Virtual Environment for Reactor Applications (VERA)

Modern high performance computing (HPC) platforms bring an opportunity for modeling and simulation (modsim) at levels of detail previously unimaginable. Many of the complex phenomena occurring in light water reactors (LWRs) can be explored and better understood through the use of modsim to exploit HPC.

VERA bridges the gap between research and engineering by bringing together a suite of coupled software applications that simulate the behavior of a commercial LWR core under a variety of normal operating conditions. VERA integrates specialized knowledge of the multiple physics involved in nuclear power production by leveraging the contributions from leading scientists and engineers in government, industry and academia. As a result of this research, systems and processes can be engineered to higher levels of performance with longer and more productive lifetimes.

VERA incorporates science-based models, state-of-the-art numerical methods, modern computational science and engineering practices, and uncertainty quantification and validation using data from operating pressurized water reactors (PWRs), separate-effects experiments, and integral tests. The resulting Virtual Environment for Reactor Applications (VERA) will be among the most comprehensive and capable modsim toolset worldwide in the field of LWR science and technology.

VERA simulates a nuclear reactor core by using an integrated suite of computational tools that predict nuclear core performance based on the governing physics.

CASL is focused on improving the performance of light water reactors with predictive, science-based simulation technology that harnesses the world-class computational power of ORNL’s Titan high performance computer. VERA is being organized to rapidly advance the CASL mission through:

- Incorporating higher-fidelity modsim tools provided by DOE National Labs, academia, and industry into an integrated set of software tools for broad user access
- Coupling of the applications simulating the physics that drive reactor core performance
- Focusing on uncertainty quantification, validation, and verification of the applications
- Directly engaging stakeholders in the requirements driven research & development process
- Assuring that CASL products are effective and practical for ultimate use by designers and operators of LWRs in the future
Many of the applications selected for CASL’s VERA are general purpose codes; CASL has added a necessary layer of capabilities to the higher fidelity applications to track fuel through multiple commercial reactor cycles and to provide inventory information such as fuel depletion. CASL has also coupled several key feedback parameters such as fuel density and temperature and has demonstrated the strong effects of the feedback parameters on the simulation. Simulation of commercial LWR operational issues such as CRUD deposition using the higher fidelity coupled physics allows for better understanding and opens the door for better solutions. This coupled, higher fidelity capability sets a new standard of performance for LWR modsim and is unmatched anywhere in the nuclear science and engineering community. This capability has been tested on user computing platforms and through the deployment of VERA on CASL Test Stands.

The foundation of CASL’s coupled capabilities lies within the physics methods and numerical solutions encompassed within the VERA components. CASL’s commitment to higher fidelity understanding of reactor phenomena incorporates a rigorous 3D approach to the underlying scientific methodologies using explicit 3D techniques and utilizing leadership-class computing capabilities. Additionally, recognizing the need for higher-fidelity simulations on an industry-sized computing platform, CASL has elected to provide a scaled capability using alternative, less computationally intensive methods to allow for faster running on smaller computing clusters. Both higher-fidelity foundational capabilities represent a transformational advance in commercial LWR modsim through the physics coupling.

CASL Consortium partner Westinghouse Electric Company LLC has provided specifications for a commercial pressurized water fuel assembly (left) for explicit modeling using VERA (right).

### A Virtual Nuclear Core
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### The Virtual Environment for Reactor Applications (VERA) provides a suite of simulation tools for analysis of physical phenomena in operating commercial nuclear fission reactors. It includes a spectrum of capabilities, with emphasis on advanced, high-fidelity approaches that provide unique and valuable insight into the behavior of reactors and effects of operational changes.

To find out more about VERA and to follow its research and development activity related to modeling and simulation of nuclear reactor cores, please visit www.casl.gov • casl-info@casl.gov

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**Comparison of VERA with Typical Industry Core Simulator Methods**

<table>
<thead>
<tr>
<th>Physics Area</th>
<th>Typical Industry Core Simulator Method</th>
<th>VERA running on an Industry Class Platform</th>
<th>VERA running on a Leadership Class Platform</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neutron Transport</td>
<td>3-D diffusion (core) 2 energy groups (core) 2-D transport on single assemblies</td>
<td>2D/1D transport 23+ energy groups 3D transport 23+ energy groups</td>
<td></td>
</tr>
<tr>
<td>Thermal-Hydraulics</td>
<td>nodal average (1-D) subchannel (w/crossflow) subchannel (w/crossflow) or CFD</td>
<td>subchannel (w/crossflow) subchannel (w/crossflow) or CFD</td>
<td></td>
</tr>
<tr>
<td>Fuel Performance</td>
<td>Bounding empirically-based pin-by-pin (r,z) empirically-based pin-by-pin empirically-based with some science based model</td>
<td>pin-by-pin empirically-based with some science based model</td>
<td></td>
</tr>
<tr>
<td>Fuel &amp; clad Temperatures</td>
<td>nodal average &amp; peak pin-by-pin (r,z)</td>
<td>pin-by-pin (r,z)</td>
<td>pin-by-pin (r,z)</td>
</tr>
<tr>
<td>Power Distribution</td>
<td>nodal average with pin-power reconstruction explicit pin-by-pin explicit pin-by-pin</td>
<td>explicit pin-by-pin</td>
<td></td>
</tr>
<tr>
<td>Depletion</td>
<td>infinite-medium cross sections, quadratic burnup correction history corrections, spectral corrections, reconstructed pin exposures</td>
<td>pin-by-pin with actual core conditions</td>
<td>pin-by-pin with actual core conditions</td>
</tr>
<tr>
<td>Reflector Models</td>
<td>1-D cross section models actual 3D geometry actual 3D geometry</td>
<td>actual 3D geometry</td>
<td></td>
</tr>
<tr>
<td>Target Platforms</td>
<td>workstation (six-core) 1,000 cores and up 10,000 cores and up</td>
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