Quantification of Extreme Event Statistics in Ship Design

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Increased operational demands on Navy vessels extend both their time at sea as well as their service life, making the accurate prediction of a catastrophic failure increasingly challenging. The high value of these capital assets puts greater pressure on designers and decision makers to prevent such failures while balancing engineering and material cost. The current method for the quantification of extreme events is direct Monte Carlo simulation supplemented by complex mathematical models. When used alone these models fall prey to statistical uncertainty when predicting rare events. High fidelity computational tools have increased engineer's capacity to explore a wider range of operating conditions but ultimately cannot capture all the physical phenomenon of model or full-scale testing. Even with advances in computers, the quantification of rare events remains an expensive endeavor.

This thesis builds on previous work at the MIT Stochastic Analysis and Non- Linear Dynamics (SAND) lab that identified improved approaches for the quantification of extreme events using wave groups. This approach combines statistics with physics models to more accurately captures rare events in ship motion and loading conditions for modest computational cost. Improvements to the wave groups methodology ensured the slope and amplitude of the incident wave set reflected the waves encountered in a given wave spectrum. The remaining discussion emphasizes the value of an improved understanding of risk and decision analysis approach to ship design, ship operations, and ongoing science. The aim is no only to reduce design and operational cost for Naval vessels, but also provides a technological pathway to realizing a near-real-time risk evaluation tool that opens the operational window for operators and ship owners.

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