



Warheads and Strategic Deterrence

LLNL is delivering on two warhead modernization programs, sustaining the active stockpile, and partnering to modernize the nation's nuclear weapon enterprise.

Introduction

Lawrence Livermore National Laboratory (LLNL) plays a key role in the nation's strategic deterrent, acting as a nuclear weapon design laboratory responsible for the safety, security, and effectiveness of the U.S. nuclear stockpile. This core responsibility includes annual assessment of the active stockpile, culminating in a quantification of confidence that the weapon systems still meet military requirements, as well as leading the modernization of systems that are approaching the end of their useful service life. LLNL is partnering through these stockpile modernization programs to modernize the nuclear weapon enterprise, ensuring resiliency in an uncertain global future.

LLNL executes this mission through development and application of world-class scientific and engineering tools, enabling the development of modern designs that ease manufacture and the assessment and certification of systems without conducting nuclear tests. These scientific capabilities include world-class computing and experimental facilities, such as the first exascale supercomputer and the world's most powerful laser system. These capabilities inform the judgement of weapon experts, underpinning the nation's confidence in its strategic deterrent.

Applications

LLNL is the lead design agency for the nuclear explosive package in two separate programs: the W80-4 Life Extension Program (LEP) and the W87-1 Modification Program. LLNL is also responsible for assessing and sustaining three systems in the active stockpile – the W80-1, B83, and W87-0 warheads – establishing scientific confidence in the systems.

More than 5,000 LLNL team members contribute to these annual assessments and stockpile modernization programs, working closely with production agencies, NNSA, and the U.S. Air Force to design and test hardware, transfer technology, address manufacturing issues, assess material compatibility, execute vital system assessments, and ultimately deliver a deterrent the nation relies on for decades.

The W80-4 is replacing the W80-1 warhead and will be employed in the U. S. Air Force's new Long-Range Standoff (LRSO) missile. The W80-4 will be the first warhead designed for use with a new missile since nuclear testing ended in 1992.

The W87-1 Modification Program will replace the W78 warhead and will sit atop the Air Force's new Sentinel Intercontinental Ballistic Missile (ICBM). The W87-1 is the first warhead to have all components newly manufactured since testing ended, unlike prior life extension programs that relied heavily on component reuse.

These systems are based on tested nuclear designs and will not require new nuclear tests. Certification will rely on improved understanding and the highly capable toolset developed by the science-based Stockpile Stewardship Program.

In 2023, the W87-1 Mod entered the development engineering phase of the program (Phase 6.3), and the W80-4 LEP entered the production engineering phase (Phase 6.4). Both programs are working hand-in-hand with production agencies to ensure successful delivery of parts and systems that meet requirements. Simultaneously, researchers at LLNL are conducting an extensive range of full-system tests and hundreds of small-scale tests to validate computational models and the scientific basis for certifying the systems.



W87-1 Mod



W80-4 LEP



Researchers at the NIF prepare for an ignition experiment that provided data to certify modernized weapon systems and confirm they can survive hostile environments.



Engineers in the W80-4 Life Extension Program conduct environmental testing on a mock test unit to ensure systems will work when needed, but never when not needed.



A researcher produces a test component using direct-ink-write additive manufacturing. LLNL is introducing new manufacturing methods into stockpile modernization programs.

Accomplishments

LLNL has come a long way in its ability to develop, assess, and certify warheads since the end of nuclear testing in 1992. Researchers today synthesize historic nuclear test data with computational simulations and a suite of modern experiments and tests to inform their expert judgement. Scientific advancements through decades of stockpile stewardship are now enabling certification of modernized systems in both normal and abnormal environments, without new nuclear testing. Recent accomplishments include:

- Achievement of fusion ignition at NIF, and accompanying development of weapon survivability platforms to leverage ignition yields. NIF has played a key role in advancing weapon physics understanding and lends confidence to today's stockpile assessments.
- High-performance computing advances are making possible regular use of high-fidelity, 3D simulations. These advancements are being furthered by the El Capitan supercomputer, the first exascale machine in the United States dedicated to national security, and through application of machine learning and artificial intelligence.
- A next generation accelerator, Scorpius, provides the nation's first capability to capture multiple late time radiographic images of subcritical experiments. This advanced diagnostic will illuminate new insights into how special nuclear material behaves when driven by high explosives.
- LLNL is partnering to revitalize the nation's atrophied capability to produce nuclear warheads. This includes the introduction of advanced manufacturing techniques and processes, enabling the enterprise to realize efficiencies and replace materials that can no longer be used.
- Advancements in material aging and compatibility assessments are lending confidence that modernized systems will last for decades, even where new materials and processes are being introduced.

These accomplishments all have roots in the stockpile stewardship era and are being leveraged to expand the envelope of the types of systems that can be certified as safe, secure, and effective without nuclear testing. Elements of each advancement were initially developed through Laboratory Research and Development (LDRD) funding. When they showed promise, they were further matured with program funding to the point where they could make a difference for the nation's strategic deterrent.

The Future

The past decade has seen the emergence of two nuclear adversaries aggressively modernizing their nuclear capabilities. Meanwhile, the 10- to 15-year timeline to field a life-extended warhead in the U.S. highlights a significant risk to the nation's ability to respond in relevant timeframes, should a new threat arise. LLNL and its partners are revitalizing the enterprise to improve responsiveness and resilience. Key prongs to the strategy include:

- Partnering with the DOD to deliver options ensuring the long-term effectiveness of our nuclear deterrent.
- Conducting pilots focused on realizing efficiencies and prototyping aimed at accelerating maturation of technologies.
- Advancing the science, technology, and engineering required to certify novel systems with confidence.
- Development of the next generation of experts responsible for future systems.
- Modernizing the vital infrastructure that has deteriorated in the absence of new weapon development activities.

LLNL is acting in earnest on these strategies, all while delivering on the W80-4 and the W87-1.