In recent years, the marine industry has actively explored new technologies and boat concepts to meet the environmental goals imposed by international and national laws for the reduction of fossil fuel emissions. One of the most promising technologies is hydrofoils, which have witnessed significant advancements due to progress made in composite materials, manufacturing techniques, control systems and actuation. The design and optimization of new foiling vessel concepts is a complex and multi-disciplinary topic that involves various physical phenomena: hydrodynamics, structures, interaction between those, dynamic modelling and control.

To achieve an efficient design workflow is necessary to explore different simulation techniques to find the right compromise between computational cost and accuracy of the result. In the preliminary design phase is important to employ fast simulation tools for exploring a broad design space and identifying the optimal concept for the specific mission objective. Subsequently, the most promising concepts need to be optimized with high-fidelity methods and tested in a dynamic environment.

This thesis addresses the theme of the design and optimization of hydrofoils made of composite materials and hydrofoil boats, providing flexible and integrated optimization tools for various phases of the design process, from initial concept, to final refinement and testing.

In this thesis, various methodologies suitable for the design of hydrofoils made of composite materials, as well as vessels employing this technology, are described. Additionally, three distinct design tools have been developed and employed to optimise a small-scale passenger transport vessel.

The dissertation is divided into two main parts: the preliminaries, which provide the necessary foundation to understand the design tools developed, and a second part that includes the optimization algorithms created for the design of new-generation foiling vessels.

The initial part of the dissertation introduces the theoretical concepts and equations needed for the development of design algorithms. It details the software and coding employed in performance assessments within the optimization tools.

Numerical models are validated against experimental data or verified and compared with high-fidelity software. The importance of striking a trade-off between precision and computational efficiency across different approaches is stressed. Various methodologies, both of low and high fidelity, are explored.

This balance is essential for selecting the most suitable methods at various design stages for optimizing hydrofoils or vessels featuring this technology.