Dr. Jess C. Gehin

Director, Consortium for Advanced Simulation of Light Water Reactors (CASL)
Oak Ridge National Laboratory

Dr. Jess Gehin joined the Oak Ridge National Laboratory in 1992 and is the Director of the Consortium for Advanced Simulation of Light Water Reactors (CASL). Previous positions at ORNL include leading Reactor Technology R&D Integration, Senior Program Manager, and Lead of the Reactor Analysis Group. Prior to this position, Dr. Gehin was a Senior R&D staff member performing research primarily in the area of nuclear reactor physics working on projects such as the development of the Advanced Neutron Source Research Reactor, Fissile Material Disposition, and modeling of experiments in the High Flux Isotope Reactor. Dr. Gehin earned a B.S. degree in Nuclear Engineering in 1988 from Kansas State University and M.S. (1990) and Ph.D. (1992) degrees in Nuclear Engineering from the Massachusetts Institute of Technology. Dr. Gehin also holds the position of Joint Associate Professor in the Nuclear Engineering Department and the Bredesen Center for Interdisciplinary Research and Graduate Education at the University of Tennessee. He is also an active member of the American Nuclear Society.

Research Interests

- Nuclear reactor physics computational methods for Light Water Reactors (LWRs) and advanced reactor concept development, design, and operations.
- Advanced nuclear reactor technology development including Fluoride salt-cooled High-temperature Reactor (FHR) and Molten Salt Reactor (MSR) concepts
- Nuclear fuel cycle systems and options analysis including fuel cycle evaluations to support R&D decisions and technical aspects of thorium-based fuel cycle systems.

Congressional Testimony

Jess C. Gehin
Director, Consortium for Advanced Simulation of Light Water Reactors
Oak Ridge National Laboratory

Before the
Subcommittee on Energy
Committee on Science, Space, and Technology
U.S. House of Representatives

Hearing on Department of Energy (DOE) Innovation Hubs

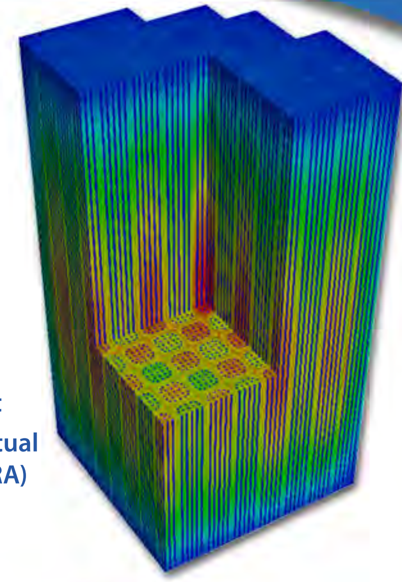
June 17, 2015

APPENDIX 1

CASL Fact Sheet

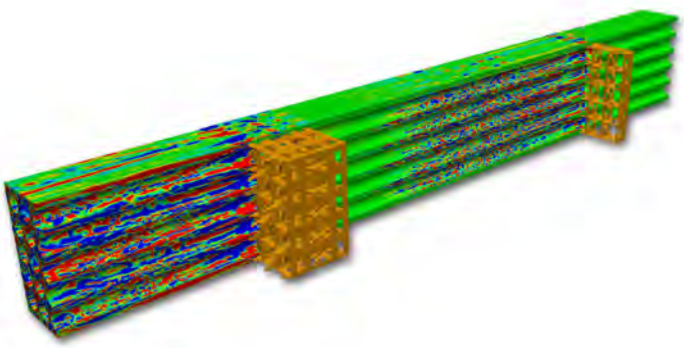
U.S. DEPARTMENT OF ENERGY

CASL



Delivering industry solutions through predictive simulation

- Improved reactor performance and output
- Technology step change with the CASL Virtual Environment for Reactor Applications (VERA)
- Informing the design and licensing of new reactors

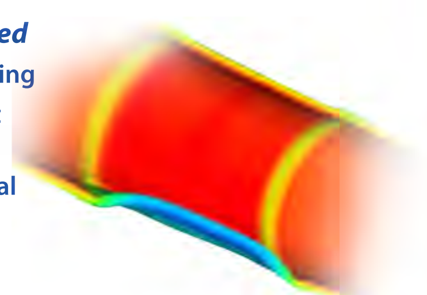


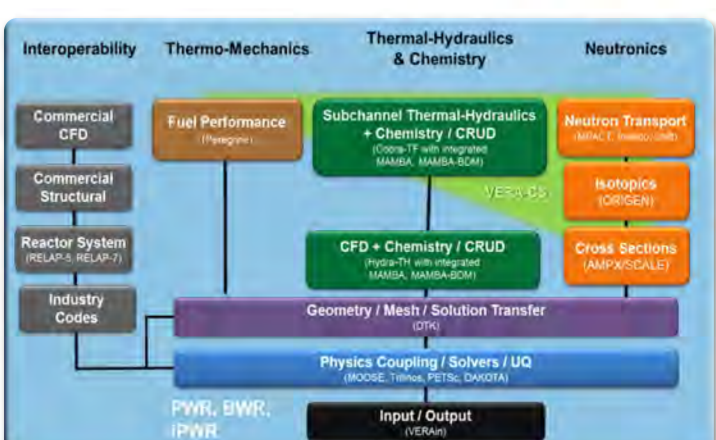
Tackling tough industry challenges that matter

- Power uprates
- Fuel performance
- Safety basis
- Next generation reactors
- Advanced fuels

Fostering innovation where it is most needed

- Essential understanding of reactor fuel cladding
- Novel numerical algorithms ready for current and future HPC systems
- Quantified uncertainties to inform operational and safety margins
- Multiphysics HPC-based tools embedded in reactor design and analysis workflows





VERA VIRTUAL ENVIRONMENT for REACTOR APPLICATIONS

Mission

Provide leading-edge modeling and simulation (M&S) capabilities to improve the performance of currently operating light water reactors (LWRs)

Vision

Predict, with confidence, the performance and assured safety of nuclear reactors, through comprehensive, science-based M&S technology deployed and applied broadly by the US nuclear energy industry

CASL Strategic Goals

- Develop and apply contemporary modeling and simulation (MODSIM) practices for design, operational, and safety challenges for light water reactors
- Engage the nuclear community (government, academia, and industry) in the research, development, and deployment process, in order to set scope and priorities and ensure outcomes of value
- Deploy advanced MODSIM technology via a "Virtual Environment for Reactor Applications" (VERA) to customers, clients, and users
- Advance nuclear technology by deploying new capabilities for predicting the performance of commercial nuclear power plants and supporting progress toward key nuclear industry goals of higher power ratings, greater fuel burnup, and next-generation designs

CASL Founding Partners

The CASL lead institution is Oak Ridge National Laboratory (ORNL), which was founded to develop the world's first nuclear fuel cycle and today is DOE's largest science and energy laboratory. ORNL has world-leading capabilities in computing and computational science and substantial programs and assets in nuclear energy R&D, as well as a record of accomplishment in leading large-scale scientific collaborations. The participation of Idaho National Laboratory (INL), Los Alamos National Laboratory (LANL), and Sandia National Laboratories (SNL) as CASL partners provides exceptional strengths in fundamental science, nuclear energy R&D, transformational HPC technology, and development of models and algorithms for the solution of complex problems. Academic partners North Carolina State University (NCSU), the University of Michigan (UM), and the Massachusetts Institute of Technology (MIT) are leaders in nuclear engineering R&D and education. The Electric Power Research Institute (EPRI) conducts R&D to ensure that nuclear power remains a safe and economically feasible generation option and provides CASL with connections to nuclear power plant operators, regulatory agencies, and other research organizations. Westinghouse Electric Company (WEC), a pioneer in nuclear power, has a long and successful history of supplying leading-edge nuclear technology. The Tennessee Valley Authority (TVA) operates six reactors (3 PWRs and 3 boiling water reactors (BWRs)) that provide more than 6,900 MW of electricity to the grid.

ELECTRIC POWER RESEARCH INSTITUTE

EPRI is a collaborative nonprofit organization that conducts research and development relating to generation, delivery, and use of electricity for the benefit of the public. Our members include operators of all U.S. nuclear power plants and a large fraction of the nuclear plants worldwide.

IDAHO NATIONAL LABORATORY

INL is the lead nuclear energy (NE) laboratory for the U.S. Department of Energy. The laboratory has designed and operated 52 test reactors, including EBR-1, the world's first nuclear power plant.

LOS ALAMOS NATIONAL LABORATORY

A world-class, multi-disciplinary research and development institution focused on national security missions, Los Alamos brings to CASL particular strengths in computational and material sciences.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

The Department of Nuclear Science and Engineering at MIT has been a leader in the development of the nuclear engineering spectrum of curriculum and research activities, integrating foundational scientific knowledge with engineering proactive to advance.

NORTH CAROLINA STATE UNIVERSITY

NC State University has a proven record of working with industry and government to advance research in support of solving nuclear industry challenges.

OAK RIDGE NATIONAL LABORATORY

Oak Ridge National Laboratory is the largest US Department of Energy science and energy laboratory, conducting basic and applied research to deliver transformative solutions to compelling problems in energy and security. ORNL's diverse capabilities span a broad range of scientific and engineering disciplines, enabling the Laboratory to explore fundamental science challenges and to carry out the research needed to accelerate the delivery of solutions to the marketplace.

SANDIA NATIONAL LABORATORY

Sandia has a long history of providing world-class capabilities in nuclear energy safety and licensing and in advance computational science and high-performance computing.

TENNESSEE VALLEY AUTHORITY

The nation's largest public power company, TVA plans to use more nuclear energy in achieving its vision to be one of the nation's leading providers of low-cost and cleaner energy.

UNIVERSITY OF MICHIGAN

The U-M College of Engineering is home to four leading engineering departments that are actively participating in CASL.

WESTINGHOUSE ELECTRIC COMPANY

Westinghouse Electric Company provides fuel, services, technology, plant design and equipment for the commercial nuclear electric power industry. Westinghouse nuclear technology is helping to provide future generations with safe, clean and reliable electricity.

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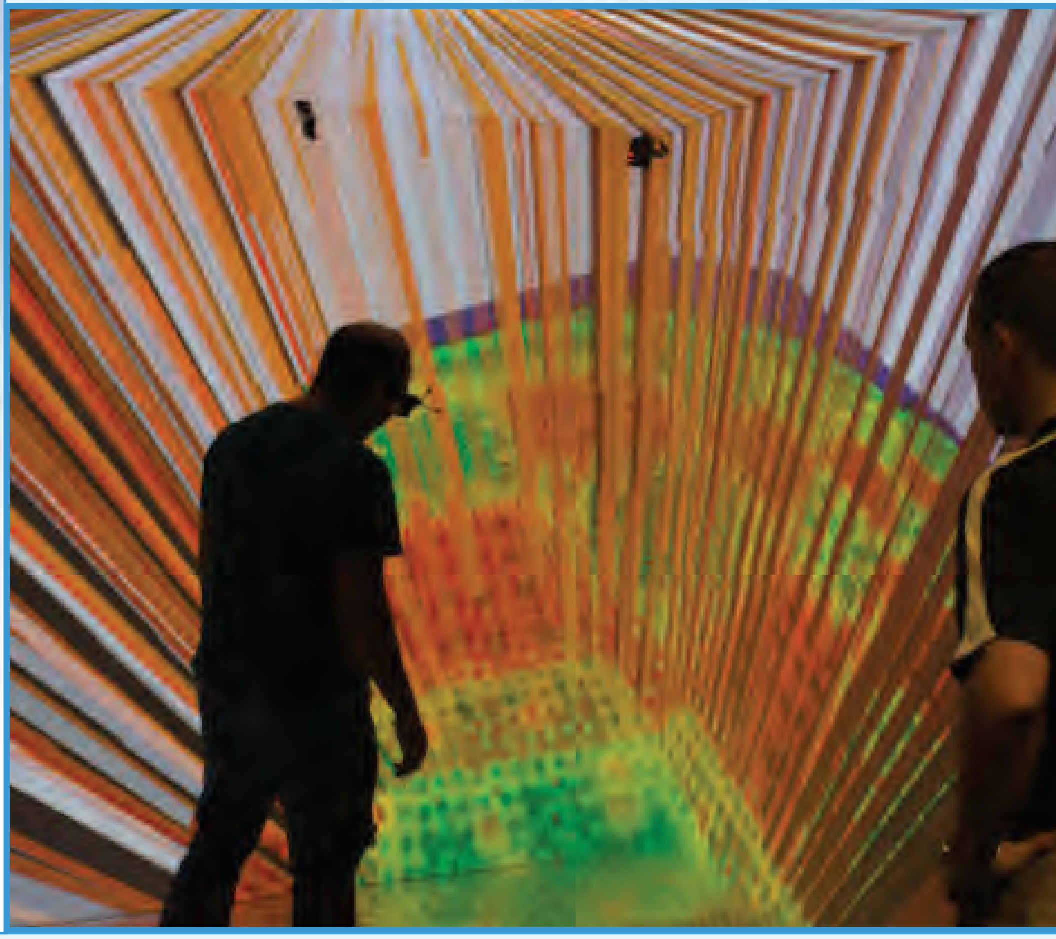
APPENDIX 2

CASL Brochure

A DOE Energy Innovation Hub

Improving reactor performance with predictive science-based simulation technology that harnesses world-class computational power



3D visualizations allow a physical walk-through of the top 20% of high-powered rods in a pressurized water reactor core. Details revealed provide insight into factors affecting core performance and aging. (Image courtesy of Tom Evans, ORNL).

Consortium for Advanced Simulation of Light Water Reactors

The Consortium for Advanced Simulation of Light Water Reactors (CASL) was established by the US Department of Energy in 2010 to advance modeling and simulation capabilities for nuclear reactors. CASL's mission is to provide computational capabilities that will make it possible to more accurately predict the behavior of phenomena that define the operational and safety performance of light water reactors (LWRs). In January 2015, the Department of Energy approved a second five-year phase for CASL, expanding its research and development activities through fiscal year 2019.

Through CASL, experts from national laboratories, universities, and industry are developing and deploying the Virtual Environment for Reactor Applications (VERA), a "virtual reactor" that can accurately simulate the physical processes taking place in a reactor at previously unattainable levels of detail. These processes include neutron transport, thermal hydraulics, nuclear fuel performance, corrosion, and surface chemistry. VERA incorporates science-based models, state-of-the-art numerical methods, modern computational science and engineering practices, uncertainty quantification and sensitivity analysis, and validation against data from operating reactors, experiments, and other sources to replicate these physical processes and to model their interactions.

Oak Ridge National Laboratory (ORNL) supercomputer, Titan, rated in 2014 as the leading HPC facility in the western world, supports CASL computational needs. (Image courtesy of ORNL)

CASL Achievements to Date

CASL is meeting milestones established by a well-defined yet flexible plan and delivering technologies that address industry issues. VERA has been deployed through "test stands" (prototype installations in actual engineering and design environments) and used to match actual startup and operations data for a Generation 2 reactor on the grid (the Tennessee Valley Authority's Watts Bar Unit 1) and to predict startup data for a Generation 3+ reactor design, the Westinghouse AP1000®, that is the basis for eight reactors now under construction. The CASL team is working to ensure that a subset of VERA, the VERA Core Simulator, can follow operational reactors through depletion, power maneuvering, and fueling cycles.

The models, methods, data, and understanding developed by CASL are being applied to create "useful and usable" tools to help the nuclear industry address three critical areas of performance for nuclear power plants (NPPs): (1) reducing capital and operating costs per unit of energy by enabling power uprates for existing NPPs and by increasing the rated powers and lifetimes of next-generation NPPs; (2) reducing nuclear waste volume generated by enabling higher fuel burnup, and (3) enhancing nuclear safety by enabling high-fidelity predictive capability for component performance through the onset of failure.

Innovations, Deployed Technologies, and an Effective Public-Private Partnership

- Integrated, goal-oriented, productive team spanning a geographically dispersed, heterogeneous set of organizations (national labs, universities, industry)
- Demonstrated, industry-reviewed predictions of reactor core behavior at previously unattainable levels of physical and geometric fidelity
- Multi-physics modeling and simulation of nuclear materials, corrosion chemistry, and fluids revealing insights that support enhanced operational maneuvering
- New fluid dynamics, chemistry, and materials modeling technologies that can resolve 3D reactor/fuel geometries via High Performance Computer oriented, advanced solution methodologies, for realistic nuclear fuel performance assessments
- Designer and researcher access to VERA's broad multi-physics simulation capabilities through a common "industry-friendly" interface for analyzing reactor operations

CASL Mission

Provide coupled, high-fidelity, usable capabilities needed to predict behaviors of light water reactor operational and safety performance-defining phenomena

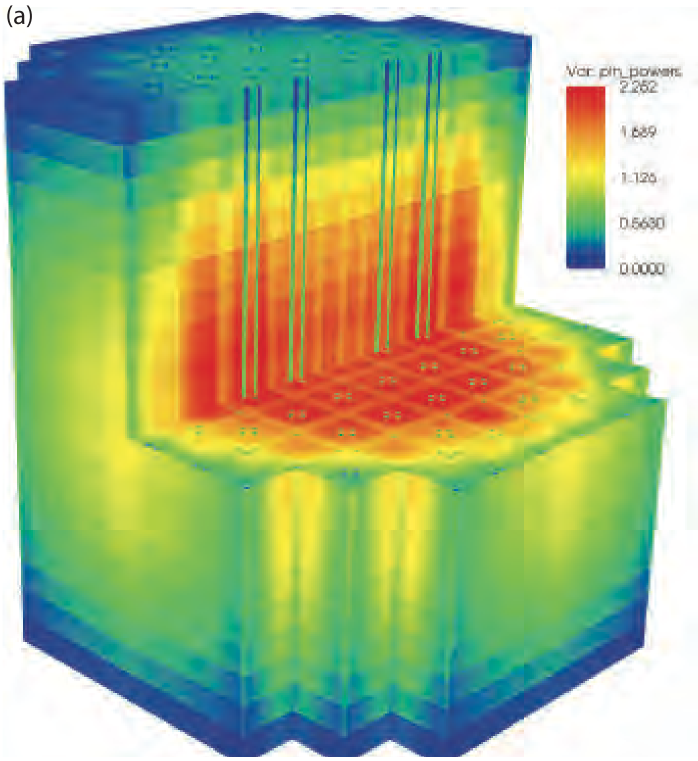
Strategic Goals

1. Develop and effectively apply modern virtual reactor technology (CASL's Virtual Environment for Reactor Applications: VERA)
2. Address design, operational and safety challenges for light water reactors (CASL Challenge Problems)
3. Engage the nuclear energy community through modeling and simulation
4. Deploy new partnership and collaboration paradigms

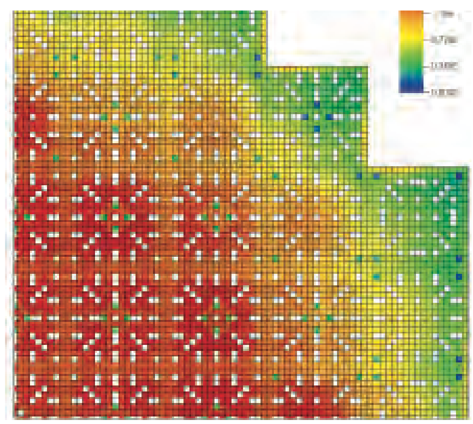
Illustration of VERA-CS Application to Integral Pressurized Water Reactor (iPWR) Small Modular Reactor (SMR)

The CASL VERA-CS is being used to model a four-year iPWR SMR cycle. The work has progressed to the 3D quarter-core calculations illustrated below: a) the 3D relative pin power distribution with a cutout section revealing the interior; b) the relative pin power distribution at the mid-axial plane; c) the core loading plan developed in the study associated with the power distributions.

(a)

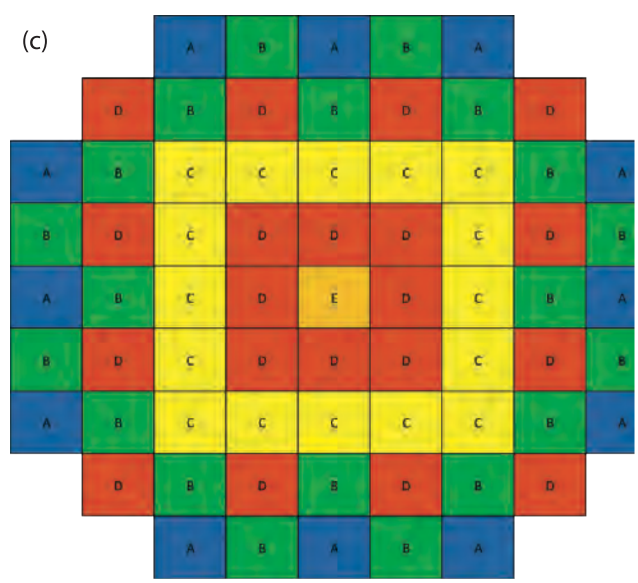


(b)



The white spaces in the image correspond to the pins that do not produce power (control rods and BPR pins).

(c)



Assembly Type	# Standard Fuel Pins	Standard Fuel Pin Enrichment	# Gd Fuel Pins	Wt% Gd
A	248	4.95	4	3
B	244	4.95	4	3
C	240	4.95	4	3
D	236	4.95	4	3
E	236	4.95	0	3

(Images courtesy of Kelly Kenner, Ivan Maldonado, University of Tennessee at Knoxville, Rose Montgomery, TVA, and Dudley Raine, B&W)

Achievements to Date
(FY 2010–FY 2014)

Year 1 . . .

- Technical roadmaps established for addressing high-priority Challenge Problems
- First high-resolution reactor core model for TVA Watts Bar plant
- First-of-a-kind three-dimensional (3D) assessment of fuel pellet-to-cladding interaction
- **VERA** founded with infrastructure and basic industry Core Simulator

Year 2 . . .

- Established methods for placing computer-based tools in industrial environments for real-life testing
- **VERA** produced neutronics simulation (prediction of changing neutron distribution in reactor core)

Year 3 . . .

- Expanded the neutronics capability to obtain unprecedented details on the movement of neutrons in a reactor core (demonstrated how to model the individual performance of thousands of fuel pins in an entire reactor)
- **VERA** internal release: Core neutronics + thermal hydraulics + fuel performance

Year 4 . . .

- Demonstrated application VERA tools to improve understanding of fuel-to-cladding interactions and the corrosion-induced power losses that result (reduding corrosion prevents power losses)
- **VERA** limited external release: Refinements to prior capabilities + corrosion and surface chemistry
- Completion and validation of VERA Core Simulator

Year 5 . . .

- **VERA** broad external release: Validate VERA with data from Watts Bar Unit 1 operating cycles and demonstrate CRUD challenge problem capababilites

CASL-U-2014-0089-001

Key Goals for 5 Year Extension
(FY 2015–FY 2019)

1. In it's second five-year phase, CASL will deepen its research and development for simulation of PWRs and broaden its applications to SMRs and BWRs through:
   - Fuel performance under accident conditions →further enhance safety of plants
   - Chemical and corrosion interactions between materials and coolants →reduce corrosion for longer-life plants
   - Two-phase thermal hydraulics for operational and transient reactor scenarios →more efficient plant performance
   - Expand to other types of reactors and reactors of the future →achieve industry-wide performance improvements
2. Develop the VERA core simulator kinetics capabilities and improve computational performance and accuracy → maximize value
3. Establish a self-sustaining organization, drawing from the CASL Industry Council, that is dedicated to the advancement and industry-wide deployment of VERA technologies → establish sustainable support for VERA

U.S. DEPARTMENT OF ENERGY | Nuclear Energy

All narrative and images contained in this publication were provided for uses relating to the Consortium for Advanced Simulation of Light Water Reactors (CASL), which is managed at Oak Ridge National Laboratory by UT-Battelle for the U.S. Dept. of Energy.

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APPENDIX 3

CASL Virtual Environment for Reactor Applications Fact Sheet

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 able to exploit HPC.

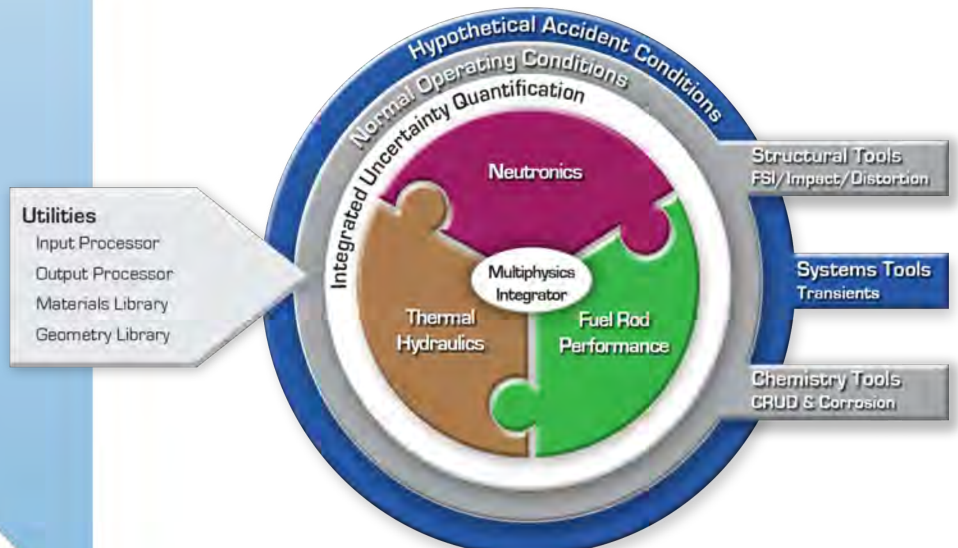
VERA bridges the gap between research and engineering by bringing together a suite of coupled software applications that simulate the behavior of a commercial LWR core under a variety of normal operating conditions. VERA integrates specialized knowledge of the multiple physics involved in nuclear power 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.

CASL Founding Partners

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:

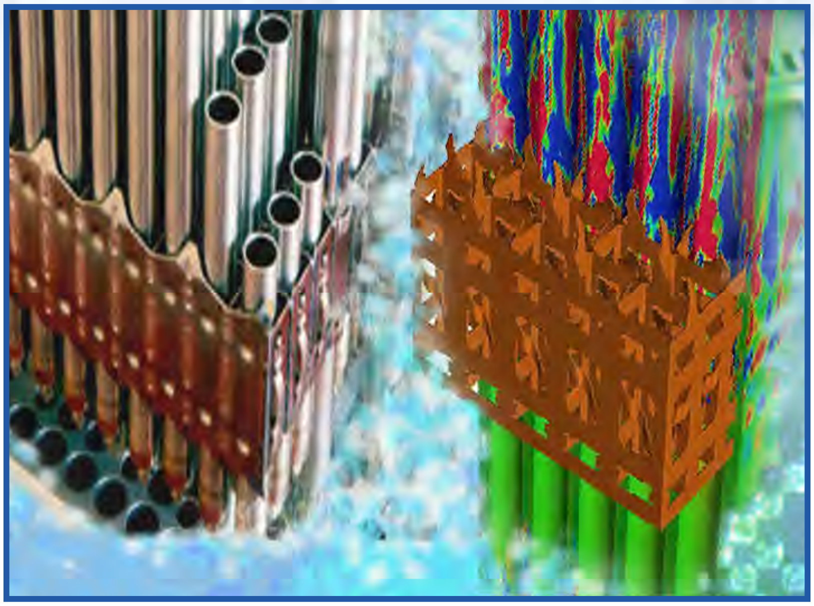
- Incorporating higher-fidelity modsim tools provided by DOE National Labs, academia, and industry into an integrated set of software tools for broad user access
- Coupling of the applications simulating the physics that drive reactor core performance
- Focusing on uncertainty quantification, validation, 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



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

Bridging the Gap between Research and Engineering

New technologies are "game-changers" in research if they can rapidly advance scientific understanding and lead to better-engineered systems and processes that are optimized for performance. However, the translation from basic scientific findings to applied engineering solutions requires tools that are practical if they are to be broadly employed in practice. CASL is working to achieve a technology "step change" by creating a scalable set of applications delivered through a powerful integration infrastructure.



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 phenomenona 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

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.

Comparison of VERA with Typical Industry Core Simulator Methods

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

The Virtual Environment for Reactor Applications (VERA) provides a suite of simulation tools for analysis of physical phenomena in operating commericial 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 follows 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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APPENDIX 4

CASL Challenge Problems Fact Sheet

CASL

Consortium for Advanced Simulation of LWRs

U.S. DEPARTMENT OF ENERGY

Nuclear Energy

Challenge Problems . . .
A Strategy that Demonstrates Progress

The nuclear industry employs a variety of science and engineering analysis techniques to understand and predict the performance of materials, components and subsystems involved in the diverse aspects of electric power generation. These analysis techniques, originating as far back as the 1960s and 1970s, have evolved over the past several decades as analytical methods have advanced and are validated based on experimental data from test reactors, commercial power reactors and unirradiated test loops.

Traditional industry simulation techniques are often based on the simplifying assumption that multiple and simultaneously interacting physical processes occurring can be conservatively bounded through simulation as uncoupled (independent), or loosely coupled (mildly dependent) processes. This approach has served the industry well and continues to support the safe operation of reactors and reliable performance of nuclear fuel. However, in order to achieve the key CASL challenges of enabling power uprates, increasing fuel burn-up and cycle length, and lifetime extension for U.S. nuclear plants, there is a need for higher fidelity tools and closely coupled tools. CASL's approach is to develop and apply modeling and simulation techniques that incorporate key science-based physical models, state-of-the-art numerical methods, and modern computational science into a useful and usable problem-solving simulation environment for nuclear scientists and engineers.

CASL's development plan is built around several issues relevant to operating commercial power reactors called "Challenge Problems" to drive development and demonstrate progress with results that can be applied to today's commercial power generation industry. CASL scientists are able to more precisely represent the normal operating conditions in a reactor. The integrated, coupled solutions are expected to reduce the uncertainties intrinsic in sequential analyses and provide a more realistic representation of the reactor behavior.

What is a Challenge Problem?

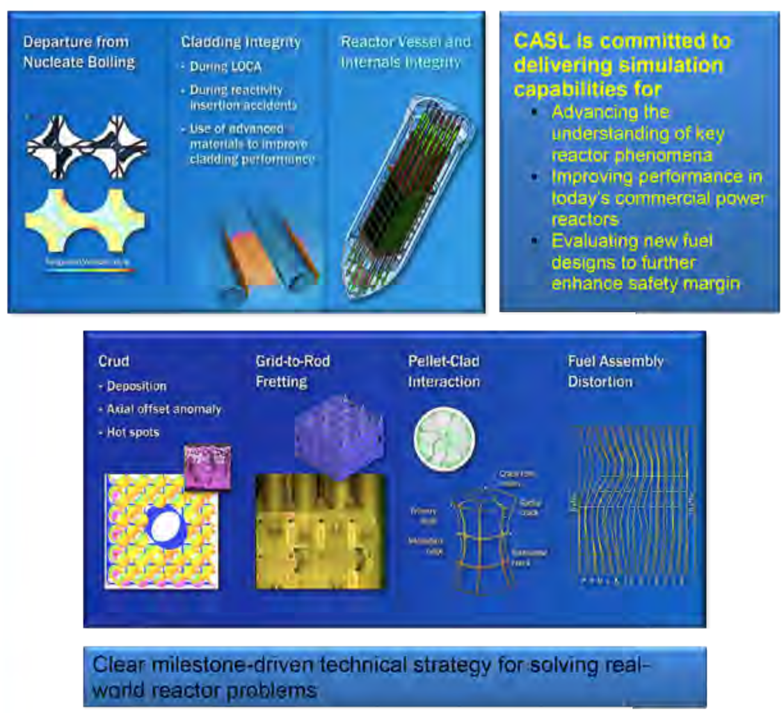
CASL is focused on a set of specific *Challenge Problems* that encompass phenomena currently limiting the performance of some pressurized water reactors. The Challenge Problems drive the development of the higher-fidelity coupled physics tools and demonstrate the application of the tools on existing issues, bringing immediate insights to the commercial nuclear power industry.

CASL defines a *Challenge Problem*s as one whose solution is:

1. important to the nuclear industry and
2. amenable to, or enabled by, modern modeling and simulation techniques.

CASL Focuses on Selected Challenge Problems

Key safety-relevant reactor phenomena that limit performance



Chalk River Unidentified Deposits (CRUD) and CRUD-induced Localized Corrosion (CILC)

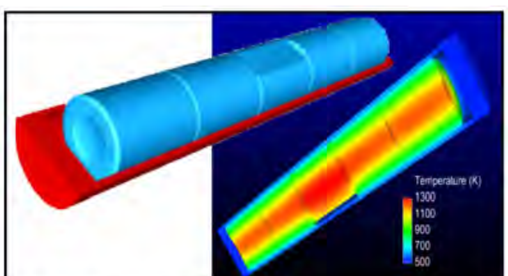
Decades ago, the unidentified deposits on Chalk River fuel elements were corrosion products from the reactor and steam generator piping; today it is known that the thickness of CRUD on the fuel is directly related to local rod power density. Thick CRUD deposits can lead to CILC and leaking fuel rods, and commercial power operations can be limited to reduce the risk of CILC failures. *Improved understanding could allow reactors to move to higher power densities.*

Grid-to-Rod-Fretting (GTRF)

Flow fields around the reactor fuel can cause the rods to vibrate against the supporting structures, eventually wearing a small hole through the fuel rod cladding. Some fuel designs are more vulnerable to vibration than others, and higher power operation and higher burn-ups can exacerbate the vulnerability. *Higher fidelity coupled physics simulations can provide a more comprehensive understanding of the design sensitivities leading to GTRF and allow for optimization of fuel designs to completely eliminate this failure mode.*

Pellet–Cladding Interaction (PCI)

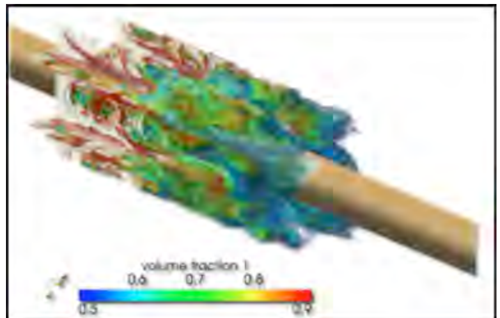
Commercial nuclear fuel utilizes pelleted uranium dioxide powder inside a zirconium-based alloy tube called "cladding." As-manufactured fuel rods include a small gap between the pellet and the cladding, and as the fuel rod is operated in the reactor, the cladding creeps down to rest on the pellet diametrical surfaces, resulting in pellet-cladding interaction. As power is varied, the pellet can swell or shrink, and the cladding tries to keep up. Very fast power changes can result in small tears in the cladding. Power uprates and increased burn-up reduce the ability for the cladding to keep up with power-induced pellet swelling, increasing the likelihood for cladding tears (fuel rod leaks). *Higher fidelity models could provide a high-resolution local simulation of the pellet and cladding behavior, providing a local best estimate (rather than bounding) performance margin for power maneuvers, insights into better pellet designs, and simulations of rod performance during postulated accident conditions.*



CASL PCI Simulation illustrating the local effects of a fuel pellet chip

Departure from Nucleate Boiling (DNB)

Nuclear reactors create electricity efficiently through the heating of the reactor coolant in a process called nucleate boiling. Departing from the nucleate boiling regime to a film boiling regime leads to local dryout of the cladding surface , causing a dramatic reduction in heat transfer capability during certain accident transients (e.g., overpower and low coolant flow). Predicting the critical heat flux (CHF) that causes the departure from nucleate boiling is currently accomplished through extensive, expensive testing and is highly design dependent. These empirical correlations do not allow for any extrapolation, and new fuel designs cannot be developed without a DNB test. *A science-based high fidelity simulation tool can allow for more efficient fuel designs and potentially allow or deriving more power from existing reactors.*



CASL Multi-field flow mixing proof of analytical concept

Cladding integrity during Loss of Coolant Accident (LOCA) or Reactivity Insertion Accident (RIA))

During an accident event, it is desirable to keep the fuel pellets contained within the fuel rod cladding. Maintaining the cladding integrity allows for containment of any fission products and provides a coolable fuel geometry. Predictions for cladding integrity during challenging accident scenarios are currently based upon a limited number of irradiated fuels tests. *A science-based high fidelity simulation tool can allow for better understanding of fuel performance, allowing for optimization of current designs and perhaps facilitating the development of future accident tolerant designs.*

CASL's Challenge Problem approach provides a flexible framework to drive development while providing near term insights for industry implementation. CASL's industry partnership allows for seamless industry integration and offers quick course corrections when needed.

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CASL-U-2013-0108-000