A Solution to the Inherent List on Nimitz Class Aircraft Carriers

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Nimitz class aircraft carriers possess an inherent list to starboard that their list control systems (LCS) are typically unable to correct while under Combat Load Conditions. As a result, it has become necessary to use fresh water ballast in a number of inner bottom voids and damage control voids to augment the LCS. Maintaining liquid ballast in damage control voids is unacceptable, as it reduces the design counter flooding capability of the ship, and thus reduces ship survivability. In order to restore the ship's operational flexibility and achieve the necessary/desired list correction, this study determines the effect of adding solid ballast to a series of voids/tanks identified on the 2nd, 4th, and 8th decks.

Based on ballast density, tank location and capacity, ease of ballast installation, minor tank structural modifications, and a decision making cost analysis, solid ballast was determined to be the most attractive alternative to correct the inherent list on the Nimitz class aircraft carriers. Fresh water ballast was also examined as a possible alternative, but not as extensively due to the large quantity of water required and its limited ability to achieve a list correction.

Nimitz class aircraft carriers currently have an average list of 1.5 degrees and a KG of 47 feet. Since their allowable KG cannot exceed 48.5 feet, the average service life allowance (SLA) for KG is approximately 1.5 feet. This study shows that by adding approximately 400 ton of solid ballast, list can be corrected by 1.5 degrees with only a 0.1 percent increase in KG. Thus, to permanently fix the average Nimitz class aircraft carrier starboard list, there would be a 0.05 foot increase in KG, which in all cases is within the SLA. Additionally, this study shows that this 1.5 degree list correction can be accomplished at a low cost of approximately $1,200 per ton. Considering the reduction in operational constraints and the benefits to ship survivability, this is truly an inexpensive proposition.

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Structural Loading of Cross Deck Connections for Trimaran Vessels

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This work investigates the fundamental relationships of wave loading of cross deck structures for trimaran vessels. In contrast with a monohull ship, trimaran vessels experience several possible structural loading cases including: longitudinal bending, transverse bending, torsional bending, spreading and squeezing of hulls, inner and outer hull slamming pressures, wet deck slamming pressures, loading from ship's motions, and whipping of slender hulls. This work investigates wave loading cases that result in transverse and torsional bending of the cross deck structure.

The wave loading cases investigated include: side hull troughing and cresting in longitudinal waves, side hull torsion in longitudinal waves, and transverse hogging and sagging. For each of these load cases, a design load using a fully statistical sea state was derived using an analytical model of a trimaran represented by rigidly connected box barges. The design loadings with a reliability index of 5 for almost 500 trimaran configurations were calculated varying main hull length, side hull length, side hull transverse placement, and side hull longitudinal placement. The design loadings were curve fit to a fourth order polynomial in the four independent variables.

The load predictions of the analytical box model of a trimaran were applied to a trimaran vessel with a realistic hull form using the finite element ship structural analysis program MAESTRO. Given the number of approximations and assumptions in the analytical model, the forces predicted by analytical model agreed closely with the finite element model’s results.

The fitted curve of design loadings allows an initial design stage loading estimate for cross deck structural loading given general characteristics of length and spacing of a trimaran's hulls. This estimate of structural loading combined with other characteristics of good trimaran design including stability, roll, and resistance characteristics will aid in optimizing an overall trimaran ship design.

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