DIPARTIMENTO di INGEGNERIA

LA RICERCA DENTRO UNIME

samothrace
Sicilian Micro and Nano Technology Research and Innovation Center

MEB
MESSINA ENERGY BOAT

Technologies and onboard monitoring systems for green boat into a context of sustainable and safe mobility for supporting the digitalization of the maritime transportation.

Supervisor: Vincenzo Crupi

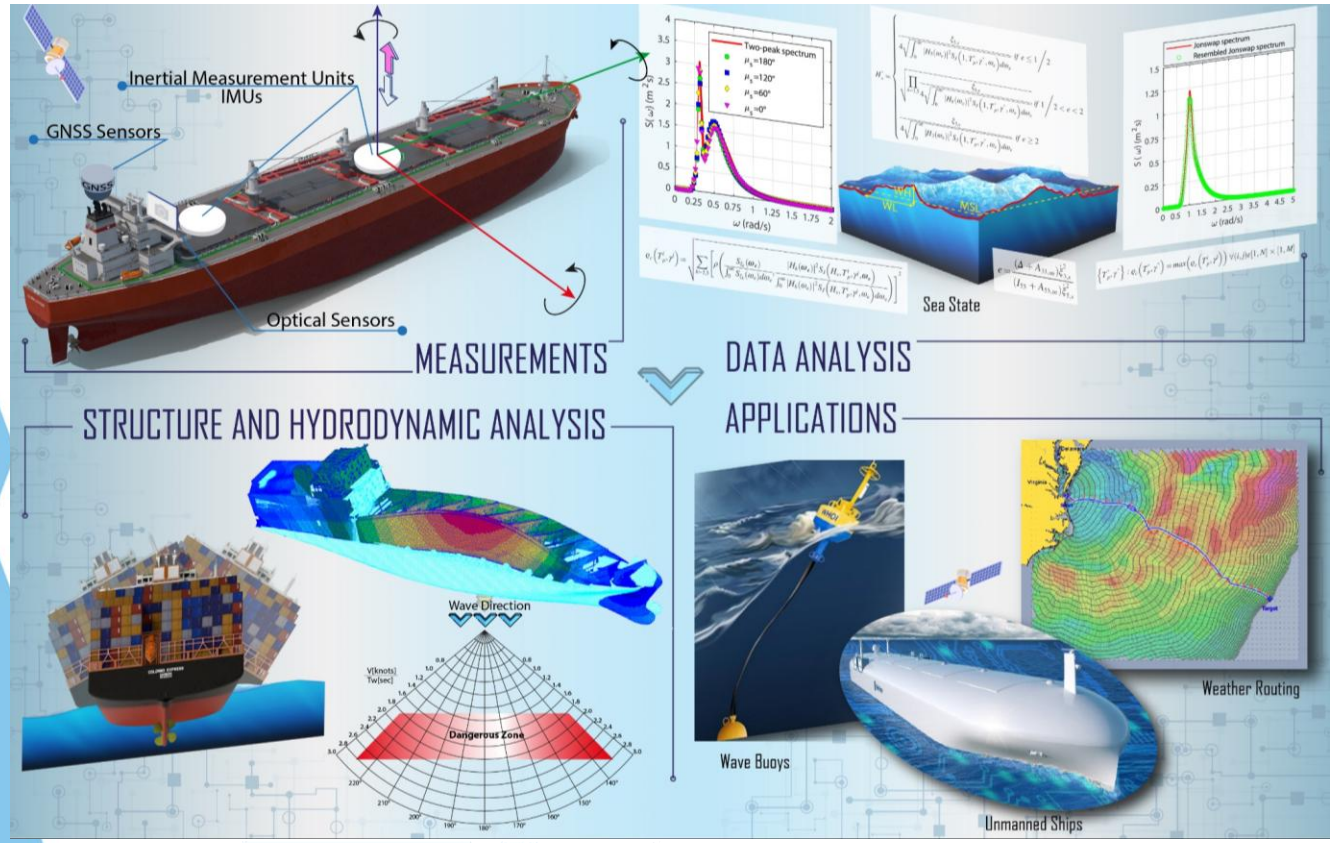
PhD Student: Giovanni Briguglio

SUSTAINABLE MARITIME MOBILITY

SAMOTHRACE - PNRR Ecosistemi per l'innovazione –
Foundation Sicilian Micro and Nano Technology Research and Innovation Center. PROJECT ECS00000022.

WP4 SMART MOBILITY

Task 4.2: Applications of sensors for sustainable, safe and intermodal mobility



Messina Energy Boat prototype is an example of smart green boat equipped with onboard sensors in order to pursue the path of the digitalization of the seas perfectly dealing with **Task. 4.2 goals** of the Samothrace project.

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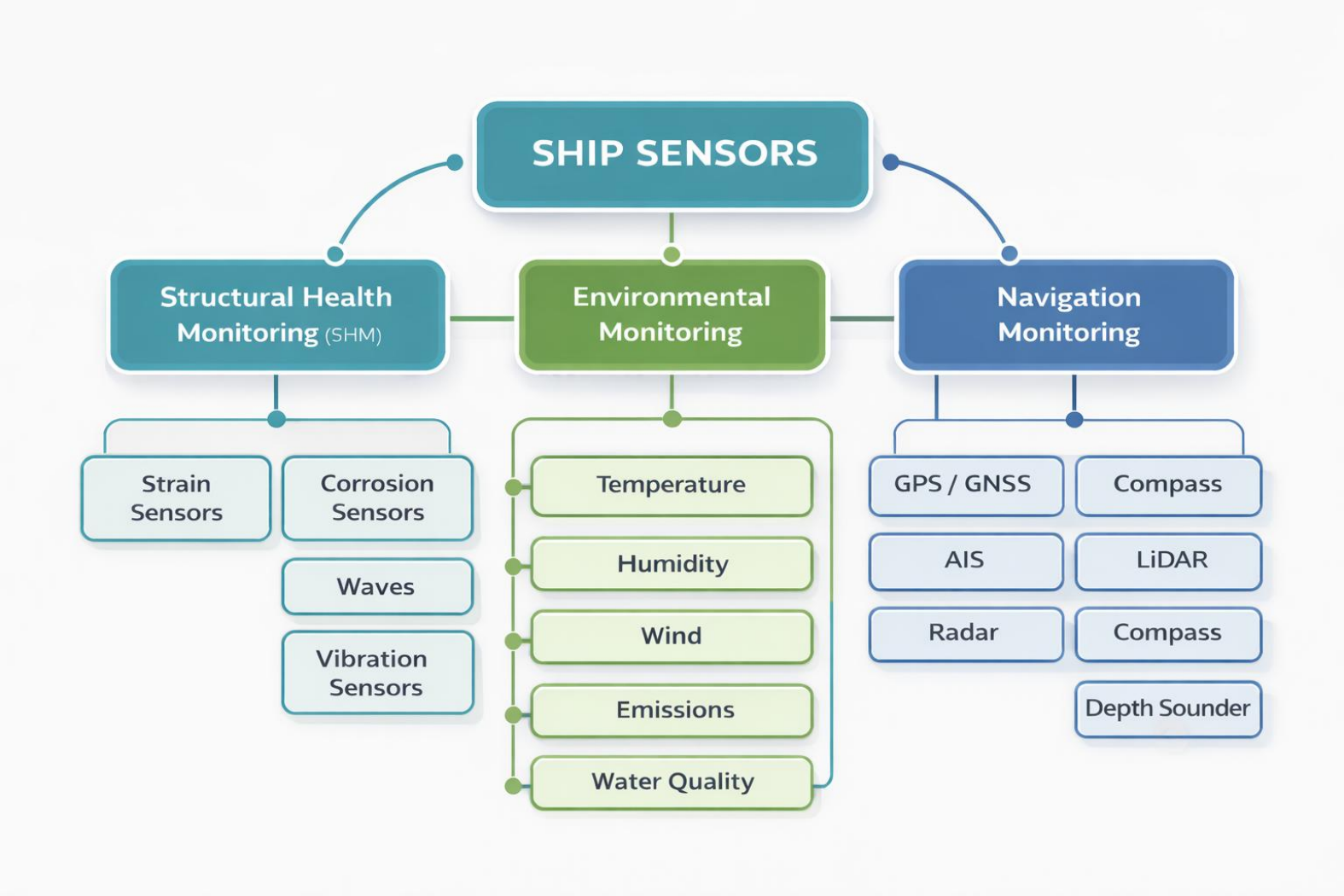
Ministero dell'Università e della Ricerca

Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA

12 gennaio 2026

Sea Digitalization

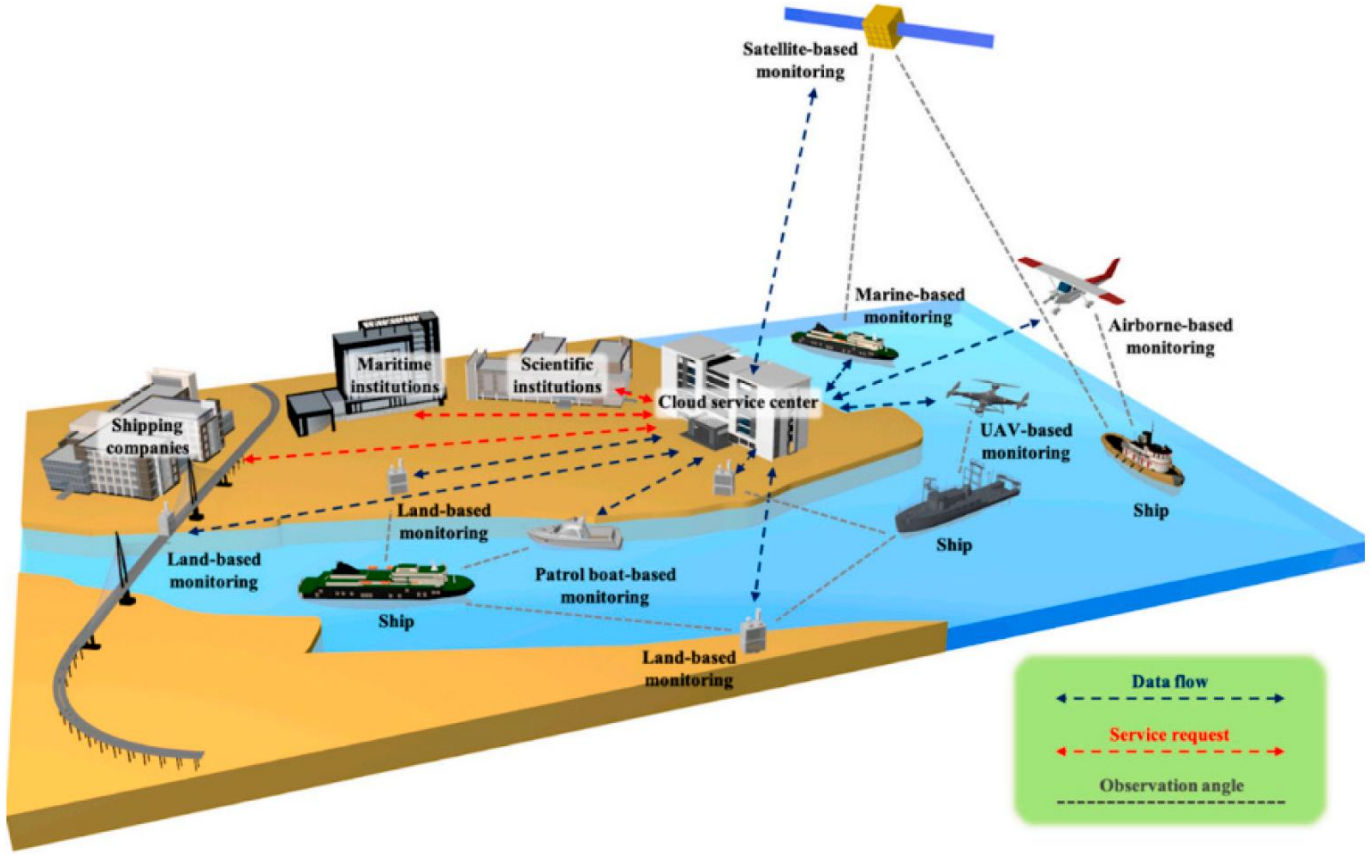


The integration of several multi-purpose sensors can guarantee the development of robust forecasts algorithms for influencing different parameters that rule energy efficiency and the safety of a certain route.

Sensors Fusion

Processing multi-modal data is essential for accurate forecasting in dynamic environments such as ships.

Sea digitalization is a promising path to pursue in order to achieve different improvements in terms of navigation safety and greenhouse gas emission reduction.



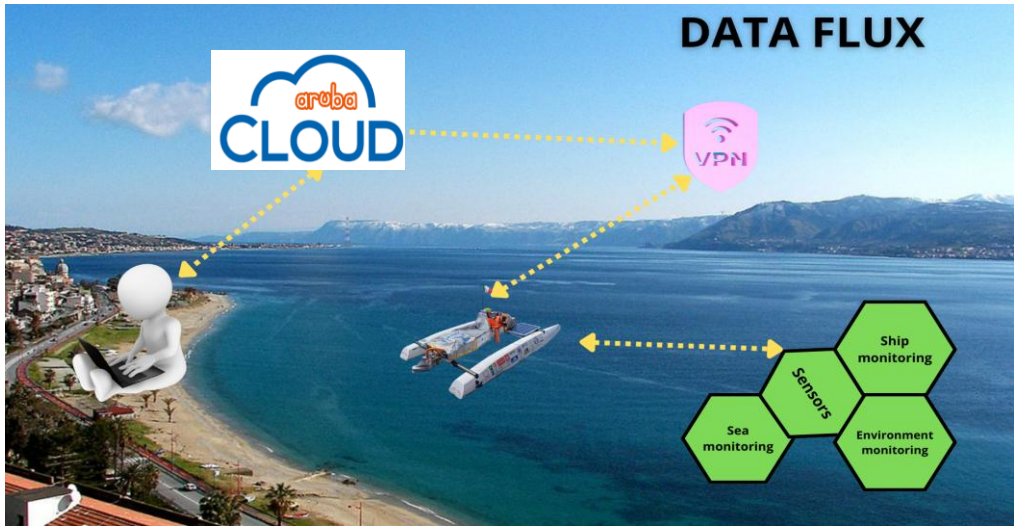
G. Briguglio, V Crupi. "**Review on Sensors for Sustainable and Safe Maritime Mobility**" Journal of Marine Science and Engineering, Vol. 12, Article 353, 2024. ISSN: 2077-1312, DOI: 10.3390/jmse12020353. Codice scopus: 2-s2.0-85187253866. Codice ISI: WOS:001171836600001

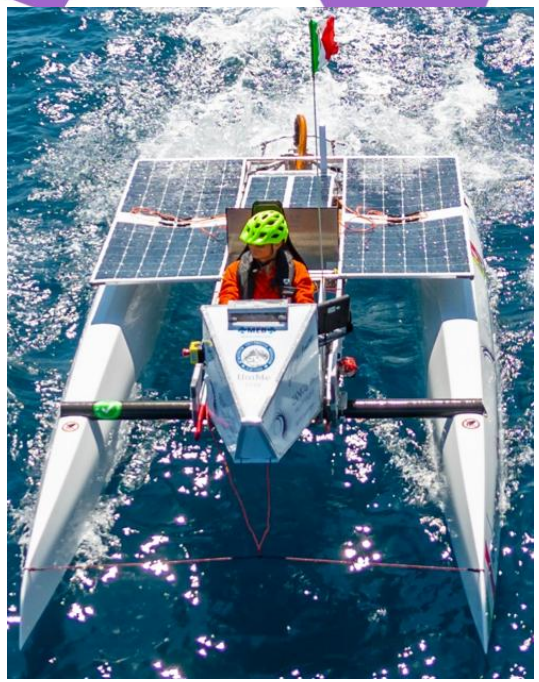
MEB – Case study

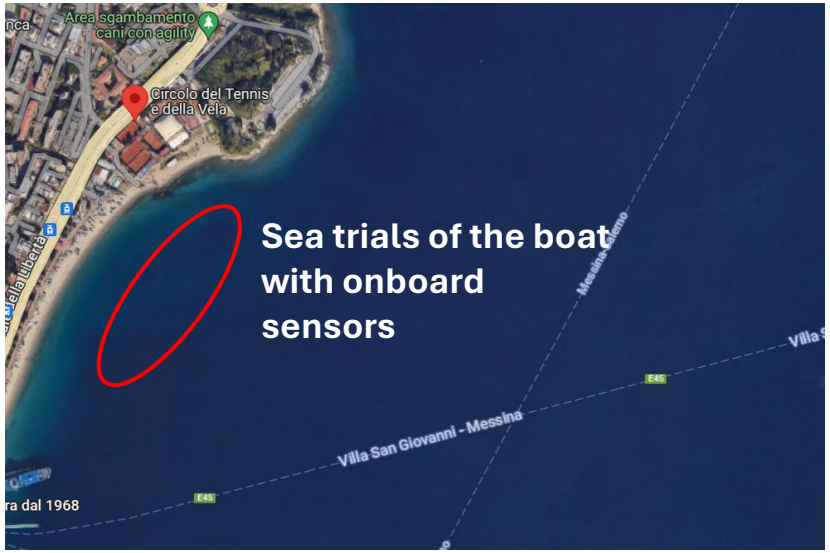
A racing catamaran with electric propulsion was developed over a three-year period. The vessel participated in three editions of the Monaco Energy Boat Challenge, achieving 4th, 5th, and 7th place among 20 international competitors.

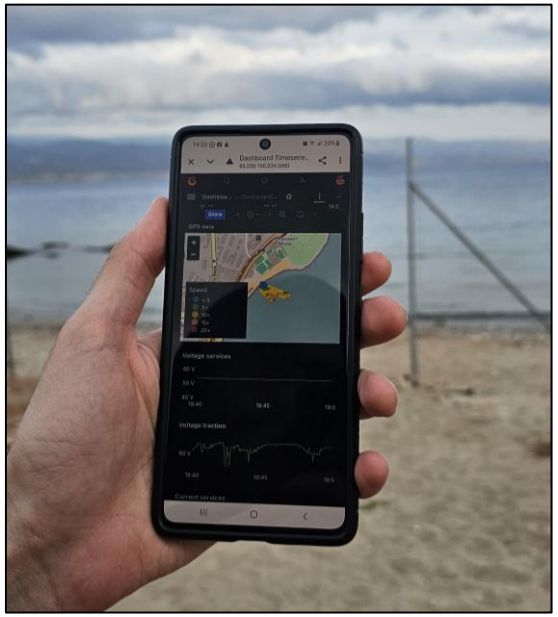
The catamaran is also a harvesting mobile laboratory to gather information and study a wide range of marine phenomena.

MEB – Case study





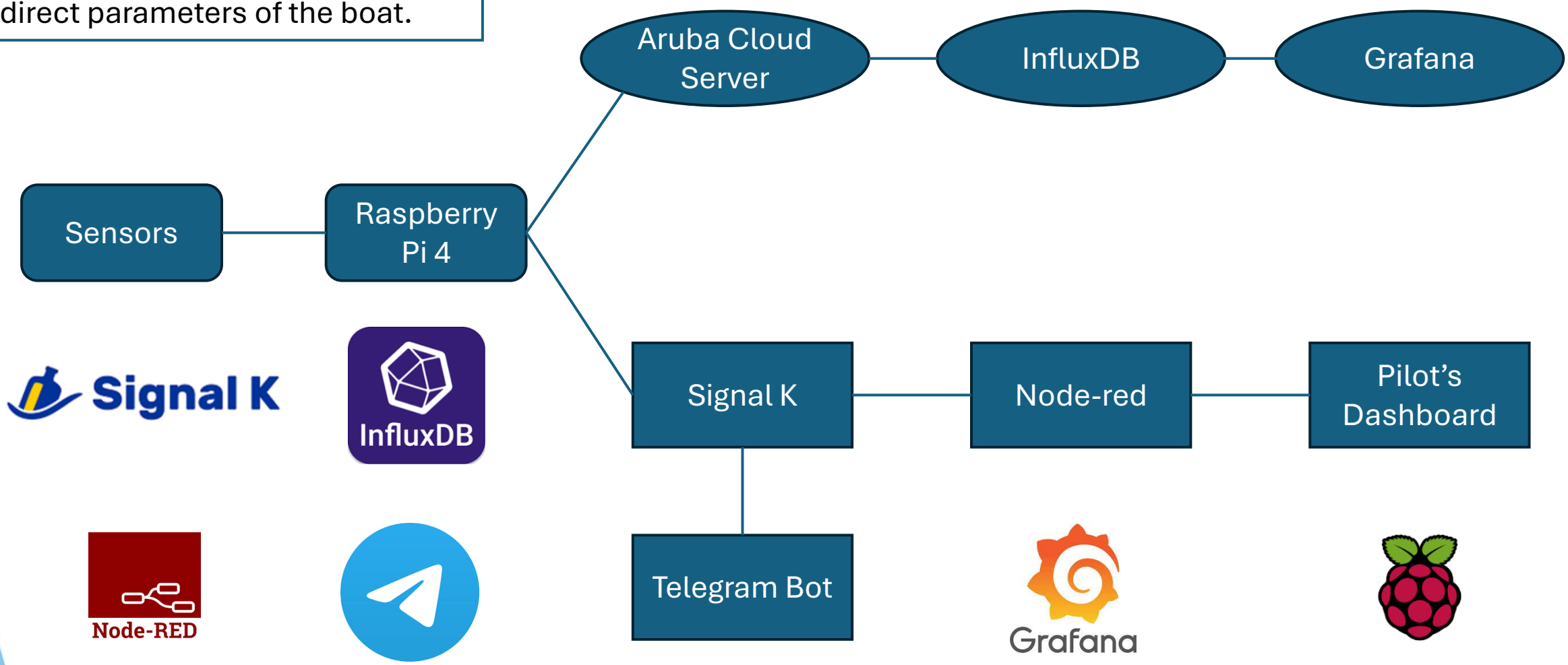




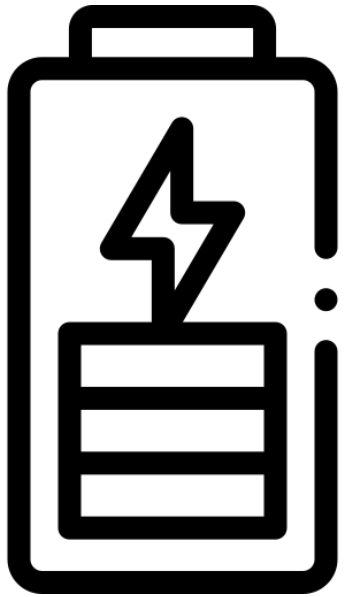
V. Crupi, **G. Briguglio**, D. Saraniti, M. Villari "**Green boat monitoring for sea digitalization**". SPEEDAM 2024, 27th International Symposium on Power Electronics, Electrical Drives, Automation and Motion, pp. 1242-1247, Ischia (NA), 19-21 June 2024. ISBN: 979-835038759-9. DOI: 10.1109/SPEEDAM61530.2024.10609066. Codice scopus: 2-s2.0-85201732703

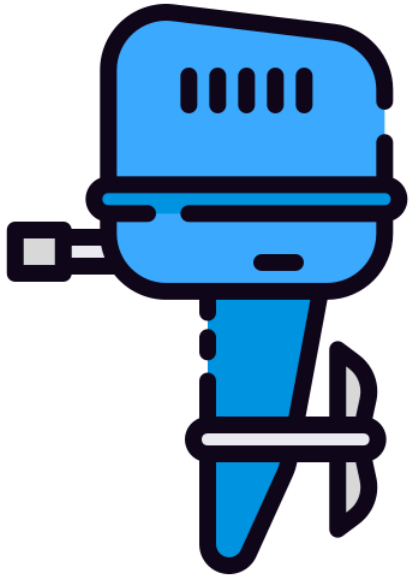
MEB - Digital Architecture system

All sensors are connected to a Raspberry Pi4 that allows a real time monitor of all direct and indirect parameters of the boat.



MEB - Digital Architecture system

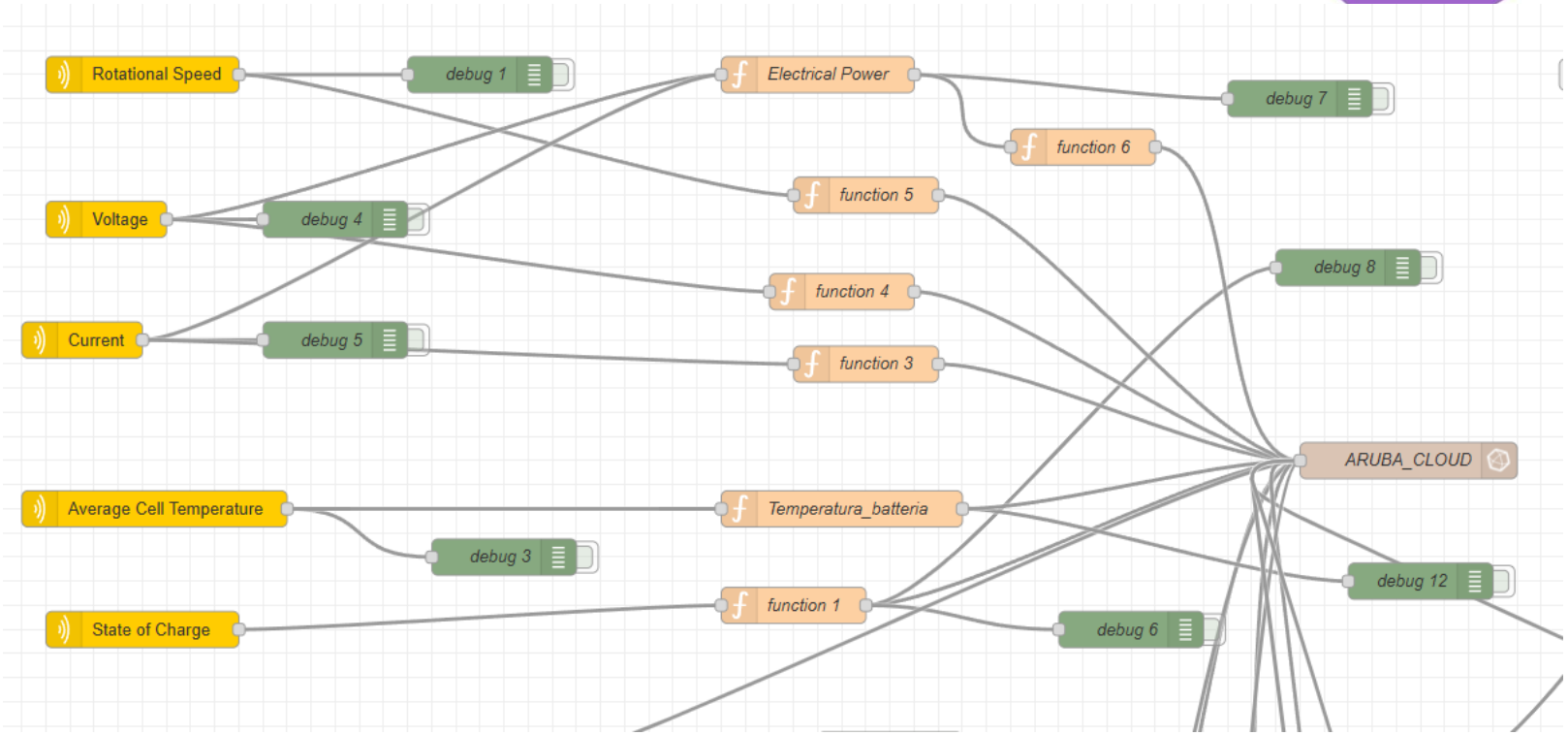




Signal K

Signal K is an **open, marine data standard** designed to **share, stream, and integrate data from onboard boat sensors and systems** in a modern, flexible way. It can integrate NMEA 2000 and CANBus standards for communicating with modern systems interfaces. It is useful for harvesting data such as, motor power, discharge current, battery voltage, temperatures, stare of charge.

MEB - Digital Architecture system



Node-RED

Node-RED is an **open-source, flow-based programming tool** used to **connect devices, APIs, and services** by wiring together visual blocks (called *nodes*). It is integrated into the Signal K architecture and can directly receive Data Browser's data. Sea-weather parameters are taken from free API services with http requests.

MEB - Digital Architecture system – Sea trials

Grafana is a **data visualization and monitoring platform** used to create: interactive dashboards,time-series charts, real-time monitoring panels. **InfluxDB** is a **time-series database** designed to store and manage data. Picture above shows sea trials data from Tennis and Vela area in Messina.

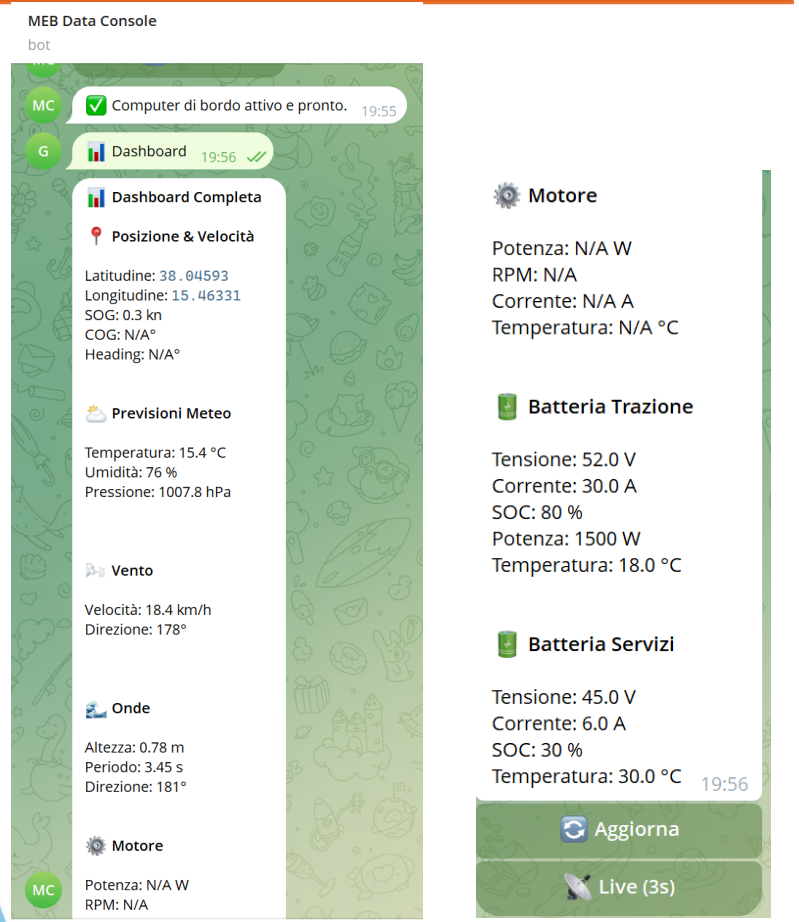
MEB - Digital Architecture system – Sea trials

Grafana

InfluxDB

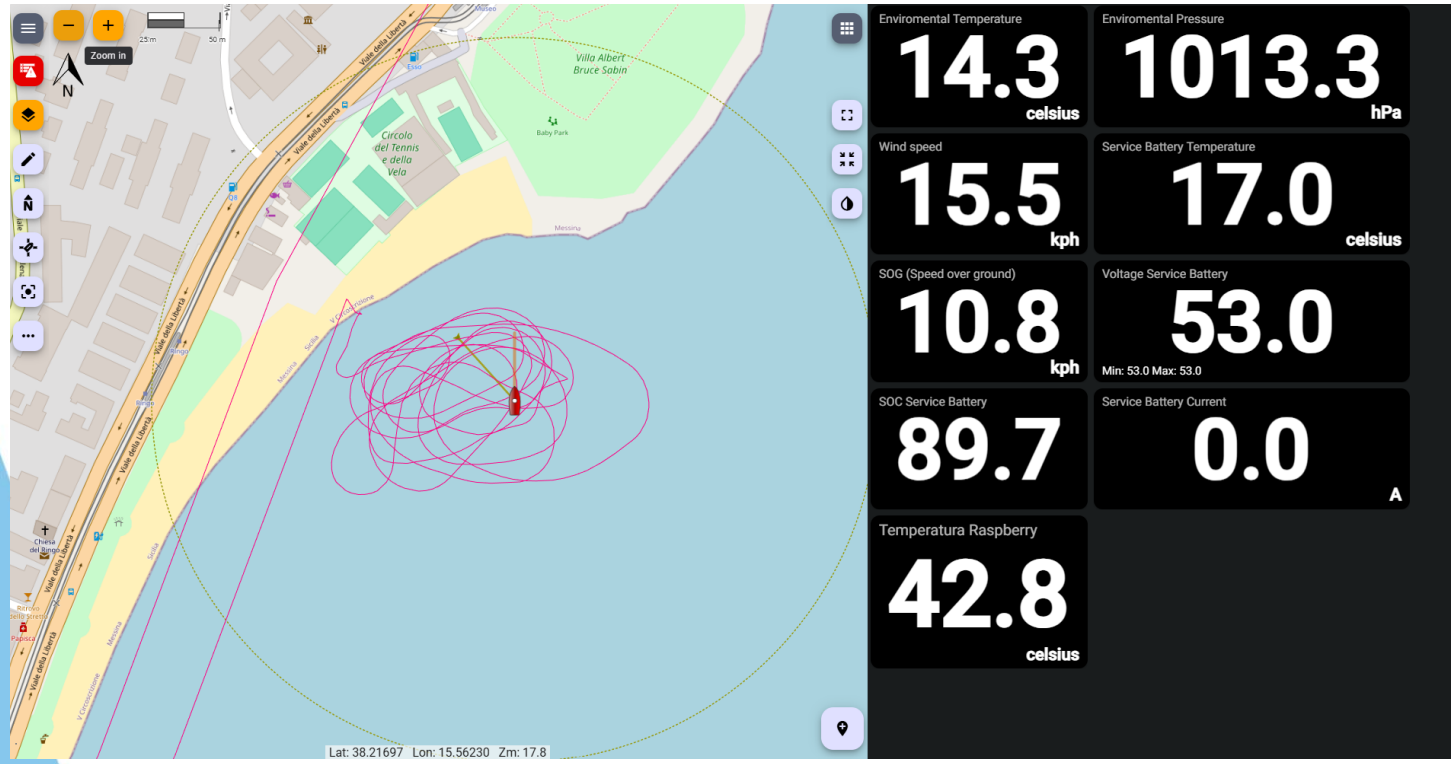
All sea trials conducted in the Messina Strait area were useful for creating multiple datasets representing different marine phenomena, which may be used to develop algorithms for optimal route planning by optimizing one or more parameters.

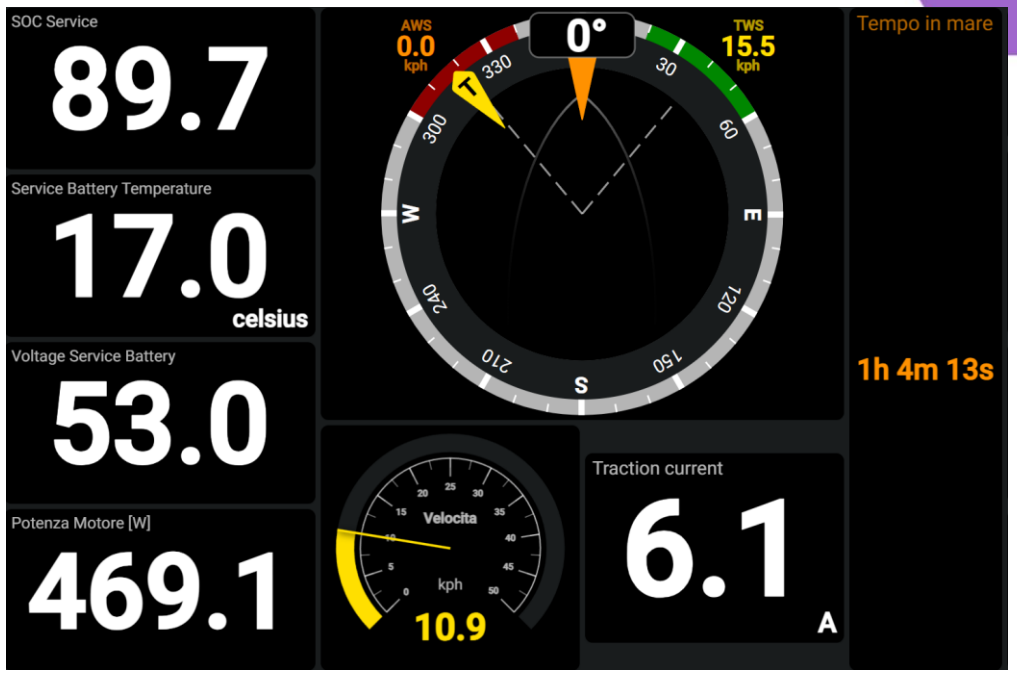
MEB Digital Architecture system – Telegram Bot



A Signal K plugin that provides to the pilot an interactive map showing real time sea-weather was developed and integrated with a Telegram Bot for allowing to multi authorized users to monitor boat's performance during sea trials/races.

MEB Digital Architecture system - Dashboards





KIP 9.8 Signal K

KIP Signal K tool was also used for realizing real time interactive dashboards integrating all propulsion and environmental parameters.

MEB Digital Architecture system – Telegram Bot

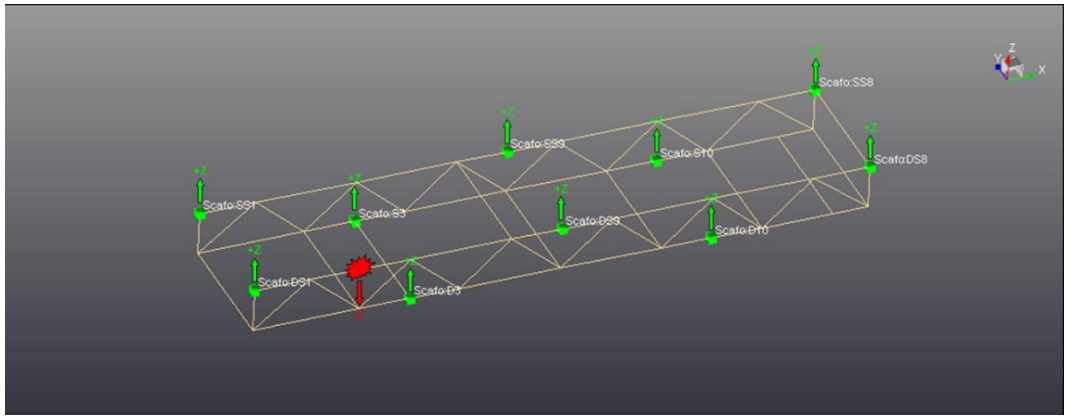
The bot uses a **token-based authentication architecture** that restricts access to authorized users only. Access tokens are issued by the host system and regenerated on first login, then permanently bound to a single Telegram chat ID to prevent reuse and improve security.

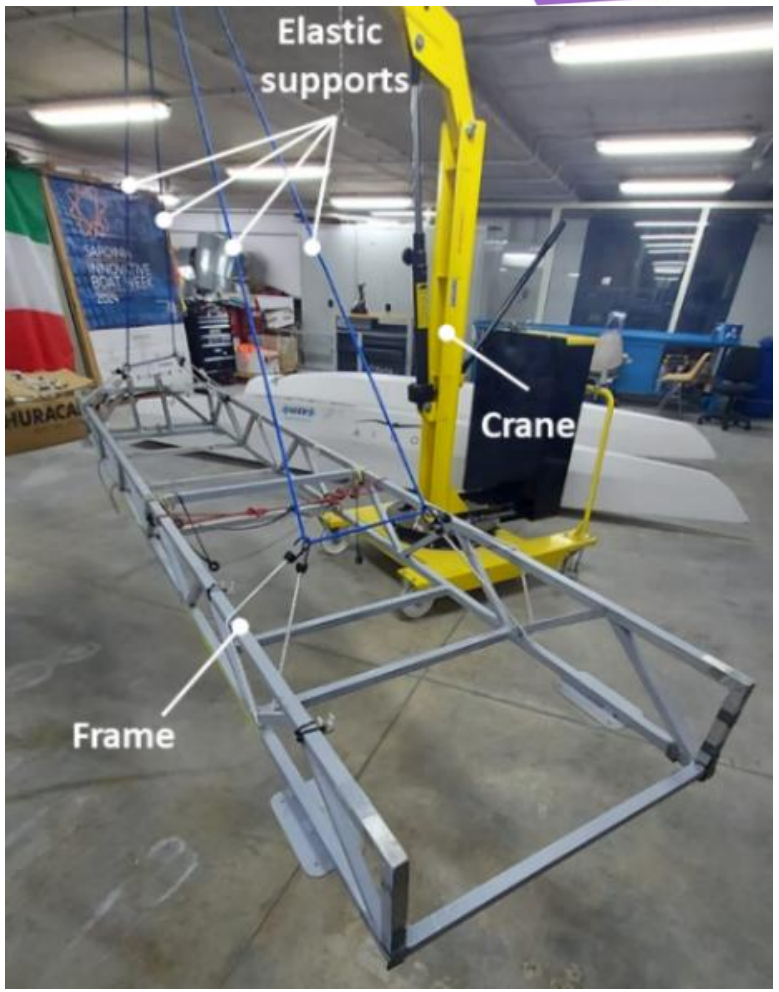
Once authenticated, users can access real-time and live-updating dashboards displaying navigation, environmental, propulsion, and electrical data, including position, weather conditions, motor status, and battery systems (traction and service batteries).

Logs are structured with explicit headers, making them suitable for **machine learning and time-series analysis**.

MEB – FEM and EMA (Experimental Modal Analysis)

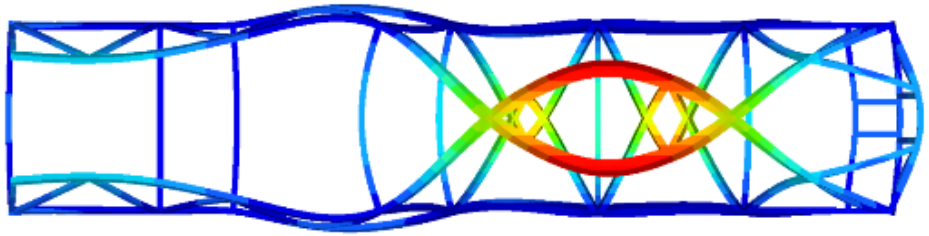
The modal behaviour of 2024 prototype's frame was investigated conducting a multi-method approach: a preliminary finite element model analysis (FEM) was performed to evaluate numerically modal parameters such as: resonance frequencies, damping and mode shapes. An experimental modal analysis (EMA) was conducted into the Department of Engineering laboratories to assess the numerical model. An excellent correspondence between the two methodologies was observed



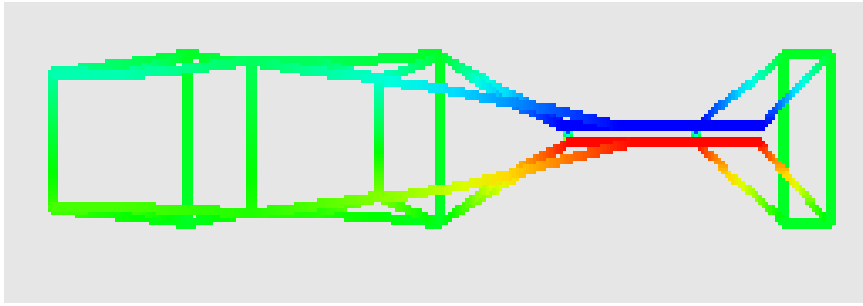


MEB – FEM and EMA (Experimental Modal Analysis) results

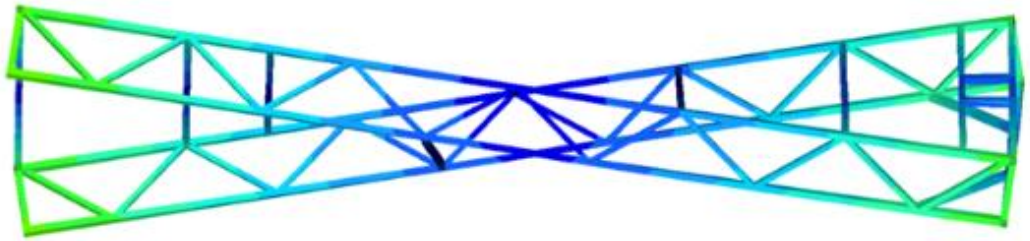
FEM 77.3 Hz (Transversal Divergent closed side)



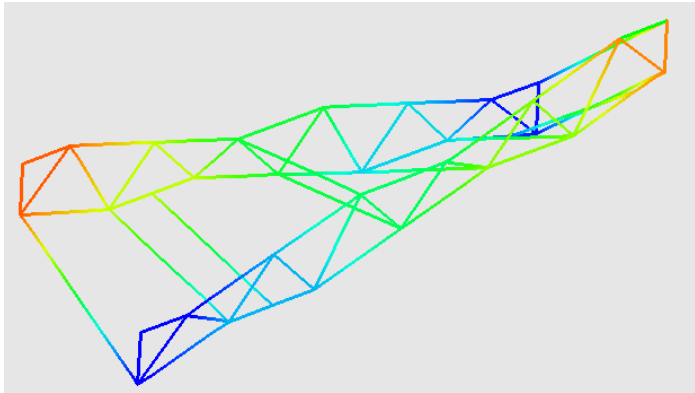
EMA 79.4 Hz (Transversal Divergent closed side)



FEM 16,1 Hz (Torsional)

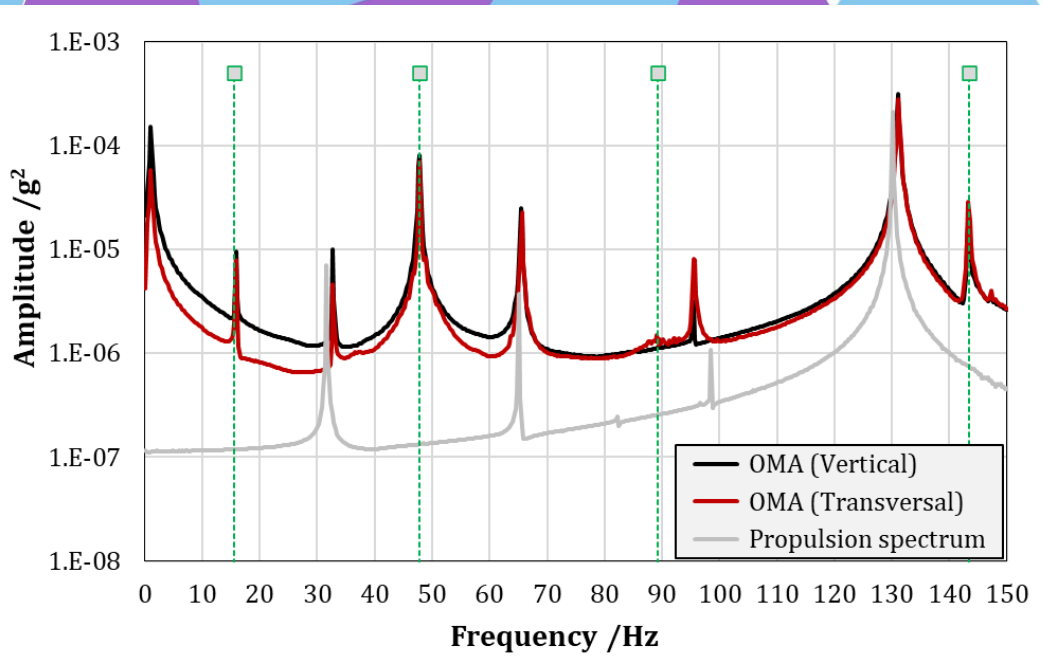


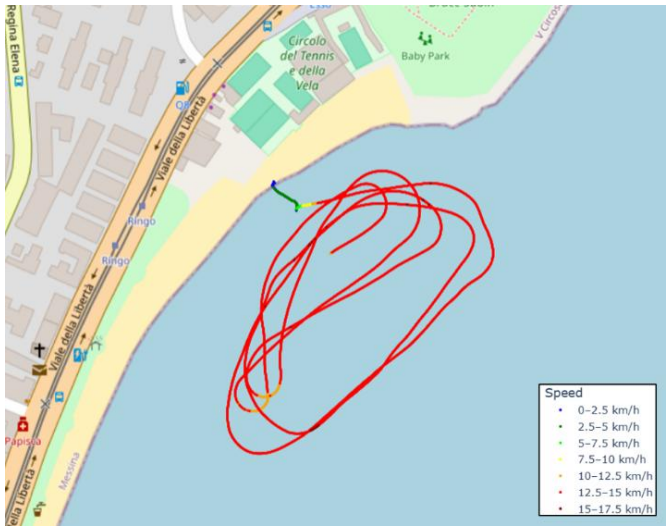
EMA 16.3 Hz (Torsional)



MEB – OMA (Operational Modal Analysis)

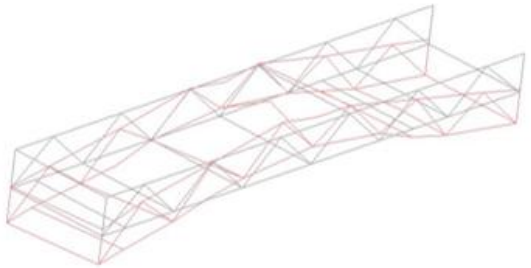
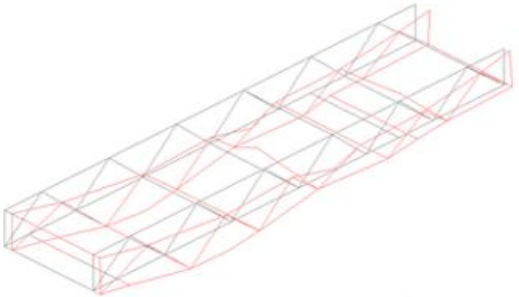
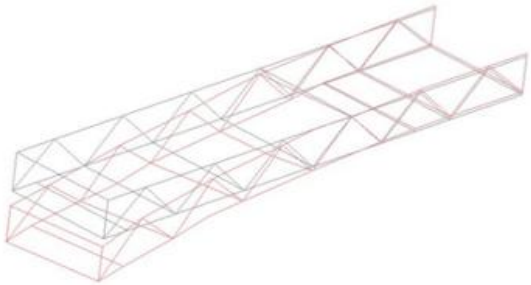
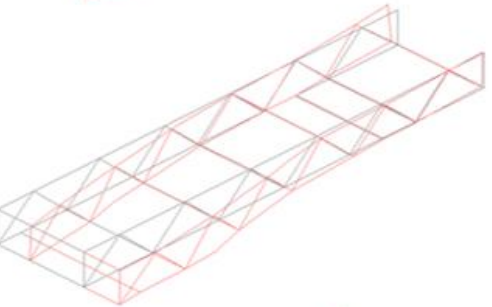
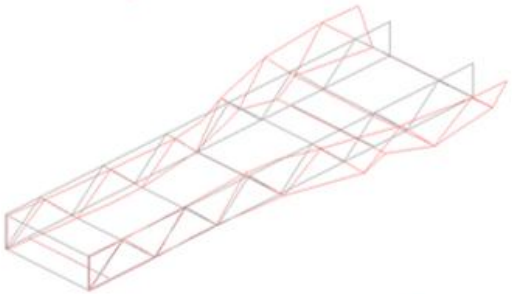
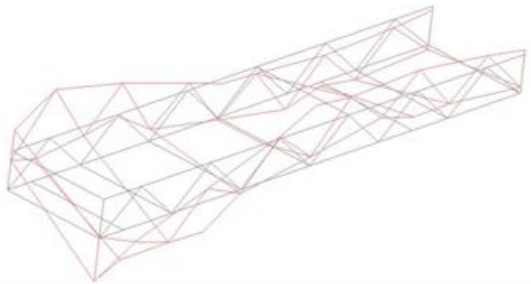
In order to harvest crucial data about the operative modal behaviour of the investigated structure it was necessary to conduct an operational modal analysis (OMA) into the Messina's strait area equipping the frame with several accelerometers connected to a Simens SCADAS-RS acquisition system to collect acceleration signals that were postprocessed for obtaining structure's mode shapes. During sea trials a set of rosette strain gauges were placed in the most critical places according FEM's results for granting a structural health monitoring activity and at the same time getting essential strain data to validate FEM model.





MEB – Operational Modal Analysis

This study confirms how the **OMA** could be employed on vessels to recognize modal parameters. In this way it will be possible to get modal parameters of the real operating ship in real time without isolating structural components for further investigations into the laboratory. The application of FEM, EMA and OMA can show how more the mass distribution conditions are similar to the laboratory conditions more are comparable the results.

Natural Frequency [Hz]	Mode shape	
	OMA - Vertical	OMA - Transversal
15.6		
47.8		
89.2	N/A	
143.4		

G. Briguglio, V. Crupi, F. Distefano, F. Freni, R. Montanini, "**Modal Analysis of a Catamaran Cockpit: Numerical Models, Experimental Tests and Sea Trials**". Progress in Marine Science and Technology, NAV 2025, 21st International Conference on Ships and Maritime Research, pp. 921–928, Messina, 18–20 June 2025. ISBN: 978-164368610-3. DOI: 10.3233/PMST250110. Codice Scopus: 2-s2.0-105016125671.

THANKS FOR THE ATTENTION