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**Title:** Numerical Optimization Methods for Ship Hydrodynamic Design

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**Abstract:** The use of computational methods in design engineering is growing rapidly at all stages of the design process, with the final goal of a substantial reduction of the cost and time for the development of a design. Simulations and optimization algorithms can be combined together into what is known as Simulation-Based Design (SBD) techniques. Using these tools the designers may find the minimum of some user defined objective functions with constraints, under the general mathematical framework of a Non-Linear Programming problem. There are problems of course: computational complexity, noise, robustness and accuracy of the numerical simulations, exibility in the use of these tools; all these issues will have to be solved before the SBD methodology can become more widespread. In the paper, some derivative-based algorithms and methods are initially described, including efficient ways to compute the gradient of the objective function. Derivative-free methods - such as genetic algorithms and swarm methods - are then described and compared on both algebraic tests and on hydrodynamic design problems. Both local and global hydrodynamic ship design optimization problems are addressed, defined in either a single- or a multi-objective formulation framework. Methods for reducing the computational expense are presented. Metamodels (or surrogated models) are a rigorous framework for optimizing expensive computer simulations through the use of inexpensive approximations of expensive analysis codes. The Variable Fidelity idea tries instead to alleviate the computational expense of relying exclusively on high-fidelity models by taking advantage of well-established engineering approximation concepts. Examples of real ship hydrodynamic design optimization cases are given, reporting results mostly collected through a series of projects funded by the ONR. Whenever possible, an experimental check of the success of the optimization process is always advisable. Several examples of this

testing activity are reported in the paper - one is illustrated by the two pictures at the top of this page, which show the wave pattern close to the sonar dome of an Italian Navy Anti-Submarine Warfare corvette: left, the original design; right, the optimized one.

**Keywords:**