SCIENCE & TECHNOLOGY ON A MISSION

Lawrence Livermore National Laboratory had another exceptional year pushing the frontiers of science and technology to strengthen national security in a rapidly changing world

LLNL Director Kimberly Budil speaks at the Department of Energy (DOE) press conference on December 13, 2022, announcing the achievement of fusion ignition at NIF.

I n 2022, Lawrence Livermore National Laboratory (LLNL) celebrated the 70th anniversary of its founding as a branch of Ernest O. Lawrence's Radiation Laboratory at the University of California at Berkeley. The theme of this year's celebration—making the impossible possible—carries forward Livermore's founding purpose to be a "new ideas" laboratory and meet pressing needs to advance nuclear weapons science and technology (S&T). One of the early big, new ideas led to the design of the first compact thermonuclear weapons, which were carried on Polaris ballistic missiles. Another "impossible" early big idea was to use a powerful energy source to implode a small pellet of fuel and create fusion energy in a laboratory setting.

After nearly 60 years of pushing the boundaries of laser technology, target fabrication, and design, on December 5, 2022, the impossible was demonstrated to be possible. In an experiment at the National Ignition Facility (NIF), 2.05 megajoules (MJ) of laser energy produced 3.1 MJ of fusion energy. The historic accomplishment of fusion ignition supports key national security goals and is a giant first step forward on the path to using fusion as a carbon-free, abundant source of energy for humankind. This achievement is what the national laboratories were created to do: pursue and persevere on technically ambitious, long-term goals through generations of hard work and breakthrough innovations. The Department of Energy (DOE), its National Nuclear Security Administration (NNSA), the entire inertial confinement fusion (ICF) research community, and the dedicated LLNL scientists and engineers that made the final push in FY 2022 have earned well-deserved congratulations.

LLNL MISSION AND VISION

At our Laboratory, we fearlessly and relentlessly pursue big ideas to solve the most important security challenges facing the nation and the world. LLNL's *FY 2022 Annual Report* illustrates the forward thinking and innovative research we undertake in support of our mission: to enable U.S. security

A panel of NIF scientists answer technical questions about the ignition experiment after the DOE press conference.

and global stability and resilience by empowering multidisciplinary teams to pursue bold and innovative science and technology. For example, LLNL is pioneering cognitive simulation (CogSim), a technique that integrates artificial intelligence with high-performance computing (HPC) and experimental results to accelerate scientific discovery. CogSim has already greatly benefited essential research, such as NIF experiments and vaccine development. We are also making breakthrough advances in additive manufacturing to produce nanoscale precision components with previously unobtainable properties, made from an ever-expanding variety of materials. These and other innovations support projects in our four mission areas.

Nuclear Deterrence continues to be the defining responsibility of our Laboratory. In a rapidly evolving security environment, we must assure the safety, security, and effectiveness of the U.S. nuclear stockpile. Our focus is on transforming the stockpile and the nuclear security enterprise to meet 21st-century national security needs. As our *Annual Report* describes, we are engaged in two programs to modernize stockpile systems: the W80-4 Life-Extension Program, a warhead that will be carried on the all-new Long-Range Standoff missile; and the W87-1 Modification Program, a warhead for the Sentinel ballistic missile being developed by the U.S. Air Force. Through close partnerships with the NNSA laboratories and production sites, we are developing new manufacturing technologies and business processes to improve efficiencies, lower costs, and increase NNSA's agility.

Threat Preparedness and Response is needed to counter severe threats, prevent the use of weapons of mass destruction (WMD), and enhance global security and resilience. We apply advanced capabilities and expertise to support the intelligence community, develop and apply cutting-edge forensic science for incident response, and further nuclear nonproliferation objectives. We are focused on enhancing bioresilience through early biological threat detection and assessment and accelerated design, development, and testing of medical countermeasures. Highlighted in our *Annual Report* is the use of CogSim tools to develop a multipathogen vaccine and advance cancer research.

Climate and Energy Security is one of today's most pressing challenges. LLNL researchers couple expertise in materials science, carbon cycle and subsurface research, and HPC simulation to assess climate impacts on national security and the functioning of critical infrastructure. Our efforts focus on improving models, such as cloud physics, to increase predictability at regional to local spatial scales. LLNL researchers are also developing ways to improve carbon capture methodologies, mitigate the impact of greenhouse gases, and enhance infrastructure resiliency.

Multi-Domain Deterrence seeks to create strategic advantages in an increasingly dangerous multipolar world. Integrated deterrence must meet multifaceted challenges: WMD proliferation, cyber- and space security, directed energy systems, and hypersonic conventional weapons. Livermore is focused on understanding the potential threats, developing advanced defense technologies, and creating

computational tools to better model and predict the behavior of complex systems. In addition, U.S. leadership in S&T is important in the face of international competition. LLNL provides expertise and cutting-edge research facilities in many areas central to national security.

TRANSFORMING THE LABORATORY

As we sustain our focus on innovation, Livermore is changing. At the start of the fiscal year, LLNL adopted a hybrid workplace as its "new normal" for operations. As illustrated during the pandemic, a flexible workplace that accommodates telecommuting and enhanced flexibility, consistent with each employee's job responsibilities, supports effective mission delivery. In addition, our physical site has changed with completed construction of the Emergency Operations Center and the Exascale Computing Facility Modernization project, which prepares LLNL for delivery of the El Capitan supercomputer in FY 2023. Many other projects are under way that modernize both Laboratory operations and facilities to meet evolving mission needs.

Outstanding people are the Laboratory's most important resource. We continue to hire exceptional individuals to join our team and are welcoming many new employees to Livermore. Recruiting, training, and retaining our workforce is a top priority. Many employee-focused initiatives were launched in FY 2022, including a Future of Work Task Force that has recommended workplace changes to optimize employee experience and mission success. As we go through generational change, LLNL is building on the heritage established by Livermore's founders. We serve as a "big ideas" laboratory, pursuing multidisciplinary "big science" in the national interest.