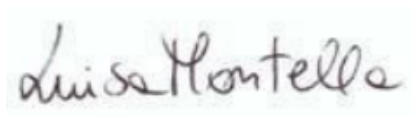

PhD in Information Technology and Electrical Engineering
Università degli Studi di Napoli Federico II

PhD Student: Luisa Montella

Cycle: XXXIX

Training and Research Activities Report

Year: First



Tutor: prof. Stefania Santini



Co-Tutor: prof. Teresa Murino (DICMaPI)

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

Date: October 31, 2024

Training and Research Activities Report

PhD in Information Technology and Electrical Engineering

Cycle: XXXIX

Author: Luisa Montella

1. Information:

- **PhD student:** Luisa Montella
- **DR number:** DR997219
- **Date of birth:** 24/07/1998
- **Master Science degree:** Management Engineering
University: University of Naples "Federico II"
- **Doctoral Cycle:** XXXIX
- **Scholarship type:** PNRR - DM 117, funding company: Grimaldi Euromed S.p.A.
- **Tutor:** prof. Stefania Santini
- **Co-tutor:** prof. Teresa Murino (DICMaPI), Eng. Dario Bocchetti (Grimaldi Euromed S.p.A.)
- **Nr. of months in company (Grimaldi Euromed S.p.A.):** 15
Nr. of months abroad: 6

2. Study and training activities:

Activity	Type ¹	Hours	Credits	Dates	Organizer	Certificate ²
"La Scorciatoia" - Futuro Remoto	Seminar	1.5	0.3	25/11/2023	Prof. Mario Di Bernardo	Y
AI for RAILS – Deep Learning for Railway Safety and Maintenance: Methodologies and Applications	Seminar	2	0.4	27/11/2023	Prof. Valeria Vittorini	N
Balancing-based model reduction for delay systems	Seminar	1.5	0.3	01/12/2023	Prof. Gabor Orosz (TDS)	Y
Adaptive Radar Detection	Seminar	1	0.2	06/12/2023	Prof. Antonio De Maio	Y
Ensemble optimal control problems governed by Boltzmann models	Seminar	1	0.2	07/12/2023	Prof. Mario Di Bernardo, Dr. Giacomo Ascione (SSM)	Y
Energy – Efficient Data Science	Seminar	1	0.2	13/12/2023	Prof. Elio Masciari	Y
Control Systems for Autonomous Ground Vehicles	Course	48	6	21/12/2023	Prof. Stefania Santini	Y

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PHD FRESHMEN CRUISE SCHOOL 2024 (ROME- BARCELONA)	Doctoral School	21	3	20/01/2024 – 23/01/2024	Prof. Roberto Revetria (UniGe)	Y
The role of second law of thermodynamics in the constitutive theories of materials	Seminar	1	0.2	25/01/2024	Prof. Mario Di Bernardo, Dr. Giacomo Ascione (SSM)	Y
Statistical Methods for Data Analysis	Course	20	3	29/01/2024	Prof. Massimilia no Villone	Y
What is emergent spacetime?	Seminar	1.5	0.3	01/02/2024	Prof. Mario Di Bernardo, Dr. Giacomo Ascione (SSM)	Y
Workshop “Hominis”	Seminar	5	1	21/02/2024	Prof. Carlo Sansone, Eng. Stefano Marrone	Y
ICT INDUSTRIAL TABLE – 32nd EACSL ANNUAL CONFERENCE ON COMPUTER SCIENCE LOGIC 2024	Seminar	5	1	23/02/2024	Prof. Aniello Murano	Y
Strategic Orientation for STEM Research & Writing 23/24	Course	24	5	27/02/2024	Dr. Chie Shin Fraser	Y
Where Data Meets Decisions: Combining data science and mathematical optimization	Seminar	1	0.2	05/03/2024	Jerry Yurchisin, Data Science Strategist, Gurobi	Y
Unresolved Anomalies and Tensions in the Standard Cosmolo gical Model	Seminar	1	0.2	14/03/2024	Prof. Mario Di Bernardo, Dr. Giacomo Ascione	Y

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					(SSM)	
Empowering Utilities: Sophisticated Approaches to Resilience and Reliability System Planning	Seminar	1	0.2	27/03/2024	Gurobi Optimization and Quanta Technology	Y
Dynamics with implicit state – dependent delay and post – Newtonian gravitational models	Seminar	1.5	0.3	05/04/2024	Prof. Gabor Orosz (TDS)	N
Analytic center selection of optimization-based controllers for robot ecology	Seminar	1	0.2	09/04/2024	Prof. Bruno Siciliano	Y
SINTEF Railway Optimization: Theory and Applications Confirmation	Seminar	1	0.2	16/04/2024	Gurobi Team	Y
Machine Learning the Universe with large astronomical surveys	Seminar	1	0.2	18/04/2024	Prof. Mario Di Bernardo, Dr. Giacomo Ascione (SSM)	Y
Statistical Data Analysis for Science and Engineering	Course	12	4	30/04/2024	Prof. Roberto Pietrantuono	Y
An overview of polytopal approximations of partial differential equations	Seminar	1	0.2	02/05/2024	Prof. Mario Di Bernardo, Dr. Giacomo Ascione (SSM)	Y
IEEE Authorship and Open Access Symposium: Tips and Best Practices to Get Published from IEEE Editors	Seminar	2	0.4	07/05/2024	Dr. Petar Popovski, IEEE Xplore Team	Y
Machine Deception	Seminar	1	0.2	23/05/2024	Prof. Alessandra Rossi,	Y

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					ICTH	
Sustainable IT: Strategies and Best Practices for a Green Engineering Future	Seminar	5	1	27/05/2024	Prof. A. Curcio, 5G Academy	Y
Using Deep Learning properly	Course	12	4	31/05/2024	Andrea Apicella, PhD	Y
Social Network Analysis: Methods and Applications	Seminar	2	0.4	07/06/2024	Prof. Giancarlo Sperli	Y
Introduction to Large Language Models: Evolution and the current state	Seminar	2	0.4	10/06/2024	Prof. Giancarlo Sperli	Y
Innovation and Entrepreneurship	Course	12	4	11/07/2024	Prof. Pierluigi Rippa	Y
Operations Management affects all of us	Seminar	2	0.4	23/07/2024	Prof. Alberto Portioli, prof. Matteo Rossini (PoliMi – Management Engineering Department)	N
From ACE Technologies to Sustainable, Accessible and Equitable Urban Mobility: An Optimization Journey	Seminar	2	0.4	16/09/2024	Prof. Stefania Santini	Y

1) Courses, Seminar, Doctoral School, Research, Tutorship

2) Choose: Y or N

2.1. Study and training activities - credits earned

	Courses	Seminars	Research	Tutorship	Total
Bimonth 1	6	1.6	2.4	0	10
Bimonth 2	11	2.5	0	0	13.5
Bimonth 3	4	1.5	4.5	0	10
Bimonth 4	4	2.6	3.4	0	10

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Bimonth 5	4	0.2	5.8	0	10
Bimonth 6	0	0.4	9.6	0	10
Total	29	8.8	22.2	0	63.5
Expected	30 - 70	10 - 30	80 - 140	0 - 4.8	

3. Research activity:

The maritime sector is a significant contributor to global pollution, responsible for approximately 3% of worldwide CO₂ emissions from energy-related sources and emitting over one billion metric tons of CO₂ each year. This underscores an urgent need for sustainable practices [1]. Various measures have been implemented by shipping companies to reduce emissions, particularly addressing the high CO₂ and NO_x emissions linked to conventional fuel consumption. In this regard, [2] assesses the potential CO₂ reduction achievable through a range of energy efficiency measures adopted across the sector. Some of these initiatives, like hybrid power and propulsion systems, including waste heat recovery, can achieve up to a 45% reduction in CO₂ emissions; while others, such as speed and voyage optimization strategies can deliver up to a 60% reduction.

Another effective strategy within these sustainability measures is the integration of renewable energy sources (RESs), such as wind, solar, and sea wave energy, alongside digitalization and ICT advancements, with a potential of CO₂ emissions reduction of up to 50%. This combination enhances fuel efficiency and reduces the environmental footprint of marine vessels. Although several studies have focused on incorporating energy storage systems (ESSs) alone [3, 4], this research aims to integrate both RESs and ESSs within shipboard power systems (SPSs). This dual approach maximizes the environmental benefits by enhancing flexibility and reducing emissions across different operating conditions.

To effectively harness power from these zero-emission sources, SPSs are conceptualized as islanded smart microgrids (MGs) that integrate multiple energy sources. This aligns with recent technological advancements, where traditional generation systems (e.g., diesel generators) are combined with ESSs and RESs [5, 6]. These systems not only enhance flexibility in power distribution among hybrid sources but also contribute significantly to emission reductions during ship operations. However, SMGs in maritime environments face unique challenges, such as fluctuating power demands due to varying routes and renewable energy availability, especially in harsh maritime conditions.

To address these challenges, an efficient Power Management System (PMS) or Energy Management System (EMS) is essential. These systems employ advanced scheduling algorithms and control methods to ensure reliable power distribution from RESs, optimize ESS performance, and adapt to variable load conditions, thus achieving a resilient and adaptable energy system. This approach not only boosts operational efficiency but also reduces emissions, ultimately delivering a highly efficient, sustainable, and cost-effective power solution for ship operations [7].

The goal is to tailor distributed control strategies to smart SPS frameworks, enhancing system flexibility and robustness ensuring resilience against uncertainties. This approach enables cooperative management

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of ships equipped with diverse energy sources. *Multi-Agent Systems (MASs)*, *distributed control approaches*, and the establishment of suitable *key performance indicators (KPIs)* will support real-time monitoring and analysis of SPS behaviour, providing an overall assessment of performance in terms of energy efficiency and environmental impact reduction.

This research also aligns with the International Maritime Organization's (IMO) sustainability targets, including: 40% reduction in carbon intensity by 2030, introduction of zero or near-zero GHG emission technologies, aiming for 5-10% of energy usage on ships by 2030, 50% reduction of greenhouse gas (GHG) emissions by 2050, relative to 2008 levels [8].

References:

- [1] Li, C., Othman, M., Ahamad, N. B., & Molinas, M. (2022). Marine Integrated Energy Microgrids. *2022 International Conference on Renewable Energies and Smart Technologies, REST 2022*, Tirana. <https://doi.org/10.1109/REST54687.2022.10022621>
- [2] Bouman, E. A., Lindstad, E., Rialland, A. I., & Strømman, A. H. (2017). State-of-the-art technologies, measures, and potential for reducing GHG emissions from shipping – A review. *Transportation Research Part D: Transport and Environment*, 52, 408–421. <https://doi.org/10.1016/j.trd.2017.03.022>
- [3] Rinaldi, G., Baby, D. K., & Menon, P. P. (2024). Optimal Observer-Based Power Imbalance Allocation for Frequency Regulation in Shipboard Microgrids. *Energies*, 17(7), 1703. <https://doi.org/10.3390/en17071703>
- [4] Luo, Y., Kong, L., Fang, S., Shu, Y., Niu, T., Chen, G., & Liao, R. (2024). Reviews on the power management for shipboard energy storage systems. *Sustainable Horizons*, 9, 100094. <https://doi.org/10.1016/j.horiz.2024.100094>
- [5] Guerrero, J. M., Jin, Z., Liu, W., Othman, M. B., Savaghebi, M., Anvari-Moghaddam, A., Meng, L., & Vasquez, J. C. (2016). Shipboard microgrids: maritime islanded power systems technologies. *PCIM Asia 2016 - International Exhibition and Conference for Power Electronics, Intelligent Motion, Renewable Energy and Energy Management*, 2016.
- [6] Gheisarnejad, M., Khooban, M. H., & Dragicevic, T. (2020). The Future 5G Network-Based Secondary Load Frequency Control in Shipboard Microgrids. *IEEE Journal of Emerging and Selected Topics in Power Electronics*, 8(1), 836–844. <https://doi.org/10.1109/JESTPE.2019.2898854>
- [7] Xie, P., Guerrero, J. M., Tan, S., Bazmohammadi, N., Vasquez, J. C., Mehrzadi, M., & Al-Turki, Y. (2022). Optimization-Based Power and Energy Management System in Shipboard Microgrid: A Review. *IEEE Systems Journal*, 16(1), 578–590. <https://doi.org/10.1109/JSYST.2020.3047673>
- [8] Akac, A., Anagnostopoulou, A., & Kappatos, V. (2023). Evaluation of maritime industry compliance with existing environmental regulations – A benchmarking assessment from energy

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efficiency perspective. E3S Web of Conferences, 436, 05002.
<https://doi.org/10.1051/E3SCONF/202343605002>

4. Research products

[1] 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

(To be published)

5. Conferences and seminars attended

- XIVth Conference on Stochastic Models of Manufacturing and Service Operations, SMMSO 2024, June 9 – 14, 2024, Naples, Italy
- Logistics & Lean Engineering for Advanced Healthcare Methodologies Modelling, LLEAHMM, Naples, Italy, 2024, October 10 – 12

6. Activity abroad

7. Activity in partner companies:

The partner company is Grimaldi Euromed S.p.A. The number of months to be spent in the company is 15, and the first agreed planned period 01/12/2023 – 01/08/2024 has been completed.

During this period, a comprehensive introduction to the maritime industry was provided, highlighting the sector's environmental challenges, as well as the specific solutions implemented by the company to reduce its environmental impact. Initial activities included familiarization with the types of data collected by the company, the methodologies and tools used for data acquisition, and a review of company reports generated from this data. This allowed for the identification of key operational parameters that affect fuel consumption and energy efficiency. Additionally, active participation in corporate meetings and activities facilitated an understanding of the company's decarbonization efforts, emission reduction strategies, and fleet sustainability initiatives. Onboard visits further enabled a close examination of propulsion systems and engines, supporting a technical understanding of the ships' operational mechanics and the specific challenges faced. These activities provided a comprehensive understanding of the company's commitment to sustainability through data-driven strategies and continuous improvements in environmental performance within the maritime sector.

8. Tutorship