NUS Sustainability CONNECT 2023

Maritime Sustainability

Sustainable Maritime Operations: Enhancing Efficiency and Environmental Performance

Future Ship Designs

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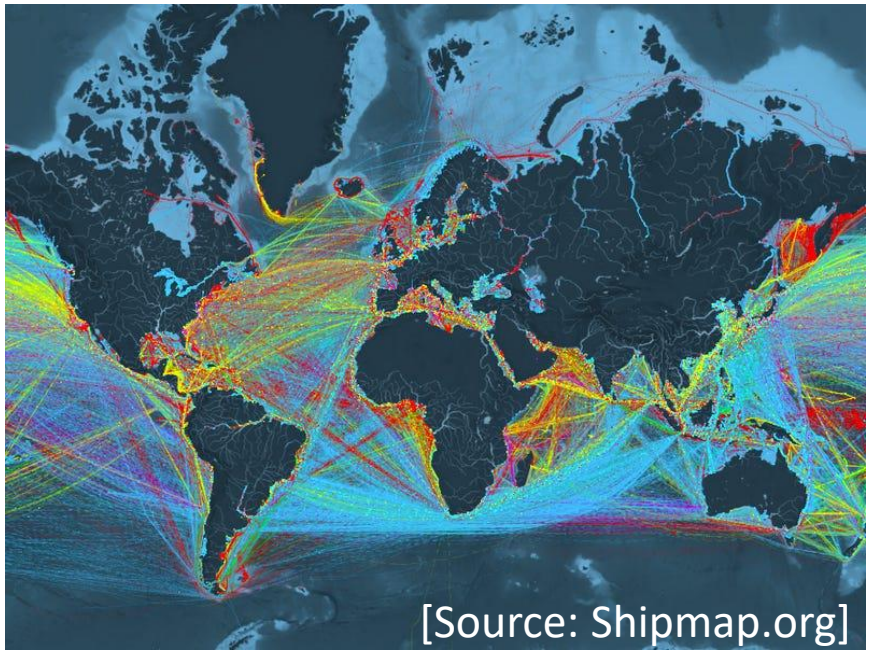
Introduction

- Waterways has been used for transportation long ago. It is still the most cost-effective and best suited for transporting bulky items over oceans.
- **Ship** is a unit platform, and her **design** is generally a sophisticated process that involves various specialists with diverse requirements.
- The naval architects, are instrumental in defining crucial principles of ship design and integrating system of systems.

[Source:http://www.mantamarinedesign.com/en/services/naval-architecture]

Introduction (Cont'd)

- 90% of goods are transported globally through water, accounted for **3%** of annual global carbon dioxide.
- If trade and transport continue to follow the trends of the last 50 years, emissions will be 3,000 million of carbon by 2050. In 2018, the IMO mandated that **by 2050** the industry must **cut its carbon footprint to half the 2008 level of emissions**, <470million tons of carbon—85% reduction. And in 2023, Net-Zero by 2050.
- **From the perspective of a global hub port and an International Maritime Centre, the challenge for the future ship design, is not just about how to achieve the ambitious carbon targets, but also how to embrace the growth opportunity, with scarcity of land and human resources.**


[Source: Shipmap.org]

What have changed the approach to future ship design?

For maritime industry to remain relevant, competitive and profitable, ship design must embrace new technologies, and adapt to changes in trends. They may be grouped into three broach categories:

A. The 4th industry revolution (I4.0) —these are technologies mainly from other industries, such as product life-cycles management approach from aerospace, and digital and autonomy technologies from automotive industry.

B. Global sustainability movement—these factors forced maritime to transit towards net-zero carbon for a sustainable environment

C. Innovative smart solutions that optimizing shipping and port operations—indigenous ideas, rules and standards, processes to transform the maritime industry.

The 4th Industry Revolution (I-4.0)

Industry 4.0 is not merely digitalization, but Internet of Things (IoT), driven by artificial intelligence (AI) and machine learning, to improve efficiency and effectiveness of assets/facilities, and reduces manning and operational expenditure. However, their contribution alone to GHG target is limited.

Digitalization and I-4.0 will remain in the future to improve efficiency, and to reduce carbon footprints. They include:

- Remote shore control, monitoring and operation of ship and ship systems
- Centralised data collection, analytics and benchmarking for cyber-physical modelling
- Predictive maintenance, forecasting maintenance and keeping the systems in optimal conditions.
- Analyse operational profile and indicators , such as fuel/energy utilization, voyage planning, leading to energy saving overtime.

Global Sustainability Movement

Technology breakthroughs has complemented environmental and business targets. They are:

- More efficient transportation performance
  - Use of computer power to develop integrated, holistic optimal performance design
  - Use of advanced material and hull design to reduce hull weight.
  - Streamlined hull form design, fitted with higher efficiency propulsion systems.
  - Adopt innovative hybrid solutions, such as wind assistance, hull friction reduction, aerodynamic superstructure design, etc.
- More Efficient shipping operations:
  - Low / super-low steaming operations
  - Bigger “smaller ships” and improved utility of fleet for economy of scale.
  - Creation of efficient shipping lanes, voyage optimization, JIT operations
- However, their contributions alone to GHG target will be small without lower carbon, and alternative fuel/Energy solutions.

An Example of Bigger and Slow Steaming Solution

The Maersk Line **Triple E class** ("Economy of scale, Energy efficiency, and Environmental impact improvement") **VLCC** (Very Large Container Carrier), of "Most Sustainable Ship Operator of the Year" award in July 2011

- Principle dimensions: 399.2 m long, 59 metres width and capacity of 18,000 TEUs.
- One of the class's main design features is its dual 29.68 MegaWatt (39,800 hp), eight-cylinder, ultra-long stroke diesel engines, driving two propellers at a design speed of 19 knots.
- This class is by design slower than its predecessors, using **a strategy known as slow steaming to lower fuel consumption by ~37% and carbon dioxide emissions per container by ~50%.**

(source: Maersk)

[Source: Maersk]

Alternative Fuel / Energy

In recent years, some of the eco-friendly vessels, is driving the industry towards a greener future:

- LNG replacing oil as fuel
- Electrification /Hybrid solution
- Clean fuel or those generated with renewable energy.

Bunkering/Charging infrastructure will play a key supporting role for:

- Deep-Sea Shipping: Fossil fuel/ methanol dual fuel, biofuel, hybrid wind assisted, ammonia, hydrogen, nuclear power, etc.
- Short-Sea Shipping: Fossil fuel/ methanol dual fuel, biofuel fuel, hybrid wind assisted, ammonia, hydrogen, nuclear power, etc.
- Inland-, river- and harbour-crafts: Pure electric ferry, launch, supply craft and Tug.

Example of Hybrid Solution

The 2023 **Nor-Shipping Next Generation Ship Award** is Terntank's 15,000-dwt hybrid tanker, with relatively new technological advancement on energy efficiency, innovation, and environmental sustainability.

- Reduce carbon emission on combination of clean technologies function with diesel, biofuel or methanol, while also featuring wind-assist technology.
- Wind-assist technology to optimise the wind's power, to reduce CO_2 emissions by up to 19%.
- Energy Efficiency Design Index close to 40%.

(source: Terntak)

(source: Terntak)

(source: Terntak)

Examples of Clean Fuel- Green Methanol-Powered Ships

- In 2021, Maersk ordered the world's first methanol-enabled container vessel.
- Jan 2022, Maersk ordered 12 X 16,000 TEU container vessels, Methanol-Powered engines, (350 meters long, 53.5 meters wide) With Fuel-Saving Design--a 20% improved energy efficiency per transported container, saving ~1,000,000 tons of annual CO_2 emissions for the entire series.
- Jun 2023, Maersk ordered of 6 X 9,000 TEU container vessels, dual-fuel engines able to operate on green methanol.
- Maersk has 25 methanol-enabled vessels on order/delivered. The global orderbook stands at more than 100 methanol-enabled vessels.


Maersk 16,000 TEU Containership (source: Maersk)

Mask 9,000 TEU Containership (source: Maersk)

[source: Maersk]

Example of Pure Electric Harbour Craft

- **P**enguin designed and built the first for Shell worldwide and a first for Singapore a full electric 200-pax ferry.

- Electric Dream ferries will ply between Singapore's Pasir Panjang ferry terminal and Shell's Energy and Chemicals Park on the southern island of Pulau Bukom.

- Electric Dream ferry is designed to eliminate about 1,427 tons of CO_2 emissions a year..

(source: Penguin International Limited)

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[source: Penguin International Limited]

Innovative Smart Shipping and Port Operations

A. Highly efficient, Low /zero-emission ships with smart features

- Develop highly optimized and integrated designs. Taking holistic approach in optimizing system of systems, through-life-cycle considerations.
    - Ship hydrodynamics and propulsion, Green fuel or hybrid propulsion systems, lightweight but robust structure design, bunkering/ charging infrastructure, etc.
    - Smart solutions: operational profile, route planning and voyage optimization, Predictive maintenance.

B. Infrastructure for safe & efficient bunkering / charging operations:

- Battery Charging / Swapping Stations: Optimal for efficient electric harbour craft operations
- Managing Bunkering of Green but more hazardous fuel (e.g. Methanol, Ammonia, etc.), incl. Scenario Planning, Risk Management and Incident management, etc.

An Example of New Fuel Bunkering Operations

Singapore's first ship-to-containership methanol bunkering operation was successfully conducted on 27 July 2023

- The operation involved Maersk's container vessel, the world's first container ship powered by green methanol, receiving approximately 300 metric tonnes of bio-methanol when she is en route to Copenhagen for its maiden voyage.
- Safety preparations were meticulously undertaken for the methanol bunkering operation in Singapore by MPA including:
  - Conducted Table-Top Exercises (TTX), and workshops, Ground Deployment Exercise (GDX).
  - Reviewed global methanol-related incidents and worked with the Meteorological Service of Singapore to provide advance lightning risk warnings
  - Developed a methanol plume model with the RI, IHL including TCOMS

[Source: MPA]

- During bunkering operation, drones equipped detectors and infrared cameras were flown to detect potential methanol leaks into the atmosphere and methanol flames in an event of an accidental leak.
- A Technical Reference (TR) for methanol bunkering is being developed by MPA.
- MPA is developing operational protocols, licensing requirements, training programs, and necessary infrastructure to fully operationalize methanol bunkering.
- Knowledge gained from this milestone will be shared to promote the safe adoption of methanol and guide our approach for future pilots and trials of new marine fuels.

[Source: MPA]

Innovative Smart Shipping and Port Operations (Cont'd)

C. Smart Autonomous Shipping:

Key considerations for autonomous shipping are:

- Sensor for the observation task directly around the ship and longer range to provide data for situation awareness
- Navigation: Route planning, traffic avoidance, CDCA, etc.
- Crew Tasks: Design to empower reassign of operations, maintenance and administration tasks, with shore-based solutions. Multi-tasked crew.
- Safety evaluation, risk mitigation and certification.

The following applications are feasible for

- Short-Sea Shipping: intermittent unmanned bridge operations during the longer hauls.
- Inland, rivers and Port waters: Fully electric, zero-emission autonomous harbour crafts

Conclusion

"As a small country with no hinterland or natural resources, trade has always been the lifeblood of Singapore – and the port its reason for being."

Founding Prime Minister Lee Kuan Yew said in the "Inaugural Singapore Maritime Lecture" on 25 Sep 2007: " Singapore's raison d'etre was its port"

[Source: MPA]

Thank you