XI International Conference on Computational Methods in Marine Engineering

Systems Elements Analysis: Integrating Model-Based Systems Engineering with Early-Stage Ship Design Tools

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ABSTRACT

The shipping industry has recently been impacted by new environmental regulations, such as EEXI and SEEMP, as well as new technologies, including alternative fuels and tubeless stern bearings. Additionally, it has seen new operations, like seabed and drone warfare, alongside emerging dangers, including pandemics, tariffs, and global unrest. To tackle these uncertainties, ship design is becoming multidisciplinary, aiming at integrating all aspects of the ship into a cohesive model. Model-Based Systems Engineering (MBSE) has been used to understand the systems architecture interdependencies, however, a gap exists in describing, understanding, and simulating the interactions between the systems architecture components. This paper proposes the Systems Elements Analysis (SEA) methodology, a FEM analogy-based approach to the MBSE framework, treating the systems architecture components, Operations, Functions, Logical Functions, and Physical Systems (OFLP) as nodes of a virtual truss structure to construct a stiffness matrix similar to a classical FEA. The framework is coupled with an existing simulation software of a typical bulk carrier's shafting system, developed using the deal.II library and HPC elements (Oikonomou, 2023), to explore the interactions between the OFLP components. The insights gained from this approach include a systematic way to explore the systems architecture design space and a methodology to quantify the interactions of the OFLP components, leading to a clearer understanding of the complexities of ship design.

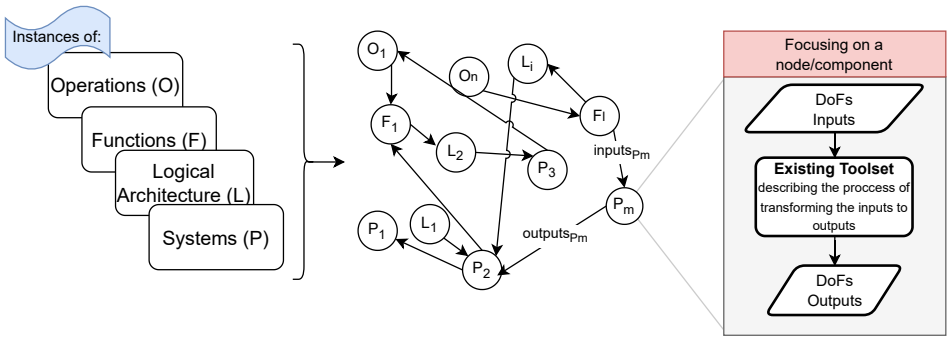

Figure 1: Proposed MBSE-FEM Coupling

References

Oikonomou, Z.-P. (2023, November). *Software Development for Dynamic Behavior Assessment of the Propulsion System with Parametric Design* [Master's thesis, National Technical University of Athens]. http://dx.doi.org/10.26240/heal.ntua.27122