Luisa Montella

Sustainable transition towards greener and cleaner Maritime Transport

Tutor
Prof. Stefania Santini

co-Tutor
Prof. Teresa Murino (DICMaPI)

Cycle: XXXIX

Year: 2024/25

Eng. Dario Bocchetti
(Grimaldi Euromed S.p.A.)

Background & Info

- *MSc degree* in Management Engineering, University of Naples "Federico II"
- *Working team*: DAiSy Lab (Prof. Stefania Santini)
- *Co-Tutor*: Prof. Teresa Murino (DICMaPI), Eng. Dario Bocchetti (Grimaldi Euromed S.p.A.)
- *PhD start date – end date*: Academic Year 2023/24-2025/26
- *Scholarship type*: PNRR - DM 117, company – funded
- *Partner company*: Grimaldi Euromed S.p.A.
- *Nr. of months in company*: 15

Summary of study activities

- Study of key enabling concepts for the maritime sector's sustainable transition towards energy savings and reduced environmental impact.

Seminars:

- *IEEE Authorship and Open Access Symposium: Tips and Best Practices to Get Published from IEEE Editors* – Dr. Petar Popovski, IEEE Xplore Team
- *Dynamic Risk Assessment in Industrial Applications: Leveraging Bayesian Inference for Enhanced Decision-Making* – Prof. Francesco Vitale, ITEE Seminar
- *Control of multi-agent systems with time delays: theory and applications* – Prof. Stefania Santini, TDS webinar

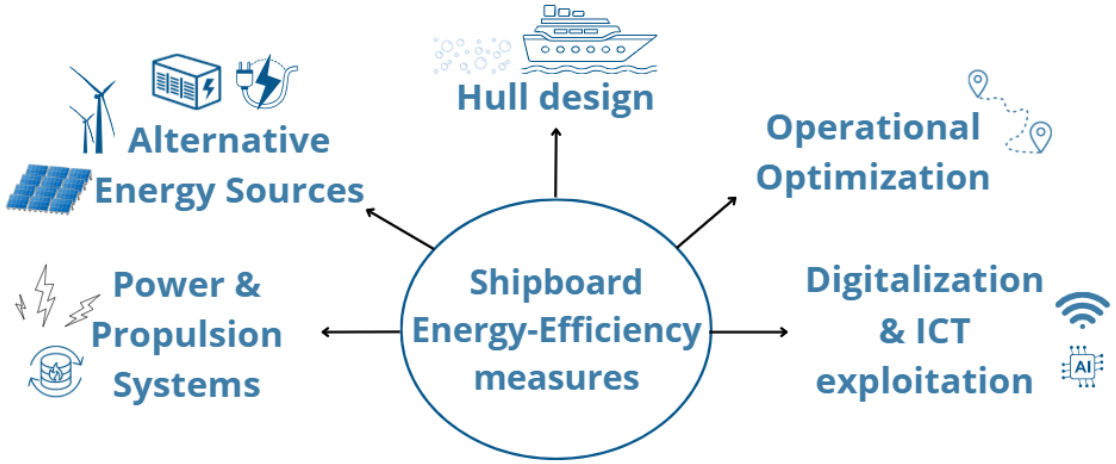
Courses:

- *II PhD Freshmen Cruise School 2025* (January 19 – 24, 2025) "AI for the Sustainable Blue Economy: Industry, Healthcare, and Government"

Research area:
Environmental impact of the maritime sector (1/2)

- The maritime sector emits over 1 billion metric tons of **CO_2** annually (approx. **3% of global emissions**), primarily from High-Sulphur Fuel Oil (HFO).

- An integrated set of measures is being adopted to enhance shipboard energy efficiency.



Research area:
Environmental impact of the maritime sector (2/2)

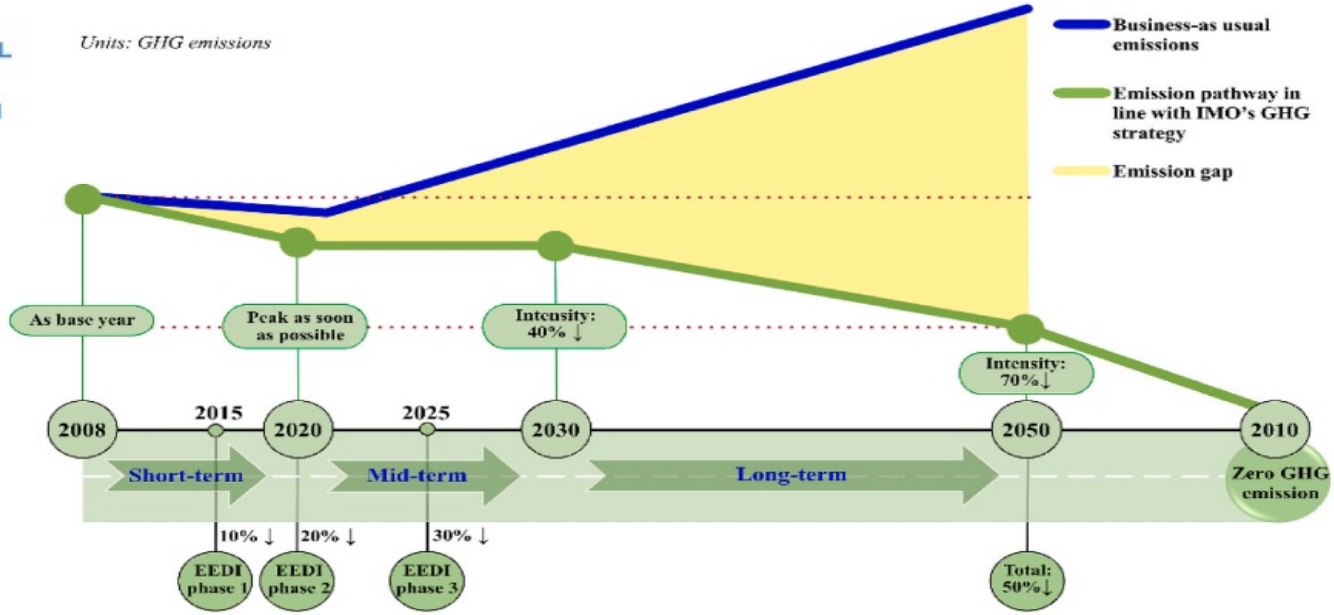
- The International Maritime Organization (IMO) defines some **sustainability metrics** to measure ships performances that need to align with IMO's goals timeline.

- These indices demand continuous, reliable, and objective **performance measurement**.

INTERNATIONAL MARITIME ORGANIZATION

IMO Sustainability Metrics:

- EEDI
- EEXI
- CII



Source: Hoang, A. T., Foley, A. M., Nižetić, S., Huang, Z., Ong, H. C., Ölçer, A. I., Pham, V. V., & Nguyen, X. P. (2022). Energy-related approach for reduction of CO2 emissions: A critical strategy on the port-to-ship pathway. *Journal of Cleaner Production*, *355*, 131772.

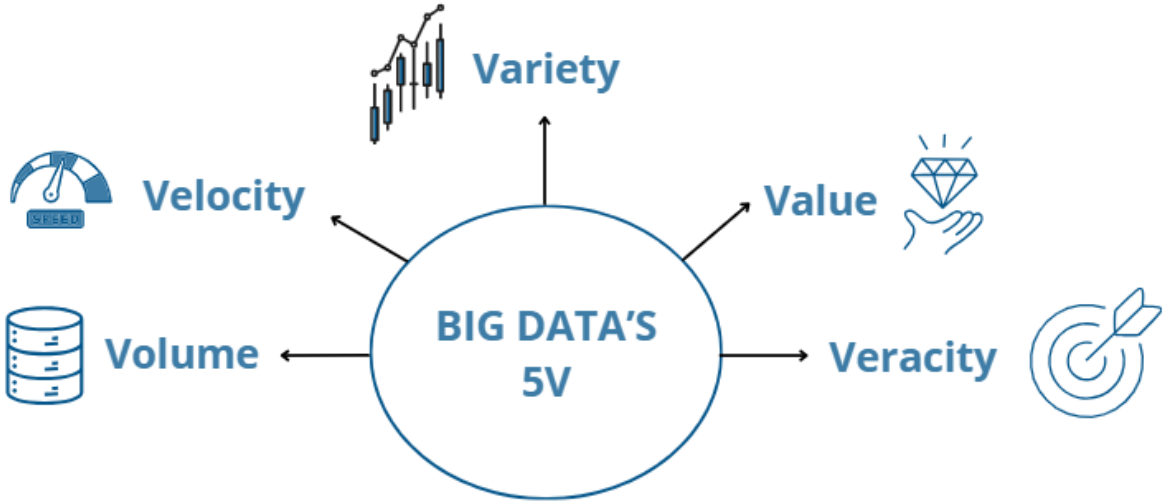
Research area:
Digitalization and Data Challenge

- Progressive digitalization leads to the acquisition of **massive amounts of high-frequency data from shipboard sensors**:
  - Raw, noisy, unstructured

- High data variety and low data veracity prevents the calculation of trustworthy **Key Performance Indicators** (**KPIs**) essential for IMO compliance and **effective fleet energy management**.

Need of a **data-driven framework** in **ship energy management** for:

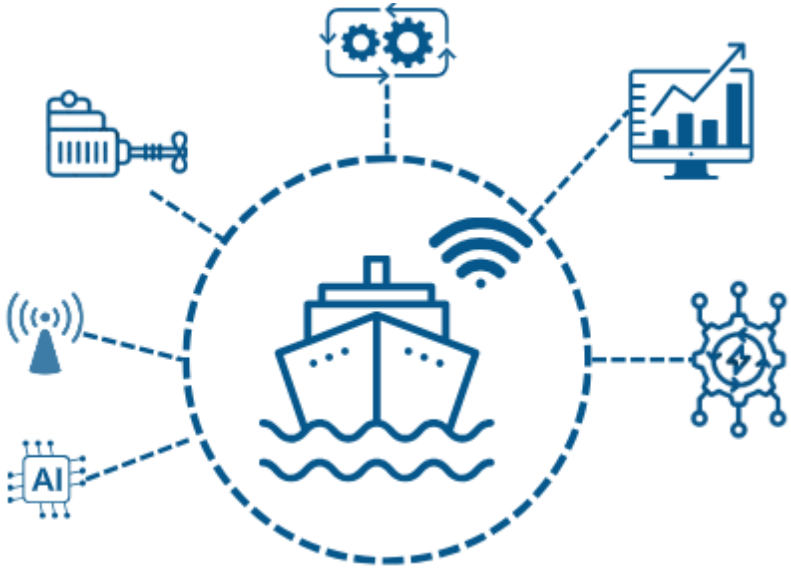
- Reliable Measurement
- Evidence-Based Decision-Making



Research area:
From Data to Knowledge

The maritime industry lacks an **integrated**, **robust data-driven framework** to bridge the gap between **raw data collection** and **practical energy management**.

- Therefore, it is required a methodological tool capable of:
  - **Cleaning** and **Structuring** heterogeneous data sources.
  - **Benchmarking** and **comparing** ship performance objectively.
  - **Supporting** strategic and operational decision-making.



Research activity: Problem Statement

Lack of an **integrated framework** to structure and clean shipboard data, compute reliable energy KPIs, and support strategic and operational decisions for energy efficiency.

The aim is to:

- Develop a **Data-Driven Decision Support System (D-DSS)** to transform raw data into evidence, enabling sustainable and monitored ship operations across the fleet.

- Provide shipowners with a **digital tool** to monitor energy use across their fleet and drive decarbonization efforts.

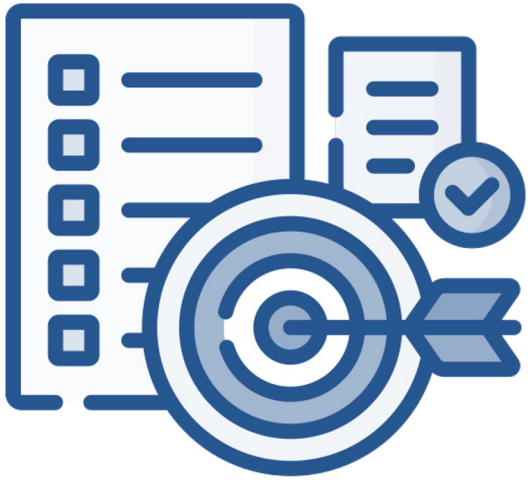
Research activity: Objective

The overall objective of the thesis is to develop a **D-DSS**, acting as the bridge between raw shipboard data and measurable decarbonization efforts.

This is realized by focusing on two primary perspectives:

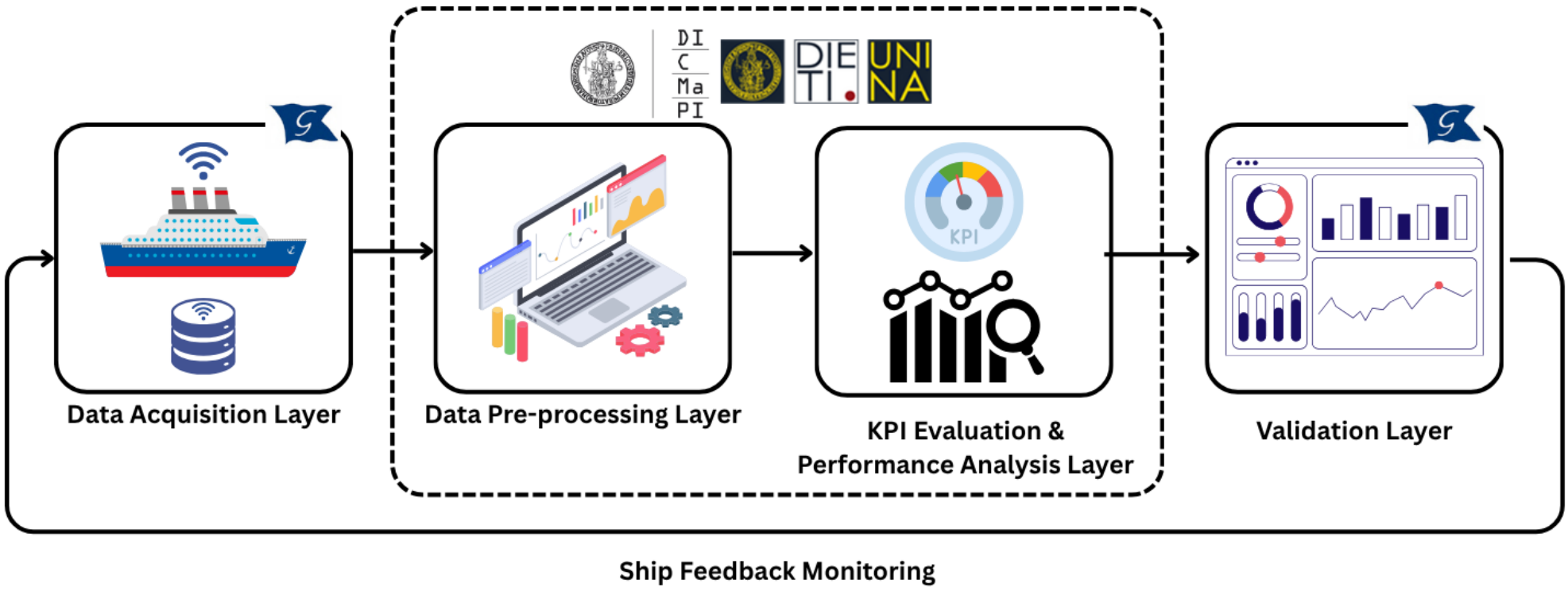
- Establishing a reliable and integrated framework for **data structuring, cleansing, and objective KPI computation** from heterogeneous shipboard data. This ensures **measurement accuracy** for objective performance.

- Tailoring the framework into a **decision support tool** to enable **proactive energy management** and measurable IMO compliance, by guiding both daily operational choices and long-term strategic planning.



Research activity: Methodology

The D-DSS follows a four – step process, designed to transform unreliable data streams into actionable insights.



Research activity: Methodology Application

- The Framework was validated using real-time operational data from the company fleet for the evaluation of the comparative energy efficiency of Autonomous vs. Traditional Berthing Maneuvers. [1]

- Environmental, operational, and economic KPIs are integrated into a unified efficiency measure for fair comparison of berthing maneuvers.

Category	KPI	Symbol	Unit
Environmental	CO_2 Emissions	E_{CO_2}	kg
	Energy Consumption	EC	kWh
Operational	Manoeuvre Duration	T_{man}	hours
Economic	External Assistance cost	C_{tug}	€
	Berthing Assistance cost	C_{ass}	€

$$BEI^{(m)} = 1 - \sum_h w_h \cdot \hat{p}_h^{(m)}$$

$\hat{p}_h^{(m)}$ = normalized value of the h-th KPI for manoeuvre m

w_h = weight associated to the h-th KPI

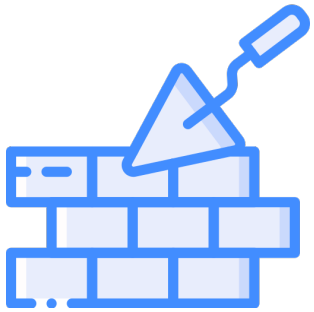
Performance Index	Vessel A (mean ± std)	Vessel B (mean ± std)
EEI_{env}	0.79 ± 0.10	0.91 ± 0.05
EEI_{op}	0.90 ± 0.08	0.98 ± 0.03
EEI_{ec}	0.90 ± 0.05	0.77 ± 0.10
BEI	0.59 ± 0.18	0.67 ± 0.14

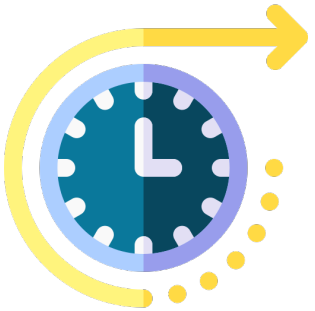
Source: Franzese G., Montella L., Murino T., Somma A., Strazzullo M., "A Data-Driven Framework for the Evaluation of Autonomous and Traditional Berthing Maneuvers in Maritime Operations", in New Trends in Intelligent Software Methodologies, Tools and Techniques, vol. 250, pp. 529–540, IOS Press, 2025. doi: 10.3233/FAIA250529.

Year Three: Open Challenges

My third year will focus on:

- The validated D-DSS framework will be applied to **additional operational scenarios** to maximize fleet efficiency, also focusing on key subsystems.
- Transitioning the framework from **diagnostic** (what happened) to **prescriptive** (what to do).
- Developing Machine Learning Models to forecast **energy consumption** based on operational and environmental variables.
- Implementing optimization algorithms that use predictive models to suggest prescriptive actions.





Research products

[P1]	Montella L., Liu X., Monaco R., Murino T., Sieverts Nielsen P. "*An integrated multi-criteria decision making framework for industrial excess heat recovery and utilization*" Energy Volume 318, 2025
[P2]	Montella L., Ayokunle O. V., Salvi F. "*Healthcare System Approach for Implementing Risk Management Models Oriented to Patient Safety*" Lecture Notes in Bioengineering pp. 411 – 419, 2025
[P3]	Franzese G., Montella L., Murino T., Somma A., Strazzullo M. "*A Data-Driven Framework for the Evaluation of Autonomous and Traditional Berthing Maneuvers in Maritime Operations*" New Trends in Intelligent Software Methodologies, Tools and Techniques vol. 250, pp. 529–540, IOS Press, 2025
[P4]	Bottani E., Gallo M., Montella L., Murino T., Somma A. *«An order release approach to improve material usage efficiency in MTO contexts»* , **XXIX Summer School «*Francesco Turco*» «Sustainability and resilience in industrial systems across the era of digitalization»** 2024

Thanks for your attention!

Get in touch:

luisa.montella@unina.it

Questions?