Vision 2030:
The Advanced Simulation and Computing Program

Shaping the Future of Nuclear Security

Los Alamos
NATIONAL LABORATORY

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Message from the ASC Program Director

Dear colleagues and partners,

It is with great pride and a clear sense of purpose that I introduce “Shaping the Future of Nuclear Security.” This vision encapsulates where we aim to lead our Advanced Simulation and Computing (ASC) program by 2030, building on the strong legacy of the ASC program across the breadth of the nuclear security enterprise. Our goal is to enable a future for nuclear security that is not only vibrant and secure but also agile and efficient in the face of ever-evolving challenges. Over the next half-decade, we are committed to investing in the capabilities and workforce that will drive us toward this ambitious future.

At the core of our mission is the critical role of simulation in ensuring the safety and security of our nation’s nuclear assets. Since 1995, our program has evolved significantly, adapting to the needs of each era while maintaining our unwavering commitment to excellence. By integrating the lessons of the past with the technological opportunities of today, we are poised to move forward with confidence, creating a legacy of progress and resilience that will serve future generations.

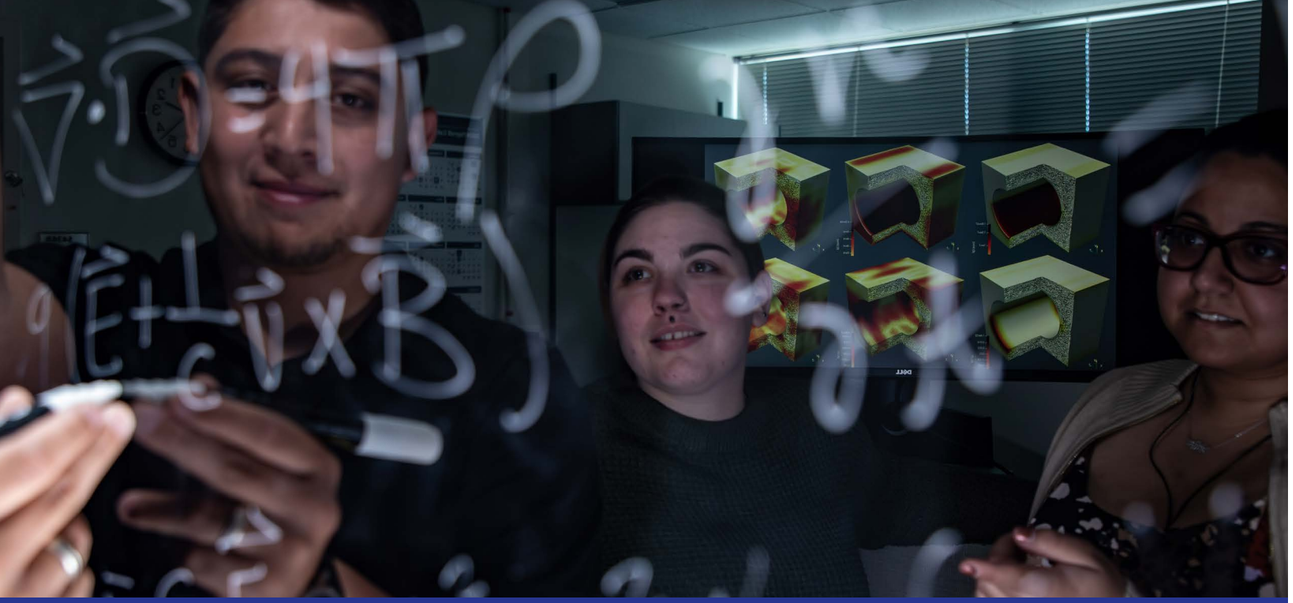
Our vision for the future is proactive and bold. We are not merely passengers on this journey; we are actively shaping the path ahead. By envisioning where we want to be, rather than settling for where we are, we strive to be faster, smarter, and better in all that we do. This means pushing the boundaries of what is possible and breaking down the barriers that limit our potential.

None of this will be possible without our dynamic and dedicated workforce. Our people are our greatest asset, and their innovation, dedication, and expertise are the driving force behind our success. As we move forward, we will continue to cultivate a culture rooted in our core values of teamwork, transparency, and trust. These principles, along with our commitment to excellence in all areas, guide our decisions and actions every day.

Together, we are shaping the future of nuclear security. I am confident that with our shared vision, dedication, and commitment to excellence, we will achieve remarkable success in the years to come.

Sincerely,

Scott Doebling, PhD
Senior Director, Advanced Simulation & Computing
Los Alamos National Laboratory

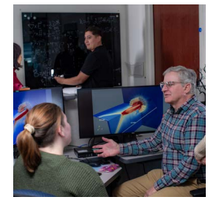


Shaping the Future of Nuclear Security:

Our Vision for Simulation and Computing in 2030

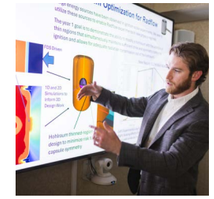
As we look toward 2030, our commitment to advancing the state of simulation and computing for nuclear security is driven by a clear vision. We aim not only to meet the demands of the future but to shape it by developing cutting-edge technologies and capabilities that will ensure the safety and reliability of our nuclear deterrent. Here is how we see the future and how we plan to lead the way.

The Future of Nuclear Security



- **New Systems and Concepts for Deterrence:** Our capabilities will be used to develop and implement innovative systems and concepts that redefine nuclear deterrence, ensuring our nation's security in an increasingly complex global landscape.
- **Increasing Reliance on Simulation for Design, Manufacturing, and Certification:** As we move forward, the role of simulation will expand, becoming integral to the design, manufacturing, and certification processes, reducing the need for physical testing, and accelerating time to deployment.
- **Agile and Efficient Responses to Emerging Threats:** The evolving nature of global threats demands that our approaches to nuclear security be both agile and efficient, enabling rapid adaptation to emerging challenges and opportunities.

How We Will Shape the Future



- **Be Leaders in Key Areas:** We will establish ourselves as leaders in the most critical areas of simulation and computing, driving innovation and setting the standards for the industry.
- **Help Lead the Conversation:** We will actively engage in and lead the national and international discourse on nuclear security, ensuring that our perspectives and expertise shape the policies and practices of the future.
- **Drive Solutions that Deliver for the Mission:** Our focus will be on developing and implementing solutions that directly support our mission, ensuring that every innovation and advancement is aligned with our core objectives.
- **Leverage Partnerships Across the Nation and World:** By building and strengthening partnerships with other leading institutions and experts around the globe, we will harness a broad range of knowledge and resources to advance our goals.

Through these strategies, we are not just preparing for the future—we are actively shaping it, ensuring that our nation remains secure and resilient in the face of any challenge.

Our Principles

Our principles embody our commitment to achieving exceptional performance across multiple dimensions, ensuring that every aspect of our work meets the highest standards. This holistic approach allows us to balance and optimize all elements of our mission, driving success in every endeavor.

Excellence in and for our workforce

We are dedicated to fostering a culture of continuous learning and development, ensuring that our workforce is equipped with the skills and knowledge needed to excel in an ever-changing environment.

Excellence in mission delivery

Our focus on delivering superior results ensures that we meet and exceed the expectations of our stakeholders, consistently achieving our mission objectives with precision and reliability.

Excellence in evolution of capabilities

We are committed to advancing our capabilities, embracing innovation, and adopting new technologies that keep us at the forefront of our field.

Excellence in envisioning and planning for disruption

By anticipating and preparing for potential disruptions, we position ourselves to adapt quickly and maintain our leadership in nuclear security.

Excellence in balance of research and development with operations and user support

We strive to get faster, smarter, and better, continually improving our research and development efforts while effectively managing operations and user support to deliver on today's mission without compromise.

Our Mission in 2030

As we look ahead to 2030, our mission remains focused on ensuring the safety and effectiveness of the nation's nuclear deterrent while adapting to emerging challenges. Our core mission applications in 2025 will continue to be critical in 2030, including the following:

Certify and assess the aging nuclear deterrent

We will continue to rigorously evaluate the reliability and safety of our aging nuclear arsenal, ensuring that it remains a credible deterrent in an ever-changing global landscape.

Design and certify the nuclear deterrent of the future and address global threats

Our work will extend to developing and certifying next-generation nuclear capabilities, addressing both current and emerging global threats to maintain national security.

Simulate fundamental and integral experiments for design, insight, discovery, and validation

Advanced simulations will be at the heart of our efforts, providing the critical insights needed for design innovation, scientific discovery, and experimental validation.

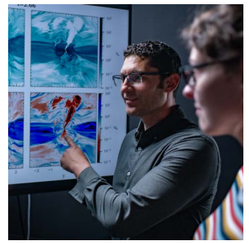
Empower agile and efficient manufacturing for the nuclear security enterprise

We will improve and promulgate simulations tools that enhance our manufacturing capabilities, ensuring they are agile, efficient, and capable of supporting the complex needs of the nuclear security enterprise, including processing of plutonium and high explosives.

Looking to 2030, the drivers shaping our mission will include the following:

- **Executive Orders and National Security Memoranda regarding Artificial Intelligence (AI)**
  As AI technology evolves, it will play a pivotal role in advancing our mission, necessitating continuous adaptation to new scientific, security, and legislative landscapes. Our work will align with national directives on AI, ensuring our strategies and implementations are at the forefront of innovation and security.
- **United States Nuclear Posture Commission Reports**
  The strategic direction provided by these reports will guide our efforts, ensuring our nuclear deterrent remains robust and responsive to national security needs.
- **NNSA Strategic Priorities**
  Our initiatives will be closely aligned with the strategic priorities set forth by the National Nuclear Security Administration (NNSA), driving our mission forward in concert with national objectives.
- **ASC Program Priorities**
  The Advanced Simulation and Computing program will continue to define the cutting-edge research and development needed to support our mission, guiding us toward technological and scientific excellence.
- **National Academies and JASONs Reports**
  Insights from these esteemed bodies will shape our approaches, ensuring our work is informed by the latest scientific research and expert recommendations.
- **Los Alamos National Laboratory Agenda**
  Our activities will be integrated with the broader Lab Agenda, ensuring that our mission aligns with the Laboratory's overall goals and vision for the future.

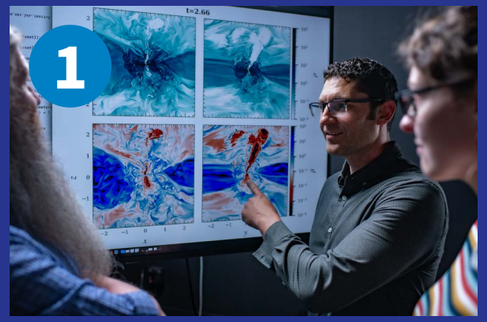
These drivers, combined with our core mission applications, will ensure that we remain at the forefront of nuclear security, prepared to meet the challenges of 2030 and beyond.



Our Strategic Capabilities

Strategic capabilities define the foundational tools and resources necessary to effectively implement and sustain our mission-critical applications, ensuring that they align with program goals and deliver desired outcomes.

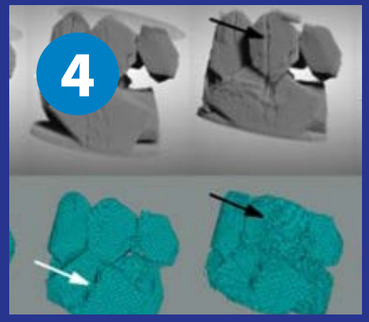
READ MORE ON THE FOLLOWING PAGES >



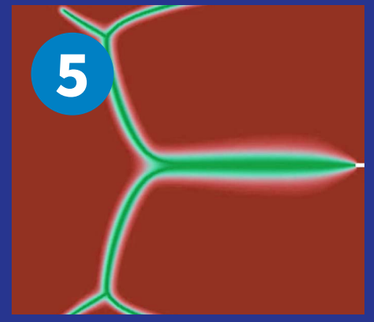
Everyday Predictive 3D Simulation

Advanced Technology Computing

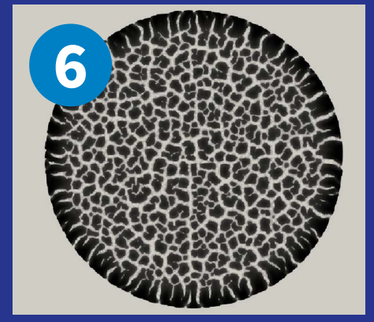
Transformative Simulation Workflow



Validated Physics Modeling



Integrated Artificial Intelligence



Leading AI-Ready Data Stewardship

Innovative Workforce Development

Next-Generation Facilities and Operations

1 Everyday Predictive 3D Simulation

We lead the way in creating and delivering cutting-edge predictive 3D-simulation solutions that empower users to answer critical questions, explore complex physical behaviors, and make informed decisions with unmatched accuracy. Our leadership is demonstrated in our ability to provide 3D simulations with turnaround times that perfectly align with the natural pace of human decision-making, setting the standard for efficiency and accuracy.

Key investment areas and vision for 2030 are:

- **Evolving Our Codebase:** We are transforming our codebase to improve portability, maintainability, and performance by leveraging advanced technologies such as GPUs, hybrid CPU/GPU architectures, and cloud computing. Our software will set the standard for computational efficiency and adaptability across evolving platforms.
- **Validated physics capabilities:** We focus on delivering highly accurate and reliable simulations with quantified uncertainties. Our validated and data-driven physics capabilities will drive confident modeling of real-world phenomena into actionable insights.
- **3D computational algorithms:** We are actively investing in 3D computational research to ensure our algorithms and numerical methods are robust, precise, and performant. Our innovations will lead the way in accurately assessing complex physical phenomena, answering mission-critical questions with unmatched precision.

2 Advanced Technology Computing

We harness high-performance computing technologies to deliver solutions that drive innovation and efficiency across complex challenges.

Key investment areas and vision for 2030 are:

- **Leadership in computing technology:** We pioneer the future of high-performance computing by integrating advanced CPU, GPU, and quantum computing systems, ensuring unmatched computational power and versatility to tackle the most complex challenges.
- **Co-design of computing systems:** We lead in co-design of computing systems and computational algorithms, which is crucial for improving computational efficiency and overcoming the limitations of current hardware and software. Success requires ever-deeper collaboration between code developers and hardware designers.
- **Partnering with industry-driven solutions:** High-performance computing platform solutions are ever-more driven by AI and other data-intensive applications and less by traditional modeling and simulations. We partner with industry to shape and employ those hardware designs that are optimized for our sparse data configurations and branch-intensive numerical algorithms.

3 Transformative Simulation Workflow

For unprecedented quality of user experience, we create and support simulation workflows that streamline processes, enhance accuracy and repeatability, and accelerate decision-making.

Key investment areas and vision for 2030 are:

- **Simulation setup and execution:** We lead in providing standardized tools that enable efficient and consistent simulation inputs, code execution, system scheduling, and job management to ensure reliable and repeatable simulation processes independent of the computing platform, configuration, or location.
- **Analysis and visualization:** We provide the user with robust and easy-to-use tools for data interpretation, visualization, and analysis to empower quicker and more accurate decision-making.
- **Connecting the digital thread:** We enable our users to integrate physics simulations with CAD geometries and engineering simulations for seamless design and simulation iterations.

4 Validated Physics Modeling

We develop, implement, and validate robust physics models that incorporate the effects of aging, microstructure, and novel materials, particularly under extreme physical conditions, ensuring our simulations are physically accurate and deliver reliable, actionable insights.

Key investment areas and vision for 2030 are:

- **Aging and microstructure research:** We conduct cutting-edge research on aging and microstructure to understand and predict the long-term behavior of materials under various conditions. By analyzing these fundamental processes, we enhance the reliability and performance of materials in demanding applications.
- **Multi-scale modeling:** We invest and lead in methods to link micro-scale material behavior to macro-scale system behavior. This enables unprecedented understanding of aging and manufacturing impacts for crucial mission-related decisions.
- **Validation suites:** We have robust, hierarchical suites of calculations that measure the accuracy of physics simulations relative to experimental data across scales of simulation ranging from single-physics to full mission-relevant systems.

5 Integrated Artificial Intelligence

We actively pursue innovative approaches to leverage AI methods, aiming to accelerate mission delivery by streamlining processes and improving efficiency. By optimizing decision-making through AI-driven insights, we empower our teams to make more informed and timely choices. Additionally, we enhance our predictive capabilities, allowing us to anticipate challenges and opportunities with greater accuracy, ultimately driving mission success.

Key investment areas and vision for 2030 are:

- **Enhanced workflow management:** We leverage AI methods to assist in creating, modernizing, improving, and maintaining our computational physics codes and workflows, leading to more robust, performant, and reliable software products and tools that can be used and maintained efficiently.
- **Modeling for the mission:** We develop AI models to assist in addressing the challenges of our mission areas by providing advanced insights, accelerating discoveries, enhancing real-time decision-making, and automating complex processes, ultimately driving more precise and effective mission outcomes.
- **Model trustworthiness:** We ensure the trustworthiness of AI models for mission-critical applications by rigorously validating and testing them to deliver reliable, transparent, and mission-aligned outcomes.

6 Leading AI-Ready Data Stewardship

As part of the digital transformation of the NNSA enterprise, we lead data stewardship that ensures AI-ready data integrity and availability and cultivates a strong data culture, laying the foundation for reliable and impactful AI-driven insights across our mission applications. We implement FAIR data practices to ensure that our data is findable, accessible, interoperable, and reusable, maximizing its value for innovation and collaboration across our organization.

Key investment areas and vision for 2030 are:

- **Data governance:** We enforce robust data governance policies to ensure the accuracy, security, compliance, and AI-readiness of our data, empowering informed decision-making and fostering trust across the nuclear security enterprise.
- **AI-ready data:** We have processes and tools that ensure data are prepared meticulously for AI applications, ensuring that it is clean, structured, and optimized to maximize the accuracy, effectiveness, and trustworthiness of our AI models.
- **Complex-wide digital thread:** We have data management systems, tools, processes, and network infrastructure that empower the seamless integration of data from across the nuclear security enterprise (labs, plants, sites) into a complex-wide digital thread to enhance decision-making, collaboration, and overall productivity.

7 Innovative Workforce Development

We invest in workforce development to equip our team with the latest skills and knowledge in leading-edge simulation and computing, ensuring they remain at the forefront of technological advancements. We provide ongoing training and hands-on experience with cutting-edge tools and methodologies, fostering a culture of continuous learning and innovation. By cultivating a highly skilled and adaptable workforce, we empower our organization to tackle the most complex challenges in simulation and computing with confidence and expertise.

Key investment areas and vision for 2030 are:

- **Partnerships:** We forge strategic partnerships with academic, industry, and government leaders to enhance our workforce's expertise and keep our team at the cutting edge of simulation and computing technologies.
- **Culture:** We foster a culture of innovation and collaboration, where our workforce is encouraged to explore new ideas, share knowledge, and continuously push the boundaries of what's possible in simulation and computing.
- **Development:** We prioritize the professional development of our team through targeted training, mentorship, and real-world experience, ensuring they are equipped to lead in the ever-evolving fields of simulation and computing.

8 Next-Generation Facilities and Operations

We drive the future of high-performance computing facilities by continually advancing our infrastructure to support the most demanding computational challenges. We optimize operations to deliver unprecedented speed, efficiency, and reliability, ensuring our systems are always at the cutting edge of technology. We innovate to create scalable solutions that meet the growing needs of next-generation scientific and industrial applications.

Key investment areas and vision for 2030 are:

- **Reliable power and cooling:** We develop and implement cutting-edge power and cooling solutions to ensure our future supercomputing infrastructure operates at peak efficiency and reliability. We site our facilities to maximize access to sufficient power and cooling resources.
- **Open ecosystem for system management and environments:** We lead the development and deployment of open collaborative software solutions for High Performance Computing (HPC) system management and HPC environments.
- **Advanced artificial intelligence and automation:** Investing in AI-driven management and automation tools will be critical for optimizing operations, improving resource allocation, and enhancing the overall efficiency and reliability of computing facilities.

Our Subprograms

Our Vision 2030 comprises an integrated view of the ASC program at Los Alamos National Laboratory. Functionally, we are organized into six subprograms to facilitate innovation, planning, and execution of our complex work scope.

Integrated Codes

We research, develop, integrate, and deliver multi-physics simulation capabilities making use of advanced methods and algorithms, physics models, and leading-edge high-performance computing platforms.

Physics and Engineering Models

We research and develop physics models, data tables, and parameters for integration and utilization in ASC multi-physics code capabilities for applications pertinent to stockpile modernization efforts, deepening our scientific understanding for future designs and for new advanced and expedient manufacturing processes.

Verification and Validation

We develop, apply, and maintain methodologies, data suites, and toolsets for verification and validation to provide statistically quantifiable assessments of the accuracy and fidelity of our most advanced multi-physics simulation capabilities. This capability includes rapidly evolving data-driven approaches and models of differing fidelity ensuring they are explainable, predictive, and trustworthy.

Computational Systems and Software Environments

We lead to the research, development, and targeted productization of integrated, scalable computational and computer science-based capabilities—encompassing both hardware and software—to meet the predictive simulation requirements of the NNSA and support the needs of other ASC subprograms at LANL.

Computing Platforms

With a deep knowledge of the HPC technology landscape and the capability needs of the integrated codes, we develop and procure the latest computer platforms for the ever-increasing performance demands for the current and future stockpile.

Facility Operations and User Support

We provide world-class HPC operations for conducting leading-edge simulation and computing to resolve critical nuclear performance and safety questions. This is accomplished through the development and support of a diverse ecosystem of HPC platforms and the physical infrastructure necessary for their operation.

Capabilities for Nuclear Intelligence

We develop the expertise and resources that support nuclear intelligence assessments and ensure the resilience of the United States nuclear deterrent.

Our Partnerships

Partnerships are essential for advancing our mission and shaping the future of nuclear security. Through strategic collaborations, we enhance our capabilities and drive innovation across the nuclear security landscape.

LANL Organizations

We work closely with key LANL organizations, including A, CCS, EES, HPC, T, WRS, XCP, XTD, ALDSCT, ALDEPS, and more, to leverage internal expertise and resources. These collaborations enable us to harness the full potential of our institution's diverse capabilities.

NNSA Programs

Our collaboration with NNSA programs and organizations, such as the Office of Experimental Sciences (NA-113), Office of Engineering and Technology Maturation (NA-115), Office of Stockpile Management (NA-12), and Office of Production Modernization & Materials Management (NA-19), will be critical for aligning our efforts with broader national security goals. By working in tandem with these programs, we ensure that our initiatives are tightly integrated with national priorities.

NSE Partners

Partnerships with Sandia National Laboratories (SNL) and Lawrence Livermore National Laboratory (LLNL), as well as partnerships across the broader family of NNSA sites and plants, strengthen our collective capabilities within the nuclear security enterprise. These collaborations enhance our ability to address complex challenges through a unified approach.

Commercial Enterprises

Collaborations with leading commercial enterprises, including Hewlett Packard Enterprise, Nvidia, and OpenAI will help us stay at the cutting edge of technology. By integrating the latest technological advancements, we ensure our systems remain robust and future-proof.

Universities and Scientific Laboratories

Engaging with academic institutions, such as the University of Michigan, Purdue University, and scientific laboratories enriches our research and development efforts and helps cultivate the next generation of scientific talent. These partnerships foster innovation and ensure a continuous pipeline of expertise and fresh perspectives.

Acknowledgements

Scott Doebling, Ed Dendy, Kris Eriksen, Jimmy Fung, Angela Herring, Jason Hick, Tabitha Lopez, Jim Lujan, DJ Luscher, John Patchett, Gowri Srinivasan

AI could have served as a research assistant, writing assistant, or editor in this content.

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NNSA National Nuclear Security Administration