Early-Stage design methodology for a multirole electric propelled surface combatant ship

A. Vicenzutti, G. Trincas, V. Bucci, G. Sulligoi
Dept. of Engineering and Architecture
University of Trieste
Trieste, Italy
avicenzutti@units.it, trincas@units.it
vbucci@units.it, gsulligoi@units.it

G. Lipardi
Directorate of Naval Armaments
IT Ministry of Defence
Rome, Italy
gennaro.lipardi@marina.difesa.it

***Abstract*— Modern Navies are facing a scenario in which the technology is changing at a fast pace, deeply affecting the expected missions their ships have to cope with. Not only new weapon systems and sensors, but also new subsystems and new threats call for the design of new ships. However, integrating these new elements into an existing ship is impossible, being it not designed to support them. Likewise, adapting an existing ship design is difficult as well, being the hull form not suited either for providing the required performance level or for accommodating the increased payload. Therefore, to face the actual evolutionary trend in naval ships, a new design strategy has to be adopted. In this paper, a multi-attribute design making approach to the concept design is depicted, able to exploit the capabilities of modern Information Technology tools. As an application example, a first simplified run of the process is shown, regarding the design of a multirole destroyer.**

***Index Terms*—early-design stage, ship design, multi-attribute design, IPES, surface combatant ship**

I. INTRODUCTION

The trend towards electrification is apparent in all the transportation systems. Ships are facing the same evolutionary trend, which is pushed forward by different factors depending on the specific application [1], [2]. As an example, in merchant area the air pollution regulations are setting stringent requirements that cannot be achieved by only upgrading the internal combustion engines. Thus, an efficiency increase is sought, by means of a more integrated design approach and enabled by the onboard loads electrification. Concerning naval ships, the main factor pushing toward electrification is the development of new weapon systems and sensors, all electrically supplied. Obviously, efficiency and air pollution concerns affect also Navies, strengthening the motivations in moving towards this direction [3]. In this context, all the major Navies in the world are undergoing fleet modernization processes, starting from the front-line combat ships (frigates and destroyers). The new ships have requirements that significantly differ from the ones of their precursors, such as dual-use capabilities and increased electric power production (to supply the new weapon systems and sensors [4÷7]). The significant electric power generation capability makes the electric propulsion a viable option, which is also boosted by the efficiency improvement achievable thanks to the electrification of onboard loads. The foreseeable result is an increase in ship's range, with related improvement in mission capabilities. Moreover, silent operation is another appreciable feature of electric propulsion, which proves to be a significant advantage for naval ships. Thus, the Integrated Power and Energy System (IPES) concept can be exploited also in front-line surface combatant ships, both as an enabler for the new weapon systems and sensors, and as a mean to improve ship mission capabilities. However, while a full-electric solution may require weights and volumes that are excessive for a front-line ship, the hybrid solution (electric propulsion for low speeds, mechanical for high speeds) is a viable option [1] [8].

The integration of new elements (i.e. more electric power generation, electric propulsion, new weapon systems and sensors) into an existing ship may be an unreachable target, being the existing vessel not designed to support them. Likewise, adapting an existing ship design for integrating these new elements is difficult as well. In fact, these new elements affect the ship design in a significant way, possibly leading to suboptimal results, or even to an unfeasible solution. As an example, the previous hull form may be not suited either for providing the required performance level or for providing a sufficient displacement to accommodate the increased payload. Therefore, the integration of new technologies into a ship requires a new design, which takes into account the presence of the IPES (and the new weapon systems and sensors) already from the early design stages. Moreover, given the fast evolution in naval armaments, a new design strategy to achieve fast and consistent technical evaluations of the ship concept is needed. Such a strategy not only has to assure the best performance to the ship, but also must lead to a design that is not surpassed already at its service start.

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