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Demonstration of Utilization of High-fidelity NEAMS Tools to Inform the Improved Use of Conventional Tools within the NEAMS Workbench on the NEA/OECD C5G7-TD Benchmark

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ABSTRACT:

The primary goal of the proposed project is to demonstrate the utilization of high-fidelity Nuclear Energy Advanced Modeling and Simulation (NEAMS) tools (PROTEUS, Nek5000, and BISON) to inform the improved use of conventional tools (DIF3D, CTF, and CTFFuel) within the NEAMS Workbench on the NEA/OECD C5G7-TD benchmark. The project will highlight and illustrate some of the main objectives of the NEAMS workbench: (i) to enable end users to use high-fidelity NEAMS tools to inform the improved use of lower-order conventional tools within the Workbench and (ii) to demonstrate the values of NEAMS tools as applied to collaborative benchmarks from a common input/template. The proposed project is envisioned as a partnership with the developers of the high-fidelity NEAMS tools and the NEAMS workbench and an industrial user of the tools. In order to make the project results relevant to industrial applications the focus will be on obtaining an optimal combination of accuracy and efficiency, which satisfies the current industry needs and performance requirements.

High-fidelity models can be used to predict physical behavior in regimes or on scales where measured data is not available. Due to their complexity, the high-fidelity calculations are computationally expensive. This motivates the use of low-fidelity models, which are less comprehensive but provide numerical efficiency required for practical applications in design and safety evaluations. Therefore, combining relatively cheap conventional model simulations with more costly high-fidelity simulations, to emulate the high-fidelity model, has been of a significant interest. To address the integration of high-fidelity and low-fidelity codes to predict quantities of interests in an efficient manner, three approaches will be utilized (and improved) within the framework of this project. The first approach is based on non-linear multi-scale frameworks and will be used for neutronics high-to-low (PROTEUS-to-DIF3D) model informing. The second approach is utilizing information theory in a Bayesian framework and will be applied for fuel rod high-to-low (BISON-to-CTFFuel) model information. The third approach, named as physics-based approach, will be used for thermal-hydraulics high-to-low (Nek5000-to-CTF) model informing. These high-to-low fidelity informing procedures will be demonstrated and combined in multi-physics simulations within the NEAMS Workbench on one of the currently on-going high-visibility international NEA/OECD benchmarks – C5G7-TD benchmark – using a common input.

Such framework of high-to-low informing procedures using the NEAMS Workbench tools has a potential to improve the modeling of the local effects, which will result in more accurate predictions of safety parameters and margins. The latest is of high importance for both safety and performance improvements of the nuclear power plants being currently operated and built. The developed Workbench-based framework will also enable the end users to apply high-fidelity simulations to inform lower-order models for the design, analysis, and licensing of advanced nuclear systems.