Development of a Functional Architecture for a Power Electronics Based Power Distribution System (PEPDS)

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The Power Electronics Power Distribution System (PEPDS) is a new power, energy, and control distribution concept enabled by ONR developed technology. PEPDS leverages recent technology advances including power dense, high-efficiency power electronics, Silicon-Carbide (SiC) power semiconductors, as well as modeling and simulation design and analysis tools and is developing applications in which to implement them as well as the modeling capabilities necessary to employee them. PEPDS is more than an energy and power system, it is a novel distribution concept and a new class of system. While the present-day Integrated Power and Energy System (IPES) uses either ac or dc electrical power distribution, PEPDS is a universal solution, able to receive power from ac and dc sources and deliver power to ac and dc loads, in the same system and at the same time. The PEPDS program aims to achieve revolutionary changes to the design and operation of power systems and will be a paradigm shift for the Navy in its approach to ship design and ship manufacturing as well as in the approach to shipboard system design, from weapons systems to C4ISR systems to future systems that we cannot even imagine today. PEPDS will offer safe, straightforward, efficient, and user-friendly implementation of these shipboard systems as well as power system updates/upgrades, maintenance, and repairs. PEPDS will be the power systems equivalent of a computer that is OS agnostic, running any software written for

any OS out of the box, that automatically configures to the hardware requirements of the application, and that is truly plug and play with any hardware peripheral, with all peripherals coexisting harmoniously.

The focus of this presentation is the development of a functional architecture for PEPDS. The PEPDS architecture development is a multi-disciplinary collaborative effort. The PEPDS architecture is being developed and modeled in Dassault Systèmes Cameo Systems Modeler, following the MagicGrid® Model-Based Systems Engineering (MBSE) process. A functional architecture is an architectural model that identifies system functions and their interactions and defines how the functions will operate together to perform the system mission(s) [2]. Hence, the functional architecture emerges from the Problem Domain of the MagicGrid® process. This presentation will describe the developed PEPDS Problem Domain components of the MagicGrid® process, including Stakeholder Needs, Use Cases, Functional Analysis, System Context, Logical Communication, and Measures of Effectiveness. Within the description of the Problem Domain components, the details of the PEPDS functional architecture and functional requirements will be presented.

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References:

[1] L. Petersen, et al., “Power Electronic Power Distribution Systems (PEPDS) – Plan”, https://www.esrdc.com/library/pepds-plan/, 2022.
[2] https://acqnotes.com/acqnote/careerfields/functional-architecture
[3] A. Aleksandraviciene and A. Morkevicius, “MagicGrid® Book of Knowledge: A Practical Guide to Systems Modeling using MagicGrid from No Magic”, Kaunas, 2018.