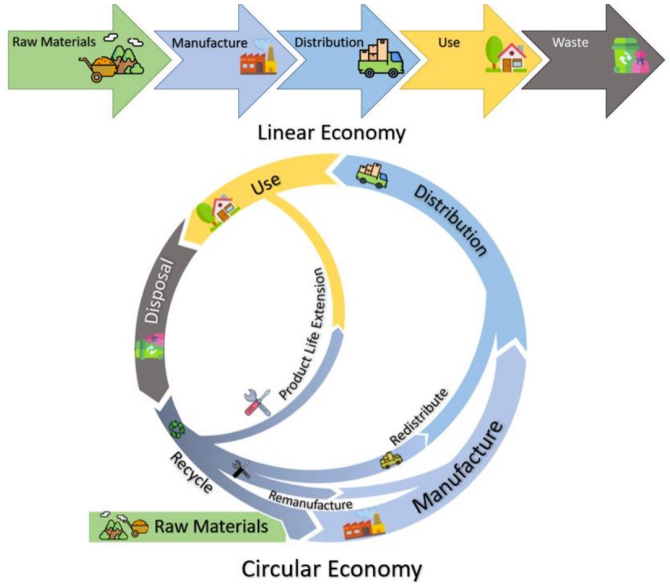
Predictive Maintenance System

In the case of equipment and systems involved in treating exhaust gas emissions, there can be no scope of downtime or low efficiency as it may affect ships' compliance with IMO MARPOL regulations along with causing severe damage to the environment. The maintenance cycle is predicted based on data collected through sensors and processed through machine learning algorithms by identifying standard condition indicators and then comparing it to them to determine an appropriate repair and maintenance model which is implemented later to test its efficiency.

Source: Marine Digital: the Path to Zero Carbgon Shipping

Circular Transition in the Maritime Industry

- The maritime industry is moving towards a circular economy, which aims to minimize waste, promote sustainability, and optimize resource utilization.
- Implementing a circular transition in the maritime industry can lead to reduced emissions, improved resource efficiency, and enhanced economic sustainability.



Smartship Solution

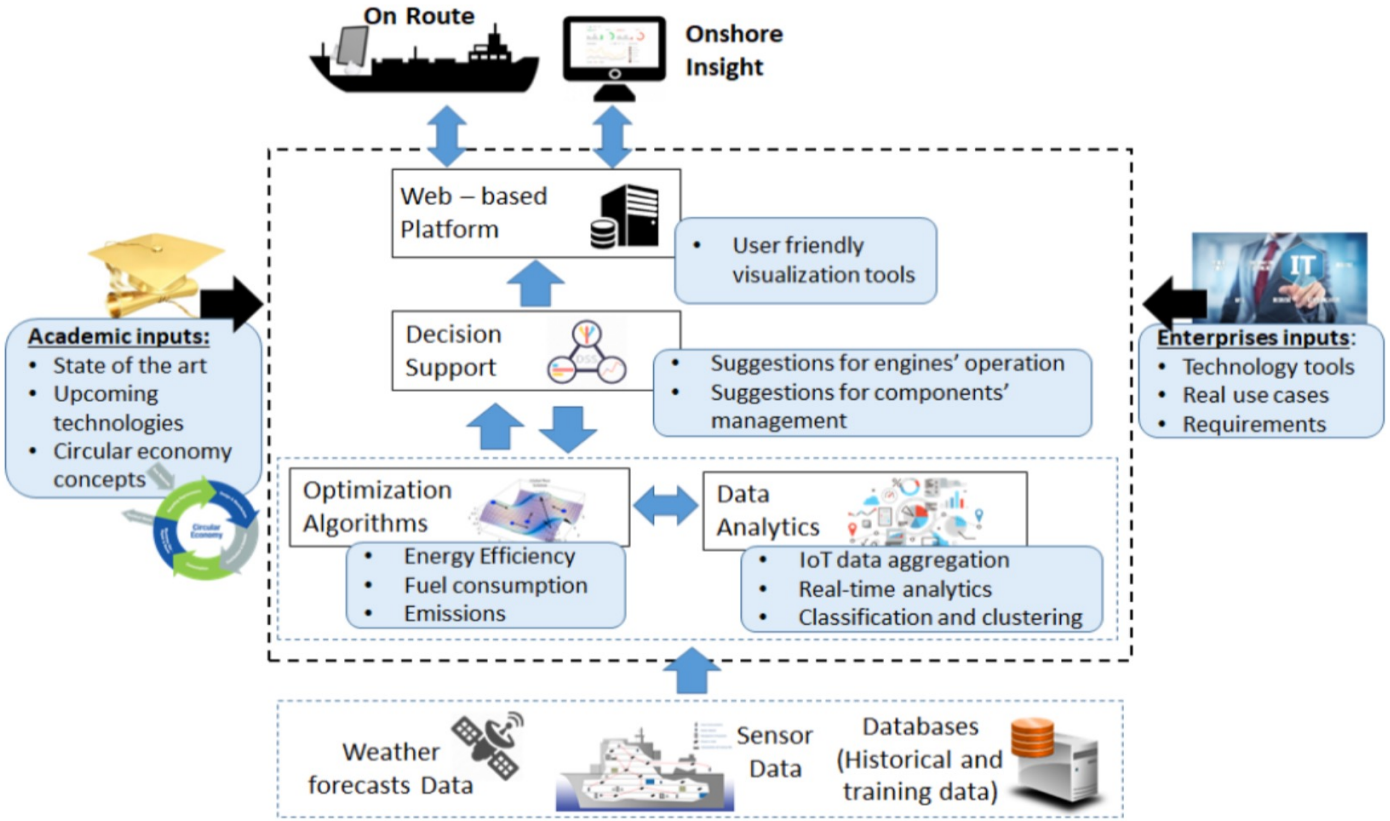
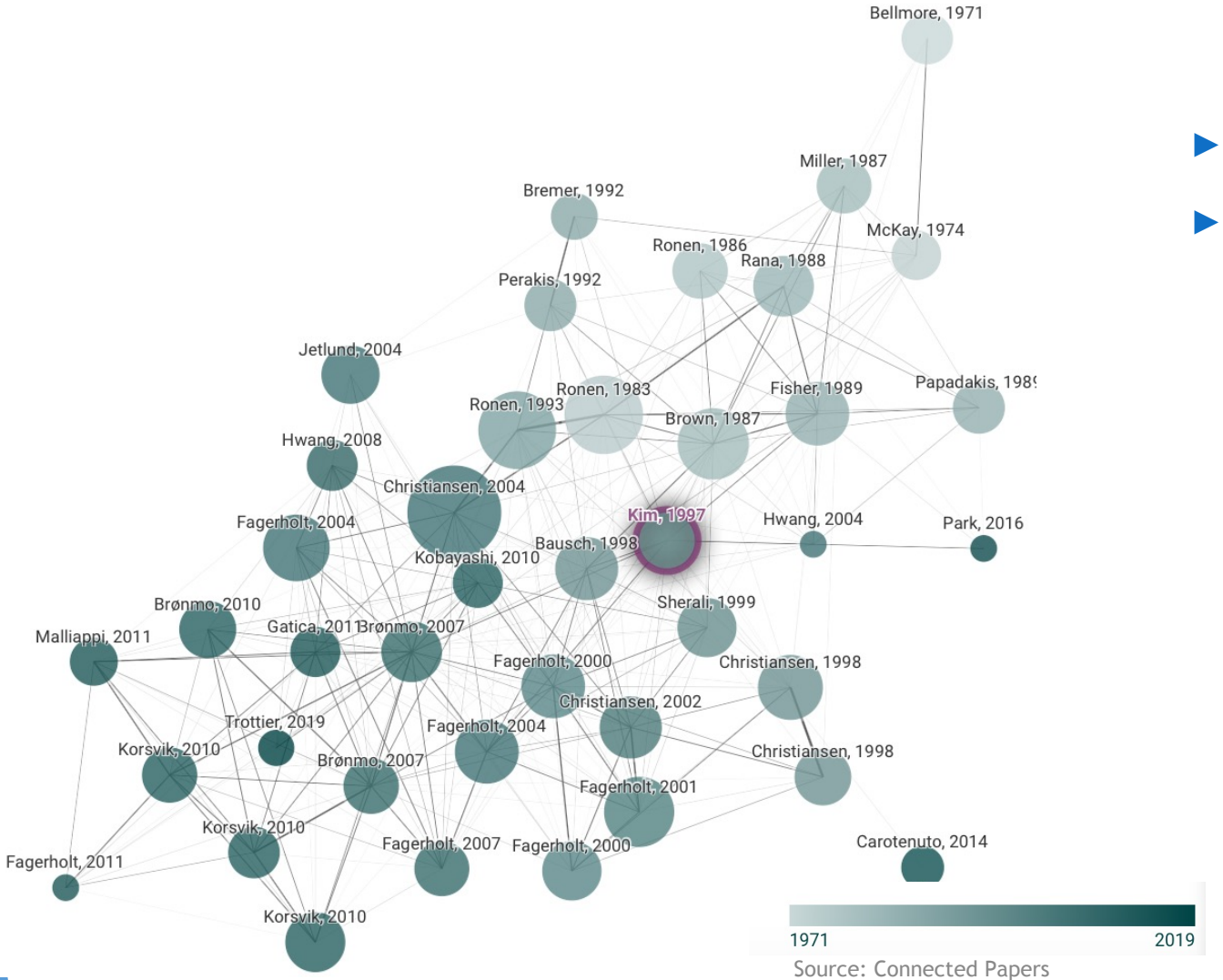


Figure 2 SmartShip's Architecture (SmartShip, 2020)

Source: Oikonomou, Fotis, et al. "Data Driven Fleet Monitoring and Circular Economy." 2021 17th International Conference on Distributed Computing in Sensor Systems (DCOSS). IEEE, 2021.

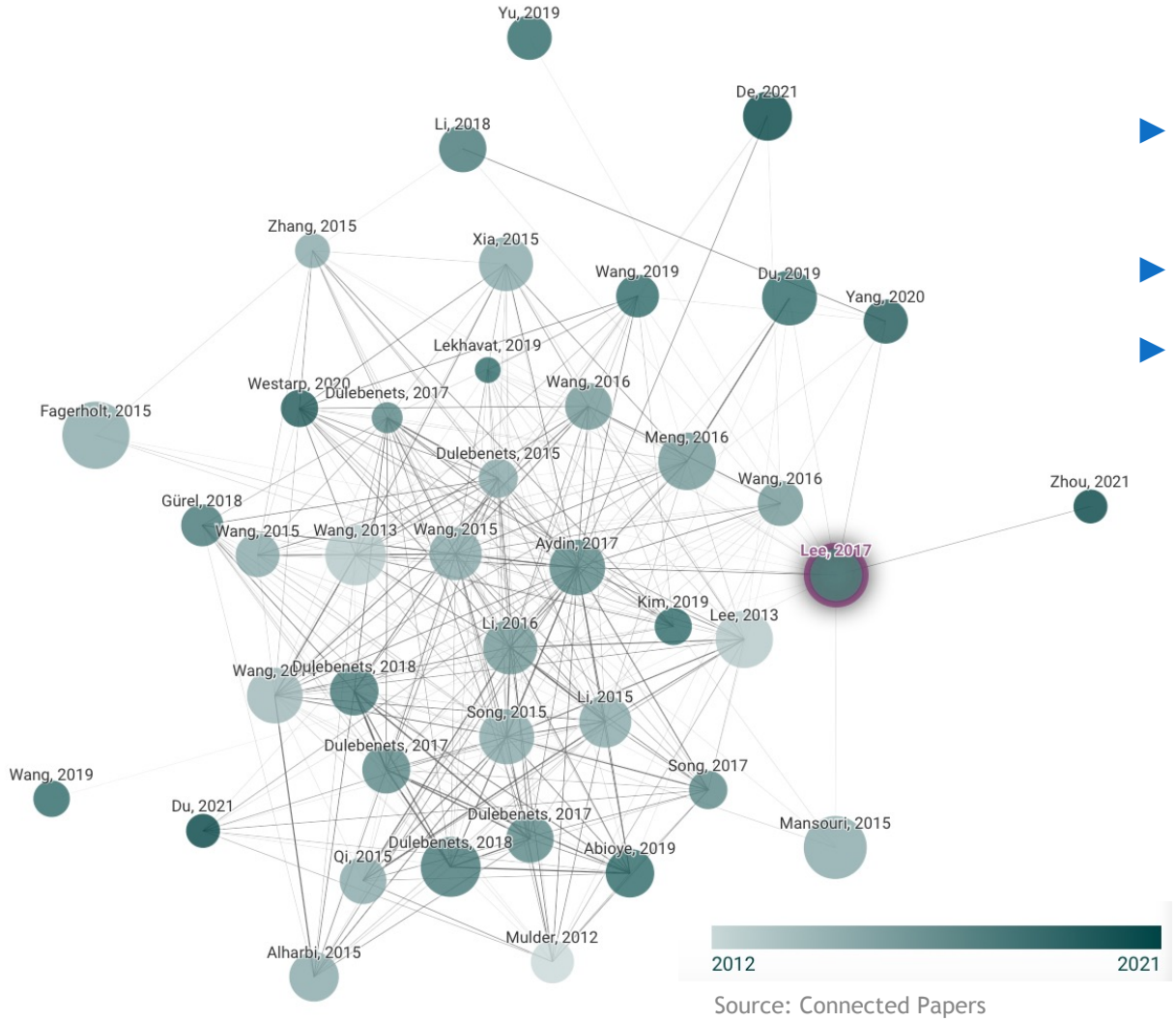
Literature on Ship Scheduling



Source: Connected Papers

- Ship Scheduling
- Fuel and Routing Optimization

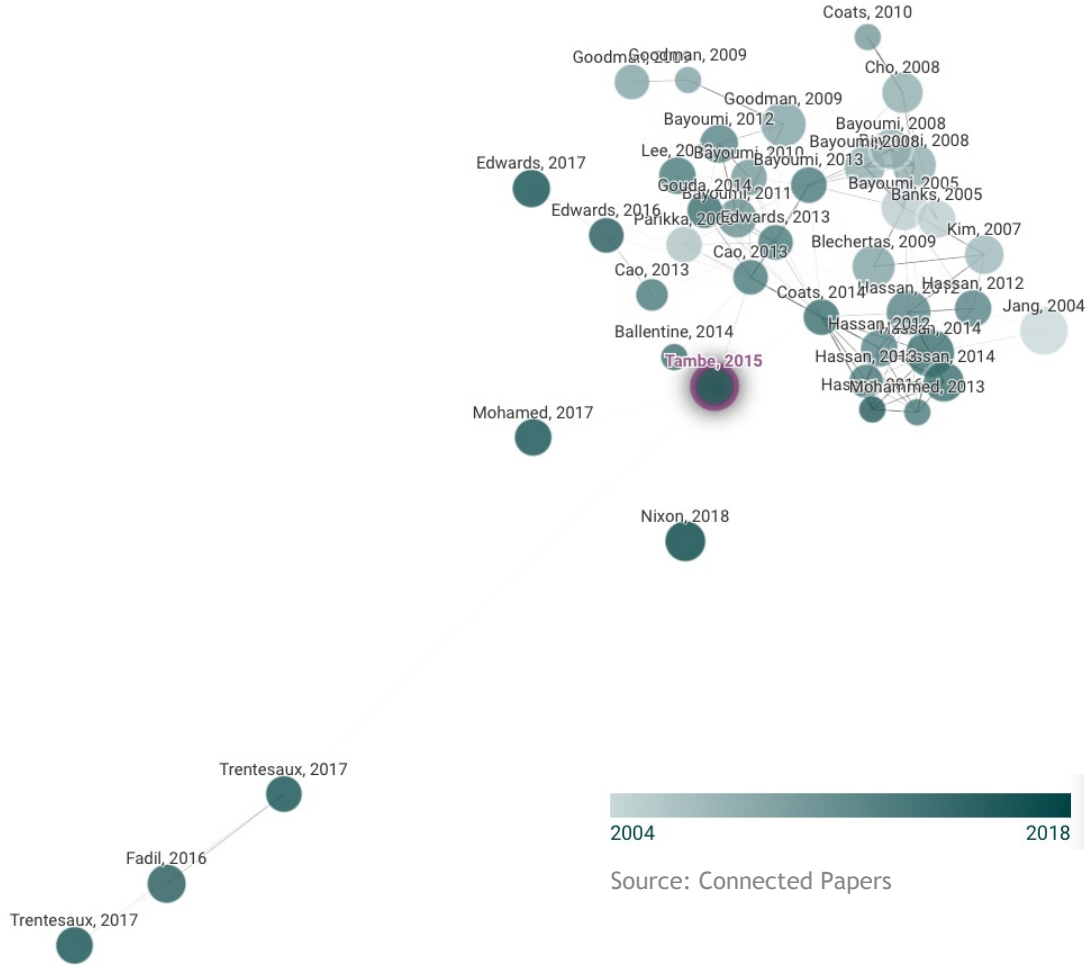
Literature on Multi-Object Optimization



Source: Connected Papers

- Fuel and Routing Optimization
- Port-Schedules
- Algorithms

Literature on Fleet Maintenance

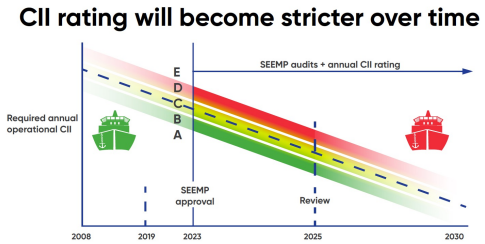


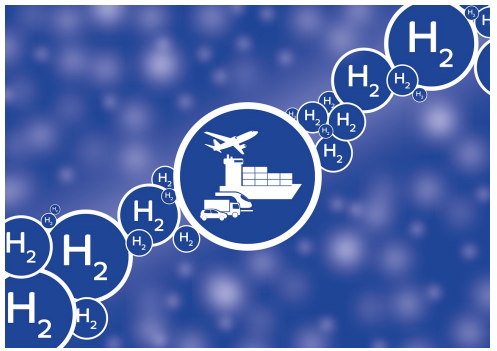
Source: Connected Papers

- Fuel and Routing Optimization
- Port-Schedules
- Algorithms

Future Trends and Challenges

- The future of DDS in the maritime industry is expected to witness further advancements in automation, integration with IoT, and the inclusion of further variables in the optimisation and DDS models
- Regulatory Challenges can be expected to increase the optimisations constraints and further demand more efficient resource utilisation
- Competition and Consolidation Trends in the in the Shipping Industry will put increased pressure to innovate





Conclusions

- Collecting and sharing digital data is essential for automating operations and achieving shorter waiting times for ships and faster processing in terminals.
- Prioritizing fuel efficiency over exhaust gas after-treatment or alternative fuels is the ultimate solution for minimizing emissions from marine engines.
- The integration of digital technologies such as the Internet of Things (IoT) and Artificial Intelligence (AI) can enable energy efficiency optimization and supports the transformation to a lower-carbon business model.
- Digital technologies enable optimized voyages by adapting navigation based on real-time weather, wind, and ocean current data, resulting in reduced energy consumption.

Thanks for your attention

Questions