# Development of Longitudinal Stability Criteria for Surfaced Submarines Through Use of Near Real Time Modeling

by

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## Abstract

Traditional submarine stability analysis has focused heavily on submerged operations. When surfaced conditions are considered, the analysis has focused on transverse stability. However, submarine accidents over the past two decades have drawn attention to the need to better understand damaged stability of surfaced submarines, especially longitudinal stability. This thesis develops a methodology and proposes a design standard to ensure a surfaced submarine is able to maintain adequate longitudinal stability. It bounds the conditions under which a submarine will be able to achieve a satisfactory static equilibrium, drawing inspiration from the submerged equilibrium polygon. It also uses tested U.S. Navy surface warship design criteria to identify potentially limiting damage scenarios. The proposed longitudinal stability standard requires the submarine to be able to avoid excessive trim angles under five scenarios: intact, routine maintenance, head on collision damage, glancing collision damage to the bow, and glancing collision damage to the stern. An Excel VBA program, Submarine Longitudinal Stability Analysis Program (SuLSA), was also developed as part of this thesis to specifically analyze submarine designs using the proposed methodology and standard. It reduces the time required to evaluate surfaced longitudinal stability of a submarine from days to hours. These proposals offer the possibility of making future submarines significantly safer.

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