PURDUE UNIVERSITY | School of Nuclear Engineering

Nuclear Engineering Seminar

Dr. Kostadin Ivanov

Professor and Department Head,
Nuclear Engineering NC State

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Verification, Validation and Uncertainty Quantification of Modern Multi-Physics Simulation Tools

Abstract

The predictive Modelling and Simulation (M&S) capabilities have evolved from the so-called traditional coupled calculations to novel first-principle high-fidelity multi-physics simulations. This seminar discuses current trends and main challenges in Verification, Validation and Uncertainty Quantification (VVUQ) of modern multi-physics M&S tools, based on authors' experience and expertise gained from their participation and contributions within national DOE initiatives such as CASL and NEAMS as well as international IAEA CRPs and OECD NEA Expert Groups and benchmark activities. Advanced M&S is essential for improvement/ enhancement of currently operating reactors (such as High Energy Fuel (HEF) program) and to support accelerated deployment of advanced nuclear reactors. Advanced M&S requires multi-physics coupling across broad ranges in space, energy and time and corresponding comprehensive VVUQ to be credible. The presentation compares and identifies traditional low-fidelity vs. novel high-fidelity, multi-physics vs. single physics, and multi-scale vs single scale M&S VVUQ issues and gaps. Further the current trends in VVUQ including development of consistent and comprehensive VVUQ protocols, code and application VVUQ plans, high-resolution validation benchmarks, uncertainty quantification and propagation methodologies, requirements for experimental data, knowledge management and preservation of experimental data are reviewed. This is followed by a discussion of current approach integrating a systematic Predictive Capability Maturity Model (PCMM) with the Best-Estimate Plus Uncertainties (BEPU) concept as a strategy for safety and licensing's analyses. The presentation is concluded with the authors' point of view for the next steps as future activities.

Dr. Ivanov is currently Professor and Department Head of Nuclear Engineering at the North Carolina State University (NC State). He was a Distinguished Professor of Nuclear Engineering and Graduate Coordinator of Nuclear Engineering Program at the Pennsylvania State University before joining NC State. Dr. Ivanov's work has been published in over three hundred (300) papers in peer-reviewed journals and proceedings. He has graduated one hundred (106) MEng, sixty (64) MS and forty (42) PhD students. Dr. Ivanov is a member of Nuclear Science Committee (NSC) of the Nuclear Energy Agency (NEA), OECD and Chair of Working Party on Scientific Issues of Reactor Systems (WPRS) at NEA, OECD. Dr. Ivanov is ANS Fellow.