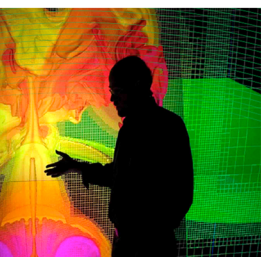# Exascale Computing: A National Imperative

The Exascale Computing Project's (ECP's) mission is to ensure all the necessary pieces are in place for the nation's first exascale systems. The project, a US Department of Energy (DOE) initiative, is delivering an ecosystem that includes mission-critical applications and an integrated software stack and is working closely with US high-performance computing (HPC) hardware companies to identify and drive the development of advanced computer system engineering and hardware components. All three of these elements are necessary to enable fully functional, capable exascale computing environments, which are critical to national security, scientific discovery, and a strong US economy.

About Exascale and ECP Impacts

The ECP is focused on accelerating the delivery of a capable exascale computing ecosystem in support of the forthcoming exascale systems such as Frontier at Oak Ridge National Laboratory. The ECP's efforts will ensure the availability of exascale-ready applications and a functional, robust exascale software stack, enabling Frontier to address problems of greater complexity than possible today while delivering high-fidelity solutions at a significantly faster pace, enabling a new era of scientific discovery.

Advancing Scientific Discovery

The ECP's mission is to deliver the exascale computing ecosystem necessary for developing clean energy systems, improving the resilience of our infrastructure, designing new materials that can perform in extreme environments, adapting to changes in the water cycle, developing smaller and more powerful accelerators for use in medicine and industry, and much more. Several projects focus on data-intensive problems to enable effective use of the data streams from powerful scientific facilities, complex environmental genomes, and advancements in cancer research (e.g., patient genetics, tumor genomes, molecular simulations, and clinical data).

Strengthening National Security

The ECP teams are also developing new applications for supporting the National Nuclear Security Administration (NNSA) Stockpile Stewardship Program, which is responsible for maintaining the readiness and reliability of our nuclear weapons systems—without underground testing. Assessing the performance of weapons systems subject to hostile environments and potential threat scenarios in the necessary mission-critical time frames exceeds the capabilities of current HPC systems and codes. NNSA application projects are focused on providing the sophisticated modeling and analysis tools needed to sustain US nuclear deterrence.

Improving Industrial Competitiveness

Exascale systems will be used to accelerate research that leads to innovative products and speeds commercialization, creating jobs and driving US competitiveness across industrial sectors, such as the emerging energy economy. To ensure alignment with US industry needs, ECP is engaging senior technology decision makers from among the country's most prominent private sector companies.

OAK RIDGE National Laboratory

ECP EXASCALE COMPUTING PROJECT

NNSA National Nuclear Security Administration

U.S. DEPARTMENT OF ENERGY | Office of Science

ECP is structured on the principles of codesign and integration, with three key technical focus areas

- **Application development**—Exascale-capable applications are a foundational element of the ECP and will be the vehicle for delivery of solutions and insights to key national challenges. Previously intractable problems will be accessible with ECP's application development efforts.

- **Software technology**—Applications are built on underlying software technologies. As a result, software technologies play an essential supporting role in application efficacy on computing systems. The ECP's efforts span low-level system software to high-level application development environments, including the software infrastructure to support large-scale data management and data science for science and national security applications. Software technology efforts complement and integrate into the broader scientific software ecosystem that includes capabilities from industry and the US and international HPC R&D community.

- **Hardware and integration**—Hardware and integration efforts ensure a capable exascale computing ecosystem made possible by integrating ECP applications, software, and hardware innovations within DOE facilities. It supports US vendor R&D focused on innovative architectures for competitive exascale system designs, accelerated application readiness through collaboration with ECP partners, a well-integrated and continuously tested exascale software ecosystem deployed at DOE facilities, and training on key ECP technologies to accelerate the software development cycle and optimize productivity of application and software developers.

The project is a joint effort of two DOE organizations—the Office of Science and the NNSA—and is led by a team of senior scientists, project management experts, and engineers from six of the largest DOE national laboratories. Working together, this leadership team has established an extensive network to deliver a capable exascale computing ecosystem for the nation.

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