Naval Engineering and Ship Control Special Edition Editorial

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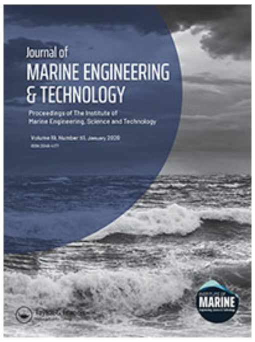

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EDITORIAL

Naval Engineering and Ship Control Special Edition Editorial

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1. Introduction

This Naval Engineering and Ship Control special edition of the Journal of Marine Engineering and Technology aims to present cutting edge research on naval engineering and ship control, as was presented during The International Naval Engineering Conference and Exhibition (INEC) and the international Ship Control Systems Symposium (iSCSS), held together in Glasgow in 2018. The overarching themes of this special edition and developments in the field of naval engineering and ship control are:

- The survivability of naval platforms and in particular design vulnerabilities (Habben Jansen et al. 2019);
- The growing role of pulsed-power and energy storage systems and their control (Rashkin et al. 2019; Edrington et al. 2019);
- The growing tension between reducing ships environmental impact and maintaining manoeuvring performance and safety (Theotokatos et al. 2019; Eriksson and Llamas 2019); and
- The transition toward reduced crews and autonomous shipping, while maintaining safety of operations (Zaccone and Martelli 2019; Bibuli et al. 2019).

2. Background

Naval platforms are becoming increasingly complex systems of systems that combine advanced high power sensors and weapons, such as solid state radars, railguns and lasers (Tate and Rumney 2017), complex information technology and control systems (Geertsma et al. 2017; Smith and Biggs 2018) to speed up decision making and the OODA loop (Coram 2004), with advanced autonomous systems and vehicles that act as force multipliers (Benson et al. 2018; Bibuli et al. 2018). As the navies around the world can only afford a limited amount of these platforms, and personnel loss is unacceptable in modern society, the vulnerability of these platforms is increasingly important. All these energy hungry systems with an increasingly unpredictable load profile, require advanced integrated power systems and energy storage to meet both energy and power demand (Doerry et al. 2015; Whitelegg 2016). In order to control these multi-source power systems, novel control strategies are required.

While power requirements on the one hand are increasing due to high power systems, on the other hand two drivers force navies to focus on reducing the energy requirement and increasing efficiency of ship systems. First, naval operations become very dependant of logistic supply lines due to their dependancy on fuels, as energy is the most fundamental enabler of military capability (Office of the Assistant Secretary of Defense for Energy 2016). Secondly, navies are also under increasing scrutiny to contribute to the reduction of the environmental impact of shipping and naval operations (Netherlands Ministry of Defence 2015; Schulten et al. 2015). Thus, for navies, but certainly for commercial shipping, increased efficiency and alternative fuels with a smaller impact on the environment, are essential to meet the goals set for shipping in IMO's *initial strategy on greenhouse gas emissions reduction for ships* (IMO MEPC 72 2018).

Alongside the energy transition, shipping is also progressing to an increase in autonomy in shipping operations, ultimately leading to autonomous shipping (Burmeister et al. 2014; Kretschmann et al. 2017). This transition is driven by the shrinking availability of suitably qualified seafarers and increasing pressure to reduce (personnel) cost, improve safety and eradicate accidents due to human failure. One of the key aspects to achieve autonomous shipping, or increased safety, is autonomous navigation, probably to be preceded by enhanced navigation support (Perera et al. 2015). Novel algorithms to

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achieve this need to be developed in combination with advanced guidance and control systems.

3. Research in this special issue

3.1. Survivability and vulnerability reduction of naval ships

Naval platforms are increasingly complex and expensive systems of systems. Therefore, increasing survivability by vulnerability reduction is very important to prevent loss of capital investment and, more importantly, personnel when the ship and their crew are being put in harms way. However, the increasingly complex nature of these vessels and their dependancy on distributed systems, such as power systems, cooling systems and information technology systems, impedes vulnerability analysis in the early design stage (Goodrum et al. 2017; de Vos and Stapersma 2018). A novel method to assess vulnerability reduction at the early ship design stage, using a Markov model is presented in Habben Jansen et al. (2019). This method allows to account for complex damage scenarios by generalising damage scenarios and thus prevents the need for simulation of a large number of individual hit scenarios at the early design phase. The work demonstrates two cases studies for power and propulsion systems and chilled water systems, as an extension to the method introduction in Habben Jansen et al. (2018).

3.2. Pulsed power weapons, integrated power systems and their control

Electric weapons, such as railguns and high power lasers, and high power radars have driven the power requirement of naval platforms (Lowe et al. 2018). In order to achieve maximum flexibility of power supply between high power weapon, sensor and auxiliary systems on one side and propulsion systems on the other side, the development of integrated power systems started in the 90's and led to the application of integrated power systems on the UK Type 45 (Vanderpump et al. 2002) and US DDG-1000 Zumwalt class destroyers (Doerry et al. 2015), and on the UK Queen Elizabeth Class aircraft carriers (Sears et al. 2010; Hodge and Mattick 2008). While the introduction of railguns and high power lasers has been long anticipated, both are still in the experimental stage of development (Tate and Rumney 2017; McNab and Beach 2005; Meger et al. 2013). Nevertheless, these pulsed-power systems are expected on naval platforms over the next decade. A novel methodology to establish energy storage requirements, taking into account these anticipated pulsed-power systems is described in Rashkin et al. (2019), as an extension of the concept presented in Rashkin et al. (2018). After establishing the power system and energy storage requirements, control strategies are important to achieve maximum performance. A novel energy management control strategy for pulsed-power loads to maintain voltage stability and energy storage state of charge is presented in Edrington et al. (2019), which is an extension to the initial energy management concept presented in Edrington et al. (2018).

3.3. Engine emissions and performance

The impact of shipping on the environment is under increasing societal scrutiny. Therefore, the emission of NO_x is limited by the *International Convention for the Prevention of Pollution from Ships* (IMO 2011) and goals for the reduction of CO_2 emissions have been established in IMO's *Initial strategy on greenhouse gas emissions reduction for ships* (IMO MEPC 72 2018). In the short term, LNG is one of the suggested alternative fuels that can cost-effectively reduce both CO_2 and NO_x emissions (Taljegard et al. 2014; Deniz and Zincir 2016). Theotokatos et al. (2019) present a study into the modelling of dual fuel engines and their control system to investigate the safety implications of switching between LNG and diesel oil, as an extension of the concept presented in Theotokatos et al. (2018). The work concludes that waste gate valve control is critical for enhancing dual fuel engine safety and suggests that detailed models and simulations can be effectively used to identify and limit hazardous situations in complex maritime systems.

Exhaust Gas Recirculation (EGR) on diesel engines can effectively limit NO_x emissions below IMO Tier 3 levels, without exhaust gas after treatment. However, EGR can either lead to reduced engine responsiveness or lead to black smoke emissions (Nielsen et al. 2018). In Eriksson and Llamas (2019) a novel EGR flow control strategy is proposed and investigated with a simulation study. The study concludes that the proposed flow control strategy can achieve increased acceleration performance over traditional EGR control, while maintaining sufficient air excess ratio and thus preventing black smoke emissions. This work is a more detailed description and analysis of the work presented at iSCSS 2018 in Llamas and Eriksson (2018).

3.4. Autonomous systems and navigation

Advanced collision avoidance algorithms are a key enabler for autonomous shipping and can be used to improve navigational safety (Huang et al. 2020; Perera et al. 2015). (Zaccone and Martelli 2019) presents a collision avoidance algorithm for ship guidance application, based on the Rapidly-exploring Random Tree (RRT*) algorithm, first introduced during iSCSS in (Zaccone et al. 2018). The algorithm finds safe and efficient routes in a number of complex scenarios simulated with a time-domain ship simulation model.

In an autonomous navigation system, after a safe and efficient route has been established, this route should be achieved with a track keeping controller (Zaccone and Martelli 2019). (Bibuli et al. 2019) presents advanced guidance and control for a twin hull autonomous vessel with azimuth thrusters, as an extension to the concept presented in (Bibuli et al. 2018). The adaptive Proprtional-Derivative (PD) control scheme achieves increased convergence rate compared to conventional PD control with limited overshoot and oscillation.

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No potential conflict of interest was reported by the authors.

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