Electrical Sciences at Sandia National Laboratories

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The purpose of this presentation is to provide an overview of the types of research, capability development, and applications that occur within the Electrical Sciences group at Sandia National Laboratories (SNL). While Electrical Sciences at SNL includes efforts in the areas of pulsed power, advanced power electronics, and electromagnetic & plasma physics experiments, this presentation will specifically feature the ongoing technical activities within the Electromagnetic (EM) Theory and the Electrical Models and Simulation departments (a subset of departments within Electrical Sciences). The need for collaboration and integrated capability development between these two teams will also be discussed.

The EM theory team within Electrical Sciences can be described as an *applied electromagnetic theory and plasma physics* resource for the laboratory. Although the group is partnered with several experimental departments, analyses and simulations are critical for addressing gaps in testing capabilities and hardware limitations, as well as for informing uncertainty quantification (UQ). While the EM theory group is engaged in a wide breadth of activities, including plasma physics analysis and code development, this presentation will focus on a selection of EM efforts related to physics and engineering model development, nanophotonic design and analysis, and system certification to various electromagnetic environments. To meet the broad needs of our internal Sandia customers, NNSA and Department of Defense (DOD), Department of Energy (DOE), and work-for-other projects, a wide breadth of technical expertise is required.

The Electrical Models and Simulation team within Electrical Sciences can be described as an *electrical modeling, simulation, and analyses* resource for the electrical analysts & designers within the laboratory. This capability is unique across all the NNSA research and development laboratories. These efforts are strongly coupled with testing capability to ensure the development of predictive UQ response of trusted (validated) electrical system models across all environments of interest (radiation, thermal, etc.). A wide range of solvers and algorithms have been developed to model multi-dimensional TCAD components (e.g., Bipolar Junction Transistors, Heterojunction Bipolar Transistors, memristors, etc.), small circuits (10s of components) to large-scale circuits (10^6 of components). In addition to transient solvers, frequency domain (Harmonic Balance) capability is currently being developed within our TCAD simulator and a multi-tone capability has been developed within our circuit simulator. The frequency-domain development is being done in part to develop more robust coupling with our EM modeling tools; a high-fidelity flow down of continuous-wave electromagnetic environments to circuit/device responses is critical for assessing functional-system impact.

The goal of this presentation will be to communicate examples of the opportunities and technical challenges for applied research in a national laboratory setting, from the perspective of these two Electrical Science departments.

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