Modular Machinery Arrangement and Its Impact in Early-Stage Naval Electric Ship Design

by

David J. Jurkiewicz

Submitted to the Department of Mechanical Engineering
on May 11, 2012 in Partial Fulfillment of the Requirements for the Degrees of

Master of Science in Naval Architecture and Marine Engineering
and
Master of Science in Mechanical Engineering

ABSTRACT

Electrical power demands for naval surface combatants are projected to rise with the development of increasingly complex and power intensive combat systems. This trend also coincides with the need of achieving maximum fuel efficiency at both high and low hull speeds. A proposed solution to meet current and future energy needs of conventionally powered naval surface combatants is through the use of an Integrated Power System (IPS), which is seen as the next evolution in naval ship design. Unfortunately, historically-based ship design process models and parametrics cannot accommodate new-concept designs that are not incremental changes to previous practice. Additionally, integrating IPS with the next generation of ship designs is also synonymous with the desire of conducting system-level tradeoffs early within the ship design process. In an effort to enhance the relationship between new-concept designs and historically-based ship design processes, this thesis focuses on a novel approach of incorporating IPS at the earliest stage of the design process as part of assessing system-level tradeoffs early.

This thesis describes a methodology for the system design and arrangement of an IPS machinery plant based on an objective of meeting a desired power generation level, effectively introducing a power constraint at the start of the design process. In conjunction with the methodology development, a hierarchical process and design tool for integration with Graphics Research Corporation's (GRC) naval architecture software suite, Paramarine, is also produced to assist in rapid development and evaluation of various IPS arrangements. The result of this process, through several case studies, provides insight into equipment selection philosophy, the initial sizing of the ship's machinery box, and the initial definition of electrical zones. Lastly, the developed tool is also used to aid in the creation of "design banks," allowing the naval architect to manage weight, power, and volume at the beginning of the ship design process; therefore, supporting early system-level tradeoffs for new-concept designs.

Thesis Supervisor: Chryssostomos Chryssostomidis
Title: Doherty Professor of Ocean Science and Engineering
Professor of Mechanical and Ocean Engineering