Effect of Inverted Bow on the Hydrodynamic Performance of Navy Combatant Hull Forms

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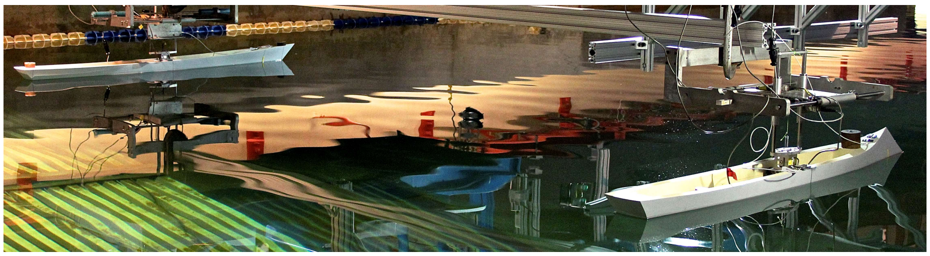

The U.S. Navy is building a new surface combatant that has an unconventional inverted bow. Very little technical data has been published on the seakeeping effects of inverted bows, especially for military applications. Following the analogy of a ship as a classical damped spring-mass system, the inverted bow serves to soften the spring constant and reduce vertical accelerations. However, in the available literature the inverted bow is often accompanied by a tumblehome hull shape, leaving the source of any improvements unclear. In this study we isolate the effect of the inverted bow by experimentally and numerically comparing the motions of an existing combatant hull, the Oliver Hazard Perry class frigate (FFG-7), with a modified version of the same hull with an inverted bow. The bow of the FFG-7 was redesigned in the MIT-iShip lab by developing a set of basic curves that define the parametric surface of the new shape. The forward 30% of the hull is elongated with a very fine entry, extremely narrow V-shaped sections below the waterline and inverted flare and stem profile above the waterline. Two 1/80th scale models were built, one of the original and one of the inverted bow frigate, with the same material, machining and finishing standards. To ensure a meaningful comparison the displacement, draft and waterline length were held constant between models. Each model was dynamically ballasted to achieve a longitudinal radius of gyration equal 25% LBP. Model tests were conducted in the United States Naval Academy Hydromechanics Laboratory for resistance in calm water and seakeeping in both regular waves and irregular head seas. From the calm water tests a comparative performance prediction revealed that the inverted bow exhibited lower resistance across a range of speeds relevant to naval operations. Regular wave tests were conducted to experimentally determine the linear ship motion transfer functions for both models. The differences between the FFG-7 and the inverted bow responses are characterized in terms of the pitch, heave and bow acceleration transfer functions. Irregular head seas tests were conducted with both models in a side-by-side configuration, a novel approach to comparative seakeeping tests. This configuration allowed for a consistent time domain analysis of the non-linear responses. A numerical verification and experimental validation of the seakeeping code Aegir was conducted using the inverted bow.

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