# Real-time Marine Vessel and Power Plant Simulator

T.I. Bø, A.R. Dahl, T.A. Johansen, E. Mathiesen, M.R. Miyazaki, E. Pedersen, R. Skjetne, A. Sørensen, L. Thorat, I. Utne, K.K. Yum

During the last decades diesel electric propulsion in combination with dynamic positioning (DP) has become industry standard for some types of vessels such as drilling rigs and offshore service vessels. With diesel electric propulsion, diesel engines are connected to generators to produce electric power. This power is, among others, fed to thrusters to keep the position and heading of the vessel. To be able to simulate the integrated performance of a vessel, a numerical model that contains both the mechanical system (diesel engines, thrusters, and vessel) and the electric power system is needed.

Such a numerical model can simulate the electric load fluctuations due to change of thrust demand from the DP system. This is crucial for the design of both the power management system (PMS) and the DP controller. A simulator that integrates the electric power plant and the vessel model with realistic responses and functional consistency is needed to test how a fault in the electrical system will influence the vessel motions during the first minutes after the fault. If well designed, such a simulator can also be easily extended with new functionality related to present and future solutions in regard to AC or DC distributions, and hybrid solutions for power production, energy storage, and control of load sharing, in order to check and optimize performance of such new methods.

The main contribution of this simulator is in the interconnection between several ship systems and the ability to run and test the overall functionality and performance in real time. Earlier works have mainly been published on simulation of isolated systems. However, this simulator includes a vessel model exposed to waves, current, and wind; a DP control system with thrust allocation and state estimation; a thruster system with propellers, thruster drives, and thruster losses; and an electric power plant model with diesel engines, generators, thruster loads and other consumers, and a PMS. Since the simulation is able to run in real time, it can be used for hardware-in-the-loop testing of proposed control algorithms. The simulator is made in Simulink ®, while the thrust allocation uses the ACADO software for solving the nonlinear optimization problem. The hardware for real-time computation is based on cRIO and LabVIEW® from National Instruments.

The developed simulation toolbox for the simulator allows flexible and rapid configuration of AC and DC distribution, and a hybrid power plant including batteries. Some models are implemented with both high fidelity and low fidelity resolution, such as the diesel engine module, which is both modeled as a mean value dynamic model and a model using industry standard rate constraints and static mapping of efficiency. Fault handling can be simulated since a power management system is included; it includes fast load reduction and power available calculations.

In this article we will presents the models and show some realistic and interesting simulation results from cases where faults on the electric power grid results in restrictions on the available thrust for the DP system, and consequently degraded positioning performance.