Joint Economic Committee

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Artificial Intelligence and Its Potential to Fuel Economic Growth and Improve Governance

Chairman Heinrich, Vice Chairman Schweikert, and distinguished members of the Committee, I want to thank you for the opportunity to testify today regarding artificial intelligence (AI) and innovation and specifically for the chance to talk about the role of the national labs in this area.

Summary

This afternoon, I want to make a few key points, and since I am a Sandia National Labs employee, I will use Sandia as an example of the critical role that the Department of Energy (DOE) national labs play in computing and highlight how this provides them with a solid foundation for leading in AI innovations going forward.

The DOE labs have:

- Led in computing breakthroughs throughout the nation's history,
- Addressed critical societal and security challenges through decades of strategic AI research, and
- Accelerated computing innovations through collaboration with universities and the private sector.

Sandia National Laboratories Overview

Sandia is one of three research and development (R&D) labs of the U.S. DOE's National Nuclear Security Administration. We are a multimission laboratory with most of Sandia's employees working in Albuquerque, New Mexico (NM) or at its second principal laboratory in Livermore, California, to deliver innovative and reliable solutions in a changing world. Our roots go back to World War II and the Manhattan Project. The lab was established in 1949 with the goal of advancing U.S. national security by developing science-based technologies. Throughout its 75-year history as a multidisciplinary, national security, engineering laboratory, [2] Sandia's primary mission has been to ensure the U.S. nuclear arsenal is safe, secure, reliable and can fully support our nation's nuclear deterrence (ND) policy, but there is strategic synergy and interdependence between Sandia's ND mission and its capability-based science and engineering foundations because breakthroughs in one area beget discoveries in others in a cycle that pushes boundaries and fuels advancement.

[1] Sandia National Laboratories is a multimission laboratory managed and operated by National Technology and Engineering Solutions of Sandia LLC, a wholly owned subsidiary of Honeywell International Inc. for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525. **SAND2024-067400**

[2] https://www.sandia.gov/news/publications/fact-sheets/

Through this cycle, Sandia has: [3]

- Designed a brain-inspired cybersecurity system to detect malicious players 100 times faster, while using less electricity than a standard 60-watt light bulb,
- Developed an ion exchange material that was later used to remove radioactive material from wastewater in Japan's earthquake-damaged Fukushima Daiichi nuclear power plant,
- Developed robots that can reach trapped miners, demilitarize submunitions, and disable Improvised Explosive Devices,
- Created zero-emission fuel cells for marine application that are now powering a passenger ferry in the California Bay Area, and
- Designed and manufactured radiation-hardened microelectronics that enabled the Galileo spacecraft to travel 2.8 billion miles and withstand Jupiter's intense radiation belts.

This cycle also allows Sandia to assist a wide variety of small businesses throughout NM through the New Mexico Small Business Assistance (NMSBA) Program. [4] The NMSBA Program facilitates access for select small businesses to experts at Sandia and Los Alamos national laboratories who can help them gain knowledge and solve challenges utilizing the labs' cutting-edge technologies. In addition, since the NMSBA was established in 2000, 11,116 new jobs have been created and retained in NM through $80.6M in technical assistance to 3,267 New Mexico small businesses, and all 33 NM counties have been supported. Overall, Sandia has contributed over $140 billion to the United States economy through its local, regional, and national partnerships since 2003.

Now, I would like to employ a quote from the past related to new stockpile needs to help our discussion transition into a segment showcasing how Sandia's history of significant contributions in computing position it and other national labs to continue the pivotal ongoing exploration and development of AI technologies.

"We have a 10-year window; if we do not have sufficient computer simulation capabilities by then, we will need to go back to testing and that will probably not be an option. We must succeed. The laboratories will need to change to being experiment- and computer-driven within a 10-year window, rather than test-driven as in the past."
-Dr. Victor Reis, DOE Assistant Secretary for Defense Programs

Dr. Reis' call to action resulted in the Accelerated Strategic Computing Initiative (ASCI), leading the three DOE NNSA national laboratories, Sandia, Lawrence Livermore, and Los Alamos to partner with each other, industry, and academia to quickly develop, deliver, and support the high-performance computational capabilities needed for the U.S. nuclear deterrence mission. ASCI, now known as the Advanced Simulation and Computing (ASC) program, has revitalized the U.S. supercomputing industry through strategic technical leadership and partnership with industry. [5]

[3] https://www.sandia.gov/app/uploads/sites/165/2022/03/70-ways_2019-12801M.pdf
[4] https://www.nmsbaprogram.org/
[5] https://www.hpcwire.com/2018/11/09/how-asci-revolutioned-the-world-of-high-performance-computing-and-advanced-modeling-and-simulation/

Snapshot of Sandia's Role in Computing Innovations

Sandia's legacy in high performance computing (HPC) has brought together experts from various fields—ranging from engineering and physics to computer science—to work collaboratively on improving computing technologies. This teamwork has led to the creation of some of the most powerful computers in the world.

Notably, Sandia developed the first massively parallel processing supercomputer in 1990 and the supercomputer Red Storm in 2006, which enabled nuclear stockpile calculations, modeled the amount of explosive powder needed to destroy an asteroid, and demonstrated how changes in the composition of the Earth's atmosphere affects climate. Peter Ungaro, the CEO of Cray in 2001, reflected on the integral nature of Red Storm and their partnership with Sandia saying, "Literally, this program saved Cray." [6] In addition, Sandia's commitment to improving supercomputing performance earned three R&D 100 Awards[7] in a 10-year period for increasing the efficiency of massively parallel computing across a variety of science and engineering systems.

On behalf of NNSA's ASC Program, the Vanguard program at Sandia continues the commitment to advancing computing technologies. One of the Labs' notable achievements includes the development of the Astra platform, [8] a computer that marked a significant advancement by using technology commonly found in smartphones (ARM processors) to perform complex calculations at unprecedented speeds. This innovation represents a major shift in how powerful computing technologies are built and used. These ARM architectures are now found in NVIDIA's Grace Hopper AI chips.

Industry engagement though the PathForward initiative[9] was also central to helping advance HPC technologies for the DOE Exascale Computing Project. This collaborative effort between U.S. national laboratories and industry partners fostered partnerships with leading tech companies such as AMD, Cray, Hewlett Packard Enterprise, IBM, Intel, and NVIDIA, and accelerated the development of exascale computing systems capable of performing a billion billion calculations per second. To get to this milestone and overcome challenges related to power, consumption, scalability, and reliability, the collaborators had to innovate in hardware, software, and system integration. The initiative overall helped ensure the U.S. remained at the forefront of computational science, facilitating significant scientific, economic, and national security advancements. As Trish Damkroger at HPE said, "Exascale supercomputing has already demonstrated a significant impact on the scientific community, which spans various initiatives across public and commercial sectors…At HPE, we are honored to continue closely collaborating with the U.S. Department of Energy, the Exascale Computing Project, and national laboratories to bring exascale technology to life and into the hands of researchers, scientists, and engineers that are solving problems to advance humanity." [10]

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[6] https://www.datacenterdynamics.com/en/analysis/after-the-storm-the-supercomputer-that-saved-cray/
[7] https://www.sandia.gov/app/uploads/sites/165/2022/03/HighPerformanceComputing_2018.pdf
[8] https://www.sandia.gov/labnews/2018/06/21/arm/
[9] https://www.exascaleproject.org/research-group/pathforward/
[10] https://www.exascaleproject.org/quotes/

Sandia is also exploring new frontiers in computing that mimic the human brain through a partnership with Intel Corp.[11] Earlier this year, Sandia researchers heralded the arrival of Hala Point, a groundbreaking brain-based computing system, housing 1.15 billion artificial neurons within a compact container roughly the size of a microwave oven. This system, believed to be the largest brain-based computing system in the world, is set to revolutionize research efforts by enabling large-scale brain-based computing. This blend of traditional and neuromorphic computing underscores Sandia's unique role in driving AI technologies forward and offering solutions to complex problems while optimizing energy efficiency.

In collaboration with industry leaders like NVIDIA, Sandia, Lawrence Livermore, and Los Alamos are also engaged in developing advanced memory technologies, underscoring NNSA's commitment to pushing the boundaries of computing even further. These partnerships are part of broader efforts to strengthen the U.S.' competitiveness in next-generation computing technologies, ensuring that the nation remains at the forefront of HPC innovation. Through initiatives like these, Sandia and its partners are creating a more robust computing ecosystem through strong engagement with industry, paving the way for future technological breakthroughs that will benefit society.

Innovations extend beyond computing hardware

Open source software, by its very nature, promotes a culture of collaboration and shared creativity. It allows researchers, developers, and organizations across the globe to contribute to and benefit from the collective intelligence of the community. Recognizing the value of open-source software for furthering innovations in computing, DOE established a policy[12] in 2003 requiring its national labs to provide all publicly releasable software as either open-source software or as government software.

To ensure the sustainability of key open-source software, the national labs took initiative to partner with the Linux Foundation and launched the High Performance Software Foundation (HPSF), [13] a key moment in the evolution of open-source software for HPC and AI. These two institutions have been instrumental in recognizing the need for HPSF and driving its creation. Their vision for a collaborative platform that enhances the development, accessibility, and efficiency of high-performance software has been a key catalyst in bringing this initiative to life.

Currently, HPSF is working on a portable core software stack for HPC, which will make high-performance software development more accessible and efficient, and further enable the exploration and implementation of AI solutions. By rallying industry, academia, and government entities around the shared goal of advancing HPC and AI through open-source collaboration, national labs have created a powerful ecosystem for innovation and underscored their commitment to spearheading the next wave of scientific computing and AI advancements that can be used to address complex challenges and pave the way for future technological breakthroughs.

[11] https://newsreleases.sandia.gov/artificial_neuron/
[12] https://science.osti.gov/-/media/ascr/pdf/research/docs/Doe_lab_developed_software_policy.pdf
[13] https://hpsf.io/

AI @ Sandia[14]

Sandia's research in AI can be traced back to the early 1980s, at least. With today's combination of algorithms, data, and computing, Sandia is making significant impacts to national security through AI.

AI revolutionizes the speed in which we model and analyze data to inform decisions. It enables us to handle vastly larger amounts of data than humans can process alone, helps significantly reduce human errors and better complete repetitive tasks. AI's unrealized potential impact on the future of Sandia's mission spaces is vast, and the research we are doing will help realize that future for the benefit of the nation.

In the last few years, leading experts at Sandia have utilized AI and machine learning (ML) to solve complex science problems such as predicting ionic liquid diffusion for renewable energy storage applications,[15] recognizing radar targets quickly and accurately,[16] and designing strong and flexible interlocking metasurfaces for aerospace applications used in extreme environments.[17] Our ground-breaking work in trusted AI and computing co-design also continues to be leveraged in support of national security applications and other mission work.

As we consider the breadth and pace of AI progress by others around the globe, Sandia weighs three factors in focusing our research activities: (1) where we have, or could have, technical strengths in AI; (2) where there is strong mission need for AI solutions for NNSA and other government agencies; and (3) where is industry unlikely to supply the AI tools. As a result, Sandia's differentiated AI strategy focuses on:

- **AI Security & Reliability:** Sandia is developing methods and measures required to produce reliable and trustworthy AI-based solutions for its core nuclear deterrence engineering and design efforts, national security programs, global security, energy and homeland security, and the Labs' underlying advanced science and technology.
- **Scientific Machine Learning:** Sandia is fusing ML with scientific principles to solve scientific and engineering problems.
- **Data-driven AI for Mission Critical Applications:** Sandia is supporting high-consequence national security missions by developing and deploying critical applications enabled by data-driven AI.
- **Generative AI for National Security:** Sandia is engaged in assessing opportunities to deploy safe, reliable, generative AI systems to address national security and advanced manufacturing challenges.
- **Transitioning AI Research into Production:** Sandia is leveraging its depth and breadth of unique expertise to mature robust AI software that meets mission needs.
- **Infrastructure, Policy, & Operations:** Sandia is ensuring that critical infrastructure, computing power, workforce, and responsible AI policies are in place to support our business needs and mission research. We are identifying, developing, and promoting training opportunities to our entire workforce, especially when it comes to increasing the use of AI operationally among non-experts.

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[14] https://www.sandia.gov/research/area/computing-information-science-and-mathematics/ai/
[15] https://www.sandia.gov/news/publications/hpc-annual-reports/article/predict-ionic-liquid-diffusion/
[16] https://www.sandia.gov/news/publications/hpc-annual-reports/article/recognize-radar-targets-quickly-and-accurately/
[17] https://www.sandia.gov/news/publications/hpc-annual-reports/article/design-strong-and-flexible-interlocking-metasurfaces/

Continuing our established practice of partnering to advance computing technologies, Sandia's AI research is making mission impacts through collaborations with academia, other national labs, and the private sector. Two recent examples highlight the diversity of these impacts.

(1) With Lawrence Livermore and Los Alamos, we have embarked on a groundbreaking project[18] with Cerebras Systems to explore the application of the Wafer-Scale Engine technology in advancing simulation and computing applications crucial for the nation's stockpile stewardship mission. The Cerebras Systems AI chip design utilizes an entire wafer of integrated circuits versus current technology which cuts wafers into individual microprocessor cores that become graphics processing units (GPU) or central processing units (CPU).

    This partnership, part of the NNSA's post-Exascale-Computing-Initiative investment portfolio, seeks to sustain technological R&D momentum, fostering a robust domestic high-performance computing ecosystem. The initiative is poised to significantly impact future mission applications by integrating AI and ML techniques into production simulation workloads, marking a pivotal step in enhancing the capabilities of the U.S. in HPC and AI technologies.

(2) Sandia's Materials Learning Algorithms (MALA) project,[19] which received a prestigious R&D 100 award in 2023, is a cutting-edge program using ML to simplify and speed up complex calculations related to the properties of materials. This tool makes it easier for scientists to model materials at different scales, enhancing our understanding and development of new materials. MALA is designed to be user-friendly and open to everyone, allowing for easy use with just a few lines of code. Developed through a partnership between Sandia and the German Center for Advanced Systems Understanding, MALA represents a major leap forward in materials science, making it simpler and faster to explore the microscopic world of materials.

Frontiers of AI for Science, Security, and Technology (FASST Initiative)

Through the DOE FASST Initiative announced several weeks ago at the AI Expo in Washington, D.C., DOE and its national labs seek to dramatically accelerate the pace of R&D and enable scientific capabilities previously thought to be impossible through AI. With all that we have covered using Sandia as a national labs' exemplar, I hope it is easy to see how the national labs will strategically support the FASST Initiative and advance U.S. leadership in AI.

Under the FASST Initiative, as outlined by DOE and NNSA, the national labs will:

- Lead R&D to develop tuned and adapted AI models that solve pressing scientific and national security challenges. They will focus on training, testing, and validating frontier foundation models and other AI tools aligned with robust data sets,

[18] https://newsreleases.sandia.gov/cerebras_research/

[19] J. A. Ellis, L. Fiedler, G. A. Popoola, N. A. Modine, J. A. Stephens, A. P. Thompson, A. Cangi, S. Rajamanickam (2021). Accelerating Finite-temperature Kohn-Sham Density Functional Theory with Deep Neural Networks. Phys. Rev. B 104, 035120 (2021)

- Continue to build on their history of partnering with the private sector and extend these partnerships to focus on the development and construction of next-generation AI platforms, and
- Prioritize the development of tools for efficient, safe, and effective aggregation, generation, curation, and distribution of AI training data sets used across the platforms.
  The national labs are already beginning to jointly create hubs and put together teams that organize data for AI training and evaluation and specifically address DOE mission grand challenges. Collaborations, such as the one exemplified by the envisioned New Mexico AI Consortium (NMAIC), enable the sharing of resources and knowledge, while allowing for the creation of proprietary outcomes that benefit commercial, public, and national security applications.

New Mexico AI Consortium

Mr. Chairman, across NM, we are finalizing the NMAIC—a Consortium envisioning a future where the collaborative power of NM's premier institutions and industrial partners transforms the landscape of AI research, workforce development, and infrastructure. By uniting the strengths of Sandia, Los Alamos, the University of New Mexico (UNM), New Mexico State University (NMSU), New Mexico Institute of Mining and Technology, Central New Mexico Community College (CNM), and our industrial partners, NMAIC will foster an ecosystem of innovation and broaden both academic and community input to shape the future of AI and propel the state and nation forward.

Research: NMAIC is committed to pioneering the advancement of AI through a synergistic approach that integrates hardware, software, numerical methods, data, algorithms, and practical applications. Our consortium aims to ensure that AI research is not only at the forefront of technological progress but will also provide trustworthy solutions directly aligned with the critical needs of our nation and state. By leveraging our collective research expertise and resources, we aim to solve complex challenges, drive economic growth, and enhance the well-being of our communities.

Workforce: NMAIC is dedicated to cultivating a diverse, skilled, and innovative workforce capable of leading the future of technology. Through comprehensive education, training programs, and collaborative initiatives, we aim to equip individuals with the knowledge and skills necessary to excel in the evolving AI landscape. Our consortium is committed to creating opportunities for lifelong learning and career advancement, ensuring that NM remains at the forefront of AI innovation and application. In addition, all the NM universities and colleges are minority-serving and Hispanic-serving institutions and will bring diverse perspectives to AI research and education. Through the NMAIC partnership with UNM, we will pilot an approach to university collaboration, and by utilizing UNM's role in the Alliance of Hispanic-Serving Research Universities (HSRU), we plan to expand these partnerships to other HSRU across the country.

Infrastructure: At the heart of the NMAIC vision is the development of a robust, state-of-the-art infrastructure that supports the ambitious goals of our consortium. NMAIC is focused on building and enhancing the physical and digital frameworks necessary for cutting-edge AI research, education, and commercialization. By investing in high-performance computing facilities, data storage and management systems, and collaborative spaces, we will provide our researchers, students, and industrial partners with the tools they need to succeed.

I would like to highlight a few Sandia examples showcasing the types of foundations that can further be built upon through the NMAIC.

- The ASC Predictive Science Academic Alliance Program[20] is the primary mechanism by which NNSA labs such as Sandia and Los Alamos can collaborate with UNM and numerous universities on advancing science-based modeling and simulation.
- The robust research and internship programs Sandia has with multiple Historically Black Colleges and Universities (HBCU) partners provides a talent pipeline for the national laboratories. Through UNM, we are integrating recruitment efforts that will attract diverse talent seeking to advance their education upon graduating from HBCU. The joint faculty loan agreements currently in place between Sandia, Los Alamos, and UNM enables staff members to teach at the university, thereby introducing students to career paths at the laboratories.
- RS21[21], founded by a former Sandia employee who separated from the laboratory through our Entrepreneurial Separation to Tech Transfer program,[22] integrates AI, data engineering, user experience, and modern software development methods to enable organizations to make data-driven decisions. Through strong collaboration, Sandia and RS21 are utilizing data science and AI to understand and solve complex challenges.

  The NMAIC envisions a future where collaboration, innovation, and excellence in AI drive national progress and prosperity and improve the quality of life for all.

Conclusion

In summary, the DOE laboratories, including Sandia, have historically been at the forefront of technological breakthroughs, particularly in computing innovations. Their pioneering development of advanced supercomputers and engagement in codesign activities have laid a solid historical foundation that should underscore the necessity of their role in driving future AI innovations forward.

Mr. Chairman and Members of the Committee, Sandia and our national lab peers are ready to continue executing in computing excellence and committed to engaging our academic and industry partners in jointly educating the future generation of AI engineers and designers. It will be our privilege to lead the nation's exploration, development, and safe use of AI in the interest of our taxpayers and our national security.

Thank you for convening this hearing, and I look forward to your questions.

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[20] https://psaap.llnl.gov/
[21] https://rs21.io/
[22] https://www.sandia.gov/labnews/2024/05/02/former-sandian-added-to-entrepreneurial-wall-of-fame/

Jennifer Gaudioso, PhD

Director, Center for Computing Research

Jennifer Gaudioso is Director of the Center for Computing Research at Sandia National Laboratories where she stewards the Center's portfolio of research from fundamental science to state—of-the-art applications. The Center's work includes computer system architecture (both hardware and software); enabling technology for modeling physical and engineering systems; and research in discrete mathematics, data analytics, cognitive modeling, and decision support materials. She is also the Program Executive for NNSA's Advanced Simulation and Computing Program at Sandia. Jen also serves on Sandia's AI Board of Directors.

Previously, she served as the Director of the Center for Computation and Analysis for National Security where she oversaw the use of systems analysis, cybersecurity, and data science capabilities to tackle complex national security challenges. In this role, Jen also led Sandia's Homeland Infrastructure Security and Resilience Program which was underpinned by "data to decision" capabilities.

Jen began her Sandia career in 2002 and, in 2010, she moved into management, leading the International Biological and Chemical Threat Reduction Program. Jen's leadership established Sandia as a critical contributor to the U.S. government's response to the Ebola outbreak in West Africa. The team's ground-breaking efforts were also acknowledged with a DOE Secretary of Energy Award. In her role as Senior Manager for Global Strategic Futures, Jen led development of the Global Security Division's mission, science and technology pipeline, and mission-aligned programs. She also led Sandia's contributions to the next-generation Nuclear Command, Control, and Communications (NC3) and coordinated a Sandia-wide emerging non-proliferation initiative at the interface of NA-10, NA-20, NA-80, and DOE-IN, earning a Department of Energy (DOE) Secretary of Energy Award for the team.

Jen served on two National Academies Committees addressing biodefense issues and was an MIT Seminar XXI Fellow. She has a PhD and a master's degree in physical chemistry from Cornell University and a bachelor's degree in chemistry from Bard College. Jen's time at Bard taught her to value diverse perspectives in problem-solving.