H.F.R.I.
Hellenic Foundation for Research & Innovation

Description of funded research project

1st Call for H.F.R.I. Research Projects in Support of Faculty Members & Researchers and for the Procurement of High-Value Research Equipment

Title of the research project:

Intelligent adaptive-controllable alignment in marine propulsion systems for performance optimization and failure prevention

Principal Investigator: Christos Papadopoulos, Associate Professor NTUA

Reader-friendly title: i-MARINE

Scientific Area: Engineering Science & Technology / Naval Engineering

Institution Country: Greece

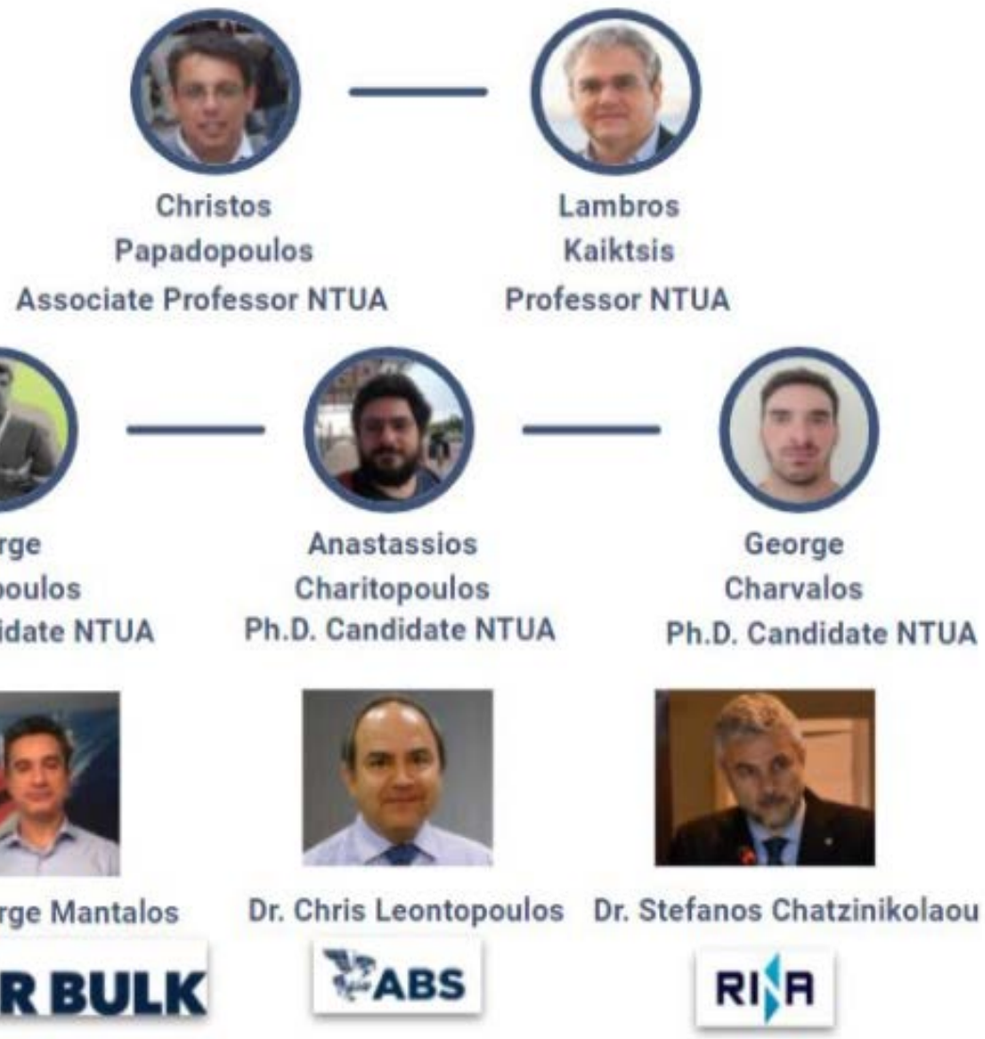
Host Institution:
National Technical University of Athens

Collaborating Institutions:
NTUA, ABS, RINA, STAR BULK

Project webpage: *i-marine.naval.ntua.gr*

Budget: €190,000.00

Duration: 36 months



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Research Project Synopsis

"**i-MARINE**" aims at developing and applying computational and experimental tools for introducing smart components in the propulsion system of commercial passenger and cargo vessels. The vision of "**i-MARINE**" is the research and development of the required technology for transforming a conventional propulsion shaft arrangement, presently characterized by sub-optimal performance, low adaptivity to operational/weather conditions and aging, as well as lack of fail-safe mechanisms, into an **intelligent, controllable and adaptive** system, capable of sensing component status, controling system performance and reacting in the case of critical behavior. A critical failure in the shafting system leads inevitably to a runaway situation, with enormous cost and substantial risk of life and property at sea. "**i-MARINE**" will enable vessels to avoid large-scale damages and to survive small-scale damages in bearings by properly adjusting the shafting system. The project **innovation** lies in putting the design focus on the actual operational profile of the shafting system, and in introducing cutting-edge technology tools, in terms of (a) advanced numerical simulation methods for modeling the behavior of the ship hull, the propulsion shaft and the bearings, (b) intelligent sensors, data acquisition and data processing for determining the present condition of the system components, and (c) adaptive control techniques to adjust operational parameters of the system for optimal response. The **goals** of "**i-MARINE**" will be achieved in a holistic manner, by studying the entire propulsion train, from the main engine to the vessel propeller, taking into consideration the different conditions throughout the vessel. **Implementation** of the project's results in marine propulsion systems is expected to have a significant impact on the **economic and environmental efficiency** of vessels, by minimizing power losses, fuel consumption and exhaust gas emissions, and substantially **increasing reliability**, decreasing failure rates and the corresponding costs, thus improving the overall vessel performance, in comparison to conventional designs.

Project Originality

"**i-MARINE**" aims at developing and applying computational and experimental tools for the introduction of smart components in the propulsion system of commercial passenger and cargo vessels. The **vision** of "**i-MARINE**" is to develop the required technology for transforming a conventional propulsion shaft arrangement, presently characterized by sub-optimal performance, low adaptivity to operational/weather conditions and aging, as well as lack of fail-safe mechanisms, into an **intelligent, controllable and adaptive system**, capable of sensing component status, controlling system performance and reacting in cases of critical behavior.

The innovation of the project lies in putting the design focus on the actual operational profile of the shafting system, and on introducing cutting-edge technology tools, in terms of (a) advanced numerical simulation methods, for modeling the behavior of the ship hull, the propulsion shaft and the bearings, (b) intelligent sensors, data acquisition and data processing, for determining the current condition of the system components in operation, and (c) adaptive control techniques, to adjust design and operational parameters of the system for optimal response.

The **key objectives** of the project are: **(i)** increased **reliability** and **safety** of the vessel, **(ii)** high **economical** and **environmental** efficiency of the vessel, and **(iii)** reduction of failure, maintenance and replacement costs related to shaft/bearing damage, in comparison to the conventional designs used at present. On these grounds, a main focus of "**i-MARINE**" is to detect and analyze the state of the shaft and the bearings in real time, predict abnormal conditions, alert the crew, and provide mitigation actions to safeguard a continuous safe system operation.

Expected Results & Project Impact

Research-scientific impact: (**a**) In the frame of the project, advanced modeling and algorithms for simulating the performance of journal bearings, vessel hull and shaft statics/dynamics will be developed. The models will promote our understanding of the underlying physics during operation of critical vessel components. (**b**) Advanced control algorithms will be developed, for optimizing the performance of the propulsion system, at every anticipated state of operation, taking into consideration component performance, as well as degradation-aging. The project concepts will be interdisciplinary in nature, since different domains will be integrated (FEM, CFD, tribology, sensor technology, AI, optimization, automation and controls).

Impact on economy: (**a**) The developments of "**i-MARINE**" are expected to contribute to reducing power losses and failures of the shafting system of commercial vessels, leading to decreased operational costs. (**b**) The NTUA team will disseminate the project results, aiming at their commercial exploitation. (**c**) The project will engage three young scientists, who will acquire technical skills and expertise in the project's scientific domain, thus mitigating the country's brain drain. (**d**) In the framework of the project, the NTUA team will collaborate with major ship operators and Classification Societies, which is expected to boost future research and development initiatives.

Impact on society: (**a**) A case of malfunction of the shafting system often leads to loss of propulsion and to vessel immobilization, putting human lives and property at risk. "**i-MARINE**" will aid in increasing the reliability and minimizing the probability of failure in marine propulsion systems. (**b**) "**i-MARINE**" will contribute to reducing fuel consumption of a vessel's prime mover, and, consequently to reducing the associated exhaust gas emissions. (**c**) The vision of "**i-MARINE**" is to establish a **Center of Excellence** in the specific area of Marine Engineering, thus establishing a collaboration core between key stakeholders of the Greek maritime industry.

Significance of Funding Support

The novel research activities of the “**i-MARINE**” project would not have been possible without the financial support by the **H.F.R.I.**. The funding will provide the necessary financial support to the research personnel of "**i-MARINE**", which is essential for the young researchers involved, including doctoral students. The funding provided will also enable the acquisition of state-of-the-art laboratory equipment, essential for a proper development of the project’s infrastructure, and for the experimental validation of theoretical-computational findings. Further, the **H.F.R.I.** funding will support the project dissemination activities, which are essential for communicating the results to the wider public, to the research and maritime communities, as well for publishing the results in esteemed international scientific journals. The funding provided is also important in terms of supporting the activities of a rather new and innovative research team, which supports the development of young researchers, and also aims at establishing a **Center of Excellence**, which will further promote a close collaboration between the School of Naval Architecture and Marine Engineering of NTUA and important institutions of the Greek maritime and broader industry.

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