U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

Fiscal Year 2024
Stockpile Stewardship and Management Plan

Report to Congress
November 2023

National Nuclear Security Administration
United States Department of Energy
Washington, DC 20585

Message from the NNSA Administrator

The Department of Energy's National Nuclear Security Administration's (DOE/NNSA) largest mission is to design, produce, deliver, and certify the Nation's nuclear stockpile while advancing the scientific, technological, and engineering skills that underpin it. Since the Manhattan Project, the talented people of the nuclear security enterprise have applied unique capabilities to promote U.S. security in an evolving global security environment. Today, our nuclear deterrent remains the foundation of the Nation's defense.

The *Fiscal Year 2024 Stockpile Stewardship and Management Plan* (SSMP) describes how DOE/NNSA will maintain and advance the safety, security, reliability, and effectiveness of the U.S. nuclear weapons stockpile without underground nuclear explosive testing. The report also details DOE/NNSA's plans to accomplish the program requirements to produce 80 plutonium pits per year; achieve the first production units for the W80-4 Life Extension Program (LEP), W87-1 Modification Program, and W93; and continue production of the B61-12 LEP and W88 Alteration 370 warheads. Finally, the report examines other key activities that support DOE/NNSA's weapons program, including stockpile modernization, infrastructure recapitalization, and science, research technology, and engineering capabilities. The SSMP discusses both on-going and planned activities.

For more than 75 years, the scientific and engineering discoveries of the nuclear security enterprise have enhanced our national and global security in the face of changing world conditions. Our greatest asset is the people of the nuclear security enterprise, whose expertise is the core of the United States' nuclear deterrence. The nuclear security enterprise workforce is comprised of technical experts at the national laboratories, production plants, and sites across the country, and a Federal workforce for planning, budgeting, management, and oversight. The SSMP discusses efforts to attract and retain a world-class workforce to steward today's deterrent and design the systems of tomorrow.

With continued support from Congress, DOE/NNSA will continue to anticipate future challenges and deliver innovative solutions to meet them. Pursuant to statute, this FY 2024 SSMP is provided to:

The Honorable Patty Murray

Chair, Senate Committee on Appropriations

The Honorable Susan Collins

Vice Chair, Senate Committee on Appropriations

The Honorable Jack Reed

Chairman, Senate Committee on Armed Services

The Honorable Roger Wicker

Ranking Member, Senate Committee on Armed Services

The Honorable Chair

Subcommittee on Energy and Water Development
Senate Committee on Appropriations

The Honorable John Kennedy

Ranking Member, Subcommittee on Energy and Water Development
Senate Committee on Appropriations

The Honorable Angus King

Chairman, Subcommittee on Strategic Forces
Senate Committee on Armed Services

The Honorable Deb Fischer

Ranking Member, Subcommittee on Strategic Forces
Senate Committee on Armed Services

The Honorable Kay Granger

Chairwoman, House Committee on Appropriations

The Honorable Rosa L. DeLauro

Ranking Member, House Committee on Appropriations

The Honorable Mike Rogers

Chairman, House Committee on Armed Services

The Honorable Adam Smith

Ranking Member, House Committee on Armed Services

The Honorable Chuck Fleishmann

Chairman, Subcommittee on Energy and Water Development, and Related Agencies
House Committee on Appropriations

The Honorable Marcy Kaptur

Ranking Member, Subcommittee on Energy and Water Development, and Related Agencies
House Committee on Appropriations

The Honorable Doug Lamborn

Chairman, Subcommittee on Strategic Forces
House Committee on Armed Services

The Honorable Seth Moulton

Ranking Member, Subcommittee on Strategic Forces
House Committee on Armed Services

Should you have any questions or need additional information, please contact Jason Miller, Acting Associate Administrator for Congressional and Intergovernmental Affairs, at (202) 586-8368.

Sincerely,

Jill Hruby
Under Secretary for Nuclear Security
Administrator, NNSA

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Message from the Secretary

The Department of Energy's National Nuclear Security Administration (DOE/NNSA) was established more than 20 years ago with the mission to enhance national security through the military application of nuclear science and engineering while upholding nonproliferation standards and supporting peaceful uses of nuclear technology. Since that time, DOE/NNSA, in close coordination with the Department of Defense, has successfully maintained a safe, secure, and effective nuclear deterrent without underground nuclear explosive testing.

DOE/NNSA's nuclear deterrence mission remains the cornerstone of our Nation's security posture. Today's uncertain global security environment and unprecedented threat landscape require the United States to maintain a modern nuclear deterrent and a set of flexible scientific, technical, and engineering capabilities to support our national security objectives. The *Fiscal Year 2024 Stockpile Stewardship and Management Plan* details DOE/NNSA's plans to modernize the stockpile; strengthen its capabilities; and recapitalize the infrastructure that supports the nuclear deterrent.

This Administration is committed to a responsive and resilient nuclear security enterprise and fully supports continued advancements in science and engineering that underpin our national defense. With the continued support of Congress, DOE/NNSA will continue to provide a safe, secure, reliable, and effective nuclear deterrent today and into the future.

Sincerely,

Jennifer Granholm
Secretary of Energy

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Executive Summary

The *Fiscal Year 2024 Stockpile Stewardship and Management Plan* (SSMP), including its classified annex, describes the Department of Energy's National Nuclear Security Administration (DOE/NNSA) program to maintain a safe, secure, and effective nuclear stockpile over the next 25 years. DOE/NNSA publishes the SSMP annually, either in detailed report form or as a summary, in response to statutory requirements to support the President's Budget Request to Congress for Weapons Activities. This fiscal year (FY) 2024 report describes current and future nuclear security enterprise activities and capabilities funded by the Weapons Activities account supporting the Nation's nuclear deterrent.

In partnership, the Department of Defense (DoD) and DOE/NNSA plan and manage weapons modernization needs to meet the nuclear deterrent objectives outlined in the 2022 *National Security Strategy* (White House), the 2022 *National Defense Strategy* (DoD), and the 2022 *Nuclear Posture Review* (DoD, interagency), while incorporating the unique deterrent effects of nuclear weapons into the Nation's integrated deterrence efforts. This SSMP reflects rigorous mapping of nuclear security enterprise capabilities to address military requirements and the priorities identified in these strategic documents.

In 2022, DOE/NNSA continued executing its significant program of record, helping to advance the Nation's nuclear security mission through innovative science and technology solutions. For Weapons Activities, DOE/NNSA worked to ensure the existing nuclear weapons stockpile's safety, security, and reliability without underground nuclear explosive testing and continued to recapitalize infrastructure and advance plutonium pit manufacturing and many other production modernization-related activities.

Additionally, researchers at Lawrence Livermore National Laboratory (LLNL) made a major scientific breakthrough by achieving fusion ignition, a feat scientists have been working toward for decades. On December 5, 2022, a team at LLNL's National Ignition Facility conducted the first controlled fusion experiment in history to reach ignition, also known as scientific energy breakeven, meaning it produced more energy from fusion than the laser energy used to drive it. This accomplishment will provide unprecedented capability to support DOE/NNSA's stockpile stewardship program—which includes research to support the U.S. nuclear deterrent without the need for underground nuclear explosive testing—and will provide invaluable insights into the prospects of clean fusion energy.

In 2023, DOE/NNSA's top priority is to deliver on its commitments in a cost-effective manner. DOE/NNSA will continue to cultivate transparent, productive, and enduring relationships with interagency partners, industrial and academic contributors, international allies and partners, and other stakeholders. By leveraging its innovative science and technology capabilities, DOE/NNSA will meet stockpile milestones, and maintain a resilient enterprise to meet the geopolitical security challenges of today and tomorrow. DOE/NNSA will:

Maintain the Nation's Nuclear Deterrent's Safety, Security, and Effectiveness

With several warhead modernizations underway, DOE/NNSA is executing an unprecedented variety of complex component development and production work. Despite the continued challenges imposed by the current industrial base environment, such as supply chain challenges, limited vendor options, and changing technologies, DOE/NNSA has continued to make significant progress in its modernization activities.

Near-Term and Out-Year Mission Goals:

- Deliver the B61-12 gravity bomb.
- Deliver the W88 Alteration (Alt) 370 (with a refresh of the conventional high explosives).
- Achieve the first production unit of the W80-4 warhead Life Extension Program and maintain alignment with the Air Force's Long Range Standoff cruise missile replacement program.
- Support initial fielding of W87-0 on Sentinel, formerly known as the Ground Based Strategic Deterrent, and advance the W87-1 Modification Program (formerly called the W78 Replacement Warhead). Decrease risks to timely delivery of the W80-4, W87-1, and W93 systems.
- Develop the W93 warhead, deployed on Mk7 re-entry body, to augment Navy forces with a more survivable weapon deployable on the Ohio-class and Columbia-class submarines.
- Develop an integrated plutonium pit production strategy to align and streamline complex-wide efforts. Provide a continuous and reliable supply of strategic nuclear weapon components and the key materials that make up the components, including plutonium, uranium, lithium, tritium, and high explosives.
- Provide experimental and computational capabilities and be prepared to address and mitigate any challenges that arise in the future.
- Qualify pit manufacturing processes and technologies to support first production unit and rate production.
- Identify new production technologies that leapfrog legacy processes and save cost and/or schedule for warhead modernization programs, including at least one Nuclear Explosive Package component and one non-nuclear component.

Key Accomplishments:

In 2022, DOE/NNSA:

- Delivered an initial operational capability (quantity of re-entry Body Assemblies) of W88 Alt 370s to the Navy. The updated W88 Alt 370, which can be launched on missiles from Ohio-class submarines, will replace older W88 warheads in the stockpile.
- Completed the Phase 1 Concept Study for the W93 Program and received Nuclear Weapons Council authorization to advance to Phase 2, *Feasibility Study and Design Options.* The W93 will hedge against technical risk in the fielded submarine-launched warheads and over-reliance on the W76, allowing the United States to keep pace with future threats.
- Executed full-scale production of the B61-12 and met Air Force shipment requirements.
- Delivered all scheduled limited life components for the B61, W76, W78, W80, B83, W87, and W88.
- Completed seven tritium extractions at the Savannah River Site (SRS), more than doubling the previous record. Base capabilities for multi-system operations and maintenance support were sustained to meet all limited life components exchange gas transfer system (GTS) fills and gas transfer system Surveillance DOE/NNSA deliverables to DoD.
- Conducted surveillance activities for all weapon systems using data collection from flight tests, laboratory tests, and component evaluations to assess stockpile reliability without underground explosive nuclear testing, which culminated in completion of all annual assessment reports and submission of the annual Report on Stockpile Assessments to the President.

- Achieved 100 percent safe and secure transport of nuclear materials and weapons. All shipments were completed without compromise or loss of nuclear weapons or components, or release of radioactive material.
- Completed the first B61-12 GTS loading run and initiated full operation for loading GTS units for weapons refurbishment.
- Completed the W87-1 Preliminary Design review and Acceptance Group review, indicating DoD accepted the baseline design and its associated plan for certification.

In 2023, DOE/NNSA:

- Completed Long Range Standoff/W80-4 warhead joint flight testing and entered Phase 6.4, *Production Engineering*.
- Entered Phase 6.3, *Development Engineering*, for the W87-1 Modification Program after completing the Weapon Design and Cost Report in FY 2022

Strengthen Key Science, Technology, and Engineering Capabilities

Nuclear weapons stockpile activities are supported by the technical expertise of DOE/NNSA's Federal and management and operating partner workforces. DOE/NNSA cultivates cutting-edge technical expertise in manufacturing, diagnostics, evaluation, and other areas at the plants and sites, and maintains unparalleled scientific and engineering capabilities at the three national security laboratories (Los Alamos, Lawrence Livermore, and Sandia National Laboratories) that execute science-based stockpile stewardship.

Near-Term and Out-Year Mission Goals:

- Advance the innovative experimental platforms, diagnostic equipment, and computational capabilities necessary to ensure stockpile's safety, security, reliability, and effectiveness:
  - Deploy DOE/NNSA's first exascale computer and establish a path forward for continued leadership in advanced computing while modernizing the nuclear weapons code base.
  - Develop a roadmap for advanced inertial confinement fusion and pulsed power.
  - Develop an operational enhanced capability (advanced radiography and reactivity measurements) for subcritical experiments.
  - Quantify and bound the plutonium aging effects on weapon performance over time.
- Support an enduring, trusted, strategic, radiation-hardened microsystems supply and expand DOE/NNSA partnerships to leverage NNSA expertise and capabilities to address current and emerging challenges.
- Maintain and upgrade science facilities enabling continued generation of world-leading results.
- Maintain and advance state-of-the-art manufacturing technologies supporting production operations.
- Continue implementing the Stockpile Responsiveness Program to fully exercise the nuclear security enterprise's workforce and capabilities and explore ways to improve processes without disrupting current operations.
- Nurture Strategic Partnership Programs that support other relevant needs while advancing the nuclear security enterprise's long-term workforce and capabilities.

Key Accomplishments:

In 2022, DOE/NNSA:

- Completed Annual Assessment Cycle 26: The three NNSA laboratory directors certified that the stockpile remains safe, secure, and effective, and that underground nuclear explosive testing is not required at this time.
- Completed seven developmental pit builds at Los Alamos National Laboratory (LANL), exceeding goals in metal production, machining, casting, and post-assembly testing. LANL sustained pit production activities allowing for stress-testing and identifying future informed modernization priorities.
- Performed two consecutive experiments using the Z pulsed power facility to measure the dynamic response of aged plutonium. These experiments were the first back-to-back plutonium experiments on the Z pulsed power facility, which resulted in operational efficiencies and returned valuable data for stockpile stewardship. Additionally, gas gun, light source, and benchtop experiments on aged plutonium supported the "Assess Lifetimes and Mitigate Aging" pegpost (Chapter 4), providing data to quantify and bound changes in plutonium properties with age.

Ensure an Adaptive Workforce and Resilient Infrastructure

Planning and investing in advanced capabilities, infrastructure, and, most importantly, the workforce are critical for achieving nuclear security objectives. DOE/NNSA continues to revitalize the facilities and corresponding infrastructure that make up the nuclear security enterprise. These upgrades are necessary to create a responsive and resilient enterprise that can meet national security missions today and in the future.

Near-Term and Out-Year Mission Goals:

- Achieve key infrastructure recapitalization milestones and improve early-stage and integrated infrastructure planning.
  - Complete key construction projects to modernize the nuclear security enterprise, the Y-12 National Security Complex (Y-12) Fire Station, Emergency Operations Center, Electrorefining, West End Protected Area Reduction interface projects, and the Sandia National Laboratories (SNL) Emergency Operations Center.
  - Accomplish key infrastructure project milestones at LANL and SRS to support the plutonium pit production mission.
  - Complete and communicate an integrated infrastructure priority plan.
- Implement enterprise-wide recruitment and retention strategies by incorporating hiring, compensation, and benefits flexibilities, and promoting a healthy work-life balance.
- Enhance cyber infrastructure and resiliency across the enterprise.
- Enable phasing out mission dependency on Building 9212 at Y-12 by relocating the facility's enriched uranium processing capabilities into existing facilities and the Uranium Processing Facility and extending key existing facilities' operational lifetime into the 2040s.
- Support long-term actinide chemistry and materials characterization and deliver the Chemistry and Metallurgy Research Replacement Project.
- Modernize lithium and tritium facilities.

- Increase tritium production by leveraging additional capacity at two commercial power reactors to meet stockpile needs.
- Recapitalize the high explosives and nuclear weapons assembly infrastructure.
- Provide new laboratory space and equipment within the U1a Complex at the Nevada National Security Site to support the Enhanced Capabilities for Subcritical Experiments portfolio through the U1a Complex Enhancements Project and Advanced Sources and Detectors equipment.
- Provide modern office and laboratory spaces to support the world-class workforce needed to maintain the nuclear weapons stockpile capabilities.
- Reduce the total deferred maintenance, as measured by the replacement plant value, of the nuclear security enterprise by not less than 45 percent by 2030.

Key Accomplishments:

In 2022, DOE/NNSA:

- Opened the new John A. Gordon Albuquerque Complex. This $169 million, 330,000 square foot Leadership in Energy and Environmental Design Gold-certified complex replaces 25 buildings, including 1950s military barracks. It will house more than 1,200 employees who provide programmatic, technical support, legal, security, procurement, human resources, business, and administrative functions that directly support DOE/NNSA's national security missions. DOE/NNSA simultaneously reduced deferred maintenance while providing modern, safer, and more efficient working conditions.
- Developed a solution with LLNL to execute High-Fidelity Training and Operations Center plans that will modernize training and accelerate the Savannah River Plutonium Processing Facility path to full plant operations.
- Completed the Exascale Computing Facility Modernization project at LLNL. The project upgraded the electrical and mechanical capabilities of the Livermore Computing Center, which will enable the facility to power the first DOE/NNSA exascale system, named El Capitan, and to provide exascale-class computing service to LLNL, LANL, and SNL.
- Reached a significant milestone in the Uranium Processing Facility project with all buildings being fully enclosed, or "in the dry." The Uranium Processing Facility project is being built in a series of seven subprojects. The first four subprojects are complete, which prepared the site for construction, provided necessary infrastructure to support construction, commissioned a new electrical substation to support the Uranium Processing Facility project and Y-12, and constructed the Mechanical Electrical Building with utility equipment and support systems for the two process buildings. The remaining three subprojects are under way.

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Fiscal Year 2024 Stockpile Stewardship and Management Plan

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Legislative Language

Title 50 of United States Code Section 2523 (50 U.S. Code § 2523), requires that:

> The Administrator, in consultation with the Secretary of Defense and other appropriate officials of the departments and agencies of the Federal Government, shall develop and annually update a plan for sustaining the nuclear weapons stockpile. The plan shall cover, at a minimum, stockpile stewardship, stockpile management, stockpile responsiveness, stockpile surveillance, program direction, infrastructure modernization, human capital, and nuclear test readiness. The plan shall be consistent with the programmatic and technical requirements of the most recent annual Nuclear Weapons Stockpile Memorandum.

Pursuant to previous statutory requirements, the Department of Energy's National Nuclear Security Administration (DOE/NNSA) has submitted reports on the plan to Congress annually since 1998, with the exception of 2012.[1]

The *Fiscal Year 2024 Stockpile Stewardship and Management Plan* (SSMP) is a detailed report of DOE/NNSA's 25-year program of record to maintain the safety, security, and effectiveness of the nuclear stockpile and is primarily captured in this single, unclassified document. A classified annex to the SSMP contains supporting details concerning the U.S. nuclear stockpile and stockpile management.

[1] In 2012, a *Fiscal Year 2013 Stockpile Stewardship and Management Plan* was not submitted to Congress because analytical work conducted by the Department of Defense and NNSA to evaluate the out-year needs for nuclear modernization activities across the nuclear security enterprise had not yet been finalized.

Chapter 1
Overview and Strategic Context for Managing the Nuclear Weapons Stockpile

The international security environment has deteriorated in recent years, in large part due to the actions of the United States' strategic competitors and their heavy investment in new nuclear capabilities. The People's Republic of China has embarked on an ambitious expansion, modernization, and diversification of its nuclear forces and has established a nascent nuclear triad. The Russian Federation continues to emphasize nuclear weapons in its strategy, modernize and expand its nuclear forces, and brandish nuclear weapons in support of its revisionist security policy. As a result, by the 2030s the United States will, for the first time in its history, face two major nuclear powers as strategic competitors and potential adversaries. For the foreseeable future, nuclear weapons will continue to provide unique deterrence effects that no other element of U.S. power can provide, given the reality of today's evolving and uncertain international security environment.

Ensuring the U.S. strategic deterrent remains safe, secure, and effective without nuclear explosive testing, and that the United States' deterrence commitments to its allies remain strong and credible requires significant and coordinated effort. Responsibility for this mission is shared by the Department of Defense (DoD) and the Department of Energy's National Nuclear Security Administration (DOE/NNSA). Only through the two Departments aligning their priorities, programs, and funding can U.S. nuclear forces meet deterrence and assurance requirements.

DOE/NNSA partners with DoD through the Nuclear Weapons Council on the joint nuclear weapons lifecycle process to execute the Nation's nuclear weapons programs. DoD and DOE/NNSA use this process to manage weapons sustainment and modernization needs, from concept assessment to full-scale production, and finally, to retirement and dismantlement. DoD and DOE/NNSA continue to make progress across the current major warhead programs as DOE/NNSA performs an unprecedented level of component development, qualification, system integration, and production activities. In December 2022, DOE/NNSA achieved a major scientific breakthrough decades in the making by reaching fusion ignition at Lawrence Livermore National Laboratory (LLNL). LLNL's National Ignition Facility conducted the first controlled fusion experiment in history to reach this milestone, also known as scientific energy breakeven, meaning it produced more energy from fusion than the laser energy used to drive it. This first-of-its-kind feat will provide unprecedented capability to support DOE/NNSA's Stockpile Stewardship Program and has implications for the future of clean power.

The weapons comprising the U.S. nuclear stockpile are currently assessed to be safe, secure, and effective. However, continued science and infrastructure investments are needed to ensure the stockpile can provide a timely response to threat developments, technology opportunities, and maintain effectiveness over time. Recapitalizing the nuclear security enterprise, including the workforce, infrastructure, production capacity and capability, and the scientific base that supports it, is key to ensuring these goals can be achieved. Therefore, DOE/NNSA is currently undertaking a risk-informed, complex, and time-constrained modernization and recapitalization effort to support continued mission success, responsive to the priorities identified in the 2022 *Nuclear Posture Review*.

DOE/NNSA draws authority for managing the Nation's nuclear stockpile from the *Atomic Energy Act of 1954* (42 U.S. Code § 2011 *et seq.*) and, more specifically, the *National Nuclear Security Administration Act* (50 U.S. Code § 2401 *et seq*.) (NNSA Act). DOE/NNSA's broad set of enduring missions are to protect the Nation by maintaining a safe, secure, and effective nuclear weapons stockpile, reduce global nuclear threats, and provide the Navy's submarines and aircraft carriers with militarily effective nuclear propulsion. Activities related to DOE/NNSA's stockpile mission conduct are referred to in this document as Weapons Activities.

DOE/NNSA's annual *Stockpile Stewardship and Management Plan* (SSMP) has two primary purposes:

- Document DOE/NNSA's plans to:
  - Maintain the current stockpile
  - Modernize the stockpile as needed to respond to evolving deterrent needs
  - Advance the science that enables stockpile stewardship to enhance the potential performance and understanding of the stockpile's aged, modified, and modernized nuclear weapons
  - Maintain and modernize supporting infrastructure
  - Sustain DOE/NNSA's highly skilled workforce
- Provide DOE/NNSA's formal response to multiple statutory and administrative reporting requirements, which can be found in Appendix A, "Requirements Mapping," including:
  - Annual life extension program reporting required under the Explanatory Statement accompanying the *Consolidated Appropriations Act, 2017* (P.L. 115-31)
  - Actual or potential risks to, or specific gaps in, any element of the industrial base that supports nuclear weapons components' subsystems or materials, in addition to any mitigation actions needed as requested through Section 3135 of the *National Defense Authorization Act for Fiscal Year 2022* (P.L. 117-81)

This fiscal year (FY) 2024 SSMP serves as the annual plan for sustaining the nuclear weapons stockpile required by statute. The 25-year strategic plan was developed in alignment with strategic guidance, including the 2022 *Nuclear Posture Review*, the *Nuclear Weapons Council's Strategic Plan for Fiscal Years (FY) 2019 – 2044,* the *FY 2020 – 2025 Nuclear Weapons Stockpile Plan,* and other policy directives (see Section 1.2).

1.1 Policy Framework Summary

The *NNSA Act* directs DOE/NNSA "to maintain and enhance the safety, reliability, and performance of the U.S. nuclear weapons stockpile, including the ability to design, produce, and test, to meet national security requirements."

Recently, the 2022 *National Defense Strategy* and the accompanying *Nuclear Posture Review* stated that as long as nuclear weapons exist, the fundamental role of U.S. nuclear weapons is to deter nuclear attack on the United States and its allies and partners. The 2022 *Nuclear Posture Review* also reinforced that the United States will maintain nuclear forces that are responsive to the threats it faces and affirmed the following roles for nuclear weapons:

- Deter strategic attacks
- Assure allies and partners
- Achieve U.S. objectives, if deterrence fails

Furthermore, the 2022 *Nuclear Posture Review* represented a comprehensive, balanced approach to U.S. nuclear strategy, policy, posture, and forces, and reaffirmed that maintaining a safe, secure, and effective nuclear deterrent and strong and credible extended deterrence commitments remains a top priority for DoD, DOE/NNSA, and the Nation.

The 2022 *Nuclear Posture Review* also identified three pillars for nuclear deterrent mission success:

- DoD and NNSA will develop and implement a Nuclear Deterrent Risk Management Strategy to identify, prioritize, and recommend actions across the portfolio of nuclear programs and monitor the overall health of the nuclear deterrent as the United States sustains current capabilities and transitions to modernized systems.
- NNSA will institute a Production-based Resilience Program to complement the science-based stewardship program and ensure the nuclear security enterprise is capable of full-scope production for new or emerging requirements.
- NNSA will establish a Science and Technology Innovation Initiative to accelerate integrating science and technology throughout mission requirements and help provide an increased focus on leveraging science and technology to support the weapon design and production phases of weapon development.

DOE/NNSA, in partnership with DoD, continues to implement the direction from the 2022 *Nuclear Posture Review*.

1.2 The DOE/NNSA Nuclear Security Enterprise

The DOE/NNSA nuclear security enterprise (**Figure 1–1**) consists of DOE/NNSA Headquarters (located in Washington, DC; Germantown, Maryland; and Albuquerque, New Mexico); the DOE/NNSA field offices; the three national security laboratories (two of which have production missions); the four nuclear weapons production sites; and the Nevada National Security Site (NNSS). DOE/NNSA implements the overall nuclear weapons strategy, in collaboration with its management and operating (M&O) partners, and oversees and coordinates activities to accomplish them in an efficient, fiscally responsible manner.

1.2.1 National Security Laboratories

Three national security laboratories are devoted to nuclear weapons design and data interpretation:

- LLNL in Livermore, California
- Los Alamos National Laboratory (LANL) in Los Alamos, New Mexico
- Sandia National Laboratories (SNL) in Albuquerque, New Mexico, and Livermore, California

The primary mission of these national security laboratories is to perform research to develop, sustain, and implement nuclear weapons design, simulation, modeling, and experimental capabilities and competencies. This research ensures confidence in the current and future stockpile without requiring nuclear explosive testing. All three laboratories are Federally Funded Research and Development Centers (FFRDCs).[1] They engage in long-term research, development, test, and evaluation activities for the nuclear

[1] FFRDCs are unique nonprofit entities sponsored and funded by the U.S. Government to meet special long-term research or development needs that cannot be met as effectively by existing in-house or contractor resources. FFRDCs are operated, managed, and/or administered by either a university or consortium of universities, another not-for-profit or nonprofit organization, or an industrial firm either as an autonomous organization or an identifiable separate operating unit of a parent organization.

weapons missions and apply science, technology, and engineering to solve many other national security challenges. Along with the national security laboratories, other DOE national laboratories also support the Weapons Activities and Defense Nuclear Nonproliferation programs.

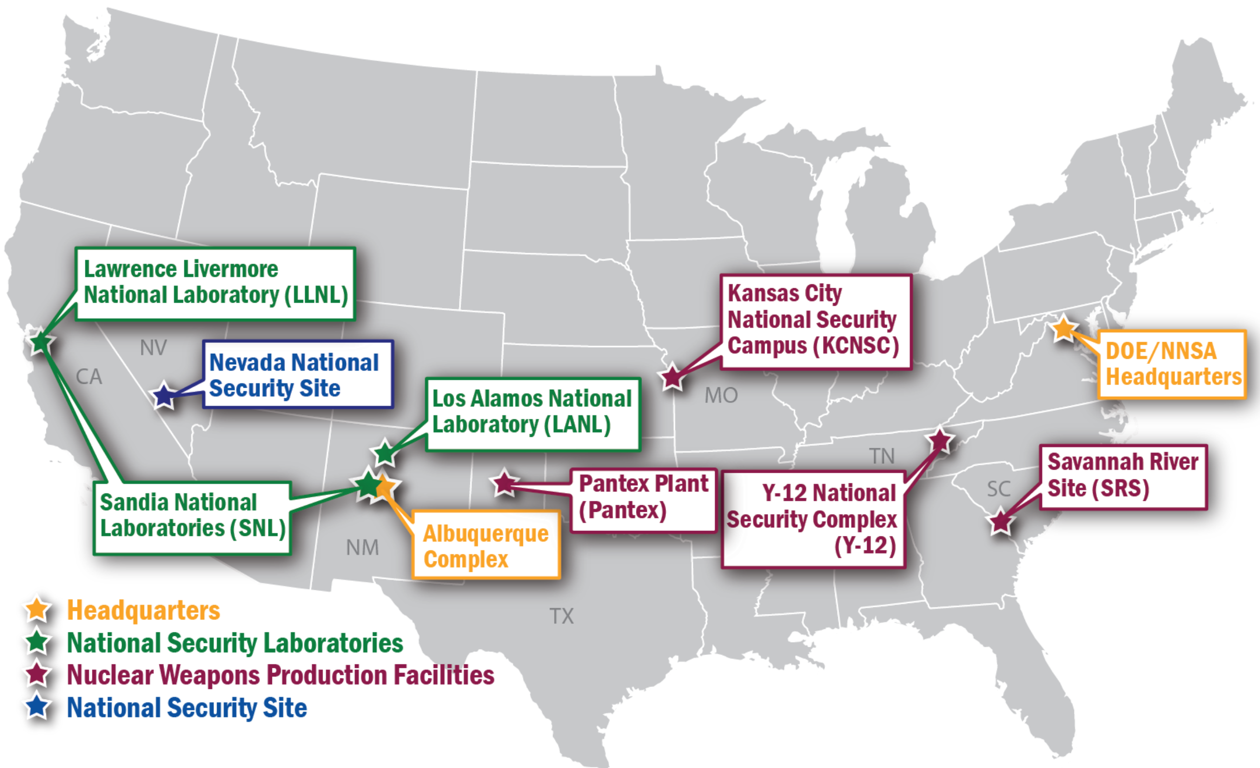


Figure 1–1. The DOE/NNSA nuclear security enterprise

1.2.2 Nuclear Weapons Production Facilities

The four nuclear weapons production sites conduct a range of stockpile management activities:[2]

- The Kansas City National Security Campus in Kansas City, Missouri, produces non-nuclear components.
- The Pantex Plant in Amarillo, Texas, manufactures and tests high explosive components and assembles, disassembles, and refurbishes stockpile weapons and components.
- The Y-12 National Security Complex in Oak Ridge, Tennessee, manufactures uranium, along with other nuclear weapon components, and dismantles and stores highly enriched uranium.
- The Savannah River Site in Aiken, South Carolina, extracts, recycles, and loads tritium into gas transfer systems.[3]

In addition, the nuclear production facilities provide or contribute to critical stockpile capabilities, including science, production, materials, and processes that are necessary for sustaining the stockpile.

[2] Some critical production capabilities also exist at LANL and SNL.

[3] DOE's Savannah River National Laboratory at Savannah River Site also conducts research and development in support of tritium processing and gas transfer system design and certification activities.

1.2.3 Nevada National Security Site

NNSS near Las Vegas, Nevada, works with the national security laboratories to provide facilities, infrastructure, and personnel to conduct unique nuclear and non-nuclear experiments that are essential to maintaining the stockpile. It is the primary location where experiments with radioactive and other high-hazard materials are conducted and the only location where high explosive-driven plutonium experiments can be conducted at weapon-scale with weapon-relevant amounts of special nuclear material. In accordance with the U.S. moratorium on nuclear explosive testing, such experiments and activities are always subcritical. NNSS also develops and deploys state-of-the-art diagnostics and instrumentation, analyzes data, stores programmatic materials, conducts criticality experiments, and supports other DOE/NNSA activities.

1.3 Introduction to the Nuclear Weapons Stockpile

The nuclear stockpile's size and composition continues to change in response to U.S. national security requirements, though the average warhead age in the stockpile remains high. Many weapons systems are past their design life expectancy and require stockpile management activities to assess their condition and perform maintenance as well as enhanced surveillance to confirm weapons are operable and extend weapon lifetimes. With several major warhead modernization activities underway, DOE/NNSA is working toward reducing average warhead age while meeting emerging challenges on a timeline that does not put the nuclear deterrent at risk.

The current stockpile consists of active weapons, which are maintained to meet military requirements, and inactive weapons, which are used to augment or replace warheads in the active stockpile as necessary. Retired weapons are not included in the count of stockpile weapons. **Table 1–1** reflects the major characteristics of the Nation's current stockpile, which is composed of two types of submarine-launched ballistic missile warheads, two types of intercontinental ballistic missile warheads, several types of gravity bombs, and a cruise missile warhead.

The classified Annex to this plan includes specific technical details about the stockpile by warhead type.

Table 1–1. Current U.S. nuclear weapons and associated delivery systems

Warheads—Strategic Ballistic Missile Platforms					
Type [a]	***Description***	***Delivery System***	***Laboratories***	***Mission***	***Service***
W78	Reentry vehicle warhead	Minuteman III intercontinental ballistic missile	LANL/SNL	Surface to surface	Air Force
W87-0	Reentry vehicle warhead	Minuteman III intercontinental ballistic missile	LLNL/SNL	Surface to surface	Air Force
W76-0/1/2	Reentry body warhead	Trident II D5 submarine-launched ballistic missile	LANL/SNL	Underwater to surface	Navy
W88	Reentry body warhead	Trident II D5 submarine-launched ballistic missile	LANL/SNL	Underwater to surface	Navy
Bombs—Aircraft Platforms					
B61-3/4	Nonstrategic bomb	F-15, F-16, certified NATO aircraft	LANL/SNL	Air to surface	Air Force/Select NATO forces
B61-7	Strategic bomb	B-2 bomber	LANL/SNL	Air to surface	Air Force
B61-11	Strategic bomb	B-2 bomber	LANL/SNL	Air to surface	Air Force
B61-12	Strategic bomb	B-2 bomber	LANL/SNL	Air to surface	Air Force
B83-1 [b]	Strategic bomb	B-2 bomber	LLNL/SNL	Air to surface	Air Force

Warheads—Cruise Missile Platforms					
W80-1	Air-launched cruise missile strategic weapons	B-52 bomber	LLNL/SNL	Air to surface	Air Force

LANL = Los Alamos National Laboratory
LLNL = Lawrence Livermore National Laboratory
NATO = North Atlantic Treaty Organization
SNL = Sandia National Laboratories

[a] The suffix associated with each warhead or bomb type (e.g., "-0/1/2" for the W76) represents the modification associated with the respective weapon.

[b] The 2022 *Nuclear Posture Review* directed the retirement of the B83-1. Specific details of the B83-1 retirement and dismantlement plan remain classified.

1.4 Overall Strategy, Objectives, and Prioritization of Weapons Activities

> ***Major Goals of Weapons Activities***
> - *Ensure the nuclear weapons stockpile continues to meet DoD deterrent requirements while enhancing warhead safety and security*
> - *Modernize production capabilities and nuclear security enterprise facilities*
> - *Provide experimental and computational capabilities to support the stockpile annual assessment and certification*
> - *Recruit, train, and retain a highly skilled and diverse workforce to meet mission deliverables*

DOE/NNSA continues to execute its long-standing nuclear warhead modernization efforts in conjunction with the modernization of DoD delivery platforms, along with the necessary modernization of its capabilities and infrastructure. This approach will allow the necessary flexibility for future policy decisions related to nuclear modernization as the United States adjusts to the changing international threats facing the country and its allies and partners. The nuclear weapons stockpile is currently safe, secure, and militarily effective. However, the United States must continue to invest in the weapons and infrastructure modernization programs to provide the capabilities needed to ensure the deterrent's viability in the future. DOE/NNSA's mission is to enhance science, technology, and engineering capabilities to address emerging challenges, improve production processes' efficiency and effectiveness, and to provide a credible deterrent despite unanticipated risks or technological surprise. Due to the long lead times necessary to prepare and establish nuclear capabilities, the United States will not have the weapons and infrastructure in place to support the nuclear stockpile unless DOE/NNSA takes action to reestablish and recapitalize these capabilities now.

The FY 2024 budget for Weapons Activities includes funding for several nuclear modernization programs and was developed in support of the Administration's 2022 *Nuclear Posture Review*:

- **Define the Capability to Effectively Engage and Defeat Hardened and Deeply Buried Targets.** The Nuclear Weapons Council established a joint NNSA/DoD Hard and Deeply Buried Target Defeat Team, coordinated through the Assistant Secretary of Defense for Nuclear Chemical and Biological Defense Programs/Office of Nuclear Matters, to determine future options for defeating such targets.
- **Advance the W87-1 Modification Program.** The W87-1 Modification Program will replace the aging W78 warhead using a modified existing legacy W87-0 design and will deploy new technologies that improve safety and security, address material obsolescence, and improve warhead manufacturability. In FY 2022, DOE/NNSA matured select technologies and furthered system test and qualification planning. In FY 2023, the Nuclear Weapons Council authorized entry into Phase 6.3, *Development Engineering*.
- **Develop the W93.** The W93 Modernization Program was established to support the Navy's identified need for a new reentry body. Anchored on previously tested nuclear components, the

W93 will incorporate modern technologies to improve safety, security, and flexibility to address future threats. It will be designed for ease of manufacturing, maintenance, and certification. Key nuclear components will be based on currently deployed and previously tested nuclear designs, and extensive stockpile component and materials experience. It will also support the continued viability of DoD's operational flexibility and effectiveness as the United States transitions from Ohio-class submarines to a smaller fleet of Columbia-class submarines. The W93 will not require additional nuclear explosive testing to be certified.

Carrying out the W93 program is vital for continuing the United States' longstanding cooperation with the United Kingdom, which is also modernizing its nuclear forces. As an allied but independent nuclear power that contributes to the North Atlantic Treaty Organization's nuclear deterrent posture, the United Kingdom's nuclear deterrent is critical to U.S. national security.

In summary, the United States must continue its ability to maintain and certify a safe, secure, and effective nuclear arsenal. Synchronized with DoD delivery platform replacement programs, DOE/NNSA will sustain and deliver the warheads necessary to support the Nation's strategic and non-strategic nuclear capabilities on time by:

- Completing the B61-12 Life Extension Program
- Completing the W88 Alteration 370
- Maintaining synchronization of DOE/NNSA's W80-4 warhead with DoD's Long Range Standoff cruise missile program
- Exploring future warhead options to meet the required military characteristics based on the threats and vulnerabilities potential adversaries pose, including possible common reentry systems for Air Force and Navy systems
- Delivering the W87-1 and W93 warheads to support the land- and sea-based legs of the triad

DOE/NNSA uses several major strategies to sustain and maintain the stockpile and support DOE/NNSA mission priorities, including:

- Assessing the stockpile annually through science-based stockpile stewardship:
  - Assessing whether the current and future nuclear stockpile's safety, reliability, and performance can be assured in the absence of underground nuclear explosive testing
  - Renewing, developing, and enhancing science capabilities to assess effects of aging, remanufacture and material options, and evolving threat environments on warhead performance
  - Maintaining the readiness to conduct an underground nuclear explosive test, if required, to assess safety and performance characteristics of the Nation's stockpile, or if otherwise directed by the President
- Extending the nuclear deterrent's life through modernizations:
  - Replacing obsolete technology
  - Enhancing stockpile safety and security
  - Meeting military requirements
- Assuring the capabilities to support the nuclear deterrent in the near and long-term (these capabilities are discussed in the FY 2023 SSMP in Chapter 3, "Weapons Activities Capabilities that Support the Nuclear Security Enterprise"):

  - Developing modern materials and design and manufacturing options to enable a more modern and efficient production complex
  - Renewing and sustaining critical production, manufacturing, and research capabilities
  - Assuring a stable, reliable, and trusted domestic supply chain for nuclear weapon materials, components, and subsystems
- Advancing innovative experimental platforms, diagnostic equipment, and computational capabilities:
  - Keeping technical expertise and capabilities on the cutting edge to support a responsive and resilient enterprise
- Providing safe and secure transport of nuclear weapons, weapon components, and special nuclear materials to meet mission requirements
- Implementing enterprise-wide recruitment and retention strategies which incorporate hiring, compensation and benefits flexibilities, and promoting a healthy work-life balance
- Enhancing cyber infrastructure and resiliency across the enterprise

The Integrated Stockpile Model in **Figure 1–2** shows how the stockpile cycle's main activities—plan, modernize, maintain, assess, and certify—link these strategies to sustain the stockpile and support mission priorities.

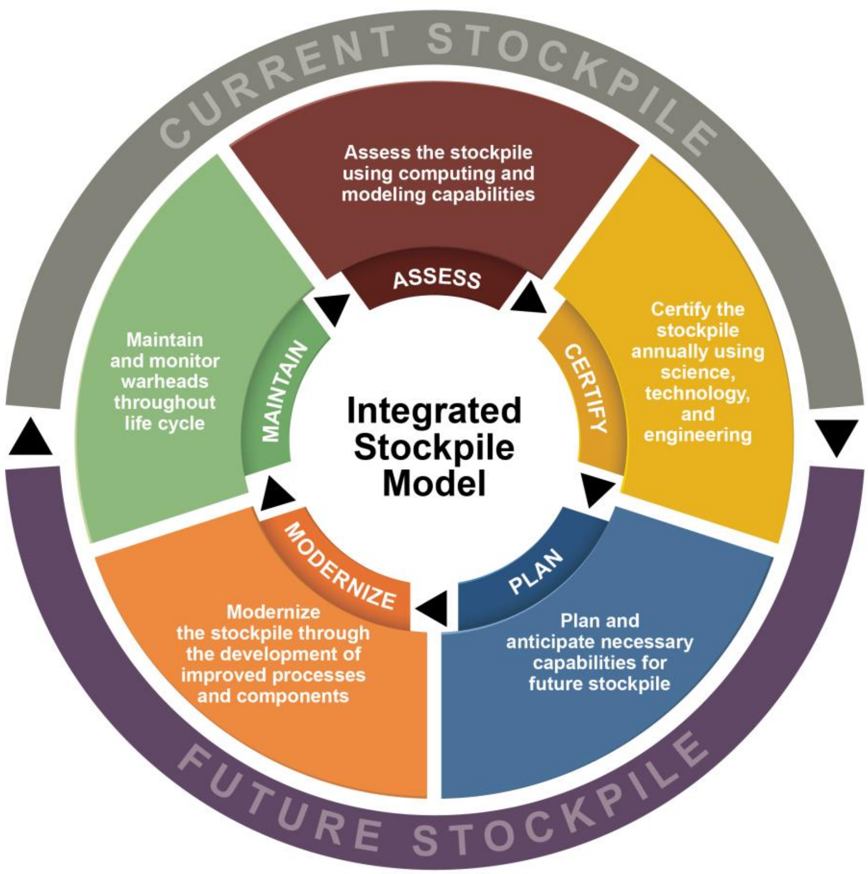


Figure 1–2. Integrated stockpile model

1.5 Partnership with the Department of Defense

DOE/NNSA and DoD work collaboratively to maintain and modernize the stockpile and delivery systems. DOE/NNSA's role is to ensure nuclear weapons remain safe, secure, and reliable, while DoD's role is to provide a range of delivery options that can be tailored to meet the desired objectives. These complementary efforts are coordinated through the Nuclear Weapons Council. This council is a joint DoD and DOE/NNSA coordinating body established by Congress to facilitate aligning requirements and determine priorities as the two departments fulfill their shared responsibility to provide the Nation's nuclear deterrent.

The Nuclear Weapons Council regularly convenes to synchronize efforts between DoD and DOE/NNSA on the vision, strategy, and execution of the nuclear program aligned with the National Defense Strategy. The Nuclear Weapons Council also reviews costs and schedules for options related to the nuclear stockpile, driving DOE/NNSA and the Military Services to meet requirements in ways that are both cost-effective and timely. The Nuclear Weapons Council fully supports DOE/NNSA's efforts to establish a responsive and resilient nuclear security enterprise to meet U.S. deterrence and assurance needs.

1.6 Challenges in Executing the Stockpile Stewardship and Management Plan

For most of the post-Cold War period, the focus of our nuclear security enterprise has been to sustain existing nuclear weapons and improve the ability to assess their safety, security, reliability, and effectiveness without nuclear explosive testing. When aging issues were identified in the stockpile, weapons were partially refurbished without changing their military characteristics. Many elements of the weapons production infrastructure were only required on a limited basis or not needed for these refurbishment efforts, causing a capability loss.

Today, much of the stockpile has aged without comprehensive refurbishment. At a time of rising nuclear risks, a partial refurbishment strategy is no longer adequate to meet mission needs. A safe, secure, and effective nuclear deterrent requires modern weapons and a modern infrastructure, enabled by a world-class workforce equipped with modern tools.

DOE/NNSA will continue to carry out robust risk management strategies within the nuclear security enterprise so that the deterrent is capable even in the face of significant uncertainties and unanticipated challenges. This proactive activity requires developing and sustaining a set of initiatives and actions that, over time, will build resilience in the stockpile, production capabilities, and science and technology capabilities.

DoD also continues to make progress on the first recapitalization of the triad[4] since the end of the Cold War, and this effort cannot be accomplished alone. Consistent, on-going schedule integration between the warhead and delivery programs managed by DOE/NNSA and DoD, respectively, is key to delivering timely and cost-effective capabilities that meet the Nation's defense needs. The partnership between DoD and DOE/NNSA continues to be managed through the Nuclear Weapons Council, which has made tremendous progress to align priorities, schedules, and investments between the Departments to ensure the nuclear deterrent's future viability.

[4] A combination of platforms and weapons, the three legs of the U.S. nuclear triad (land, sea, and air), serve as the backbone of America's national security (https://www.defense.gov/Experience/Americas-Nuclear-Triad/).

DOE/NNSA has resourced plans to renew the essential manufacturing capabilities prioritized to meet DoD near-term to intermediate-term warhead deliveries and maintain workforce safety. DOE/NNSA's plans focus on five areas:

- Establishing a pit production capability
- Reestablishing high explosives synthesis, formulation, and production capabilities
- Modernizing and enhancing the facilities and capabilities needed to meet near-term to long-term needs for tritium
- Modernizing the production capabilities for secondary assemblies, radiation cases, and replacing the current lithium production facility
- Modernizing and enhancing non-nuclear component research, development, testing, and production capabilities

Figure 1–3 shows the timeline necessary to meet warhead needs.

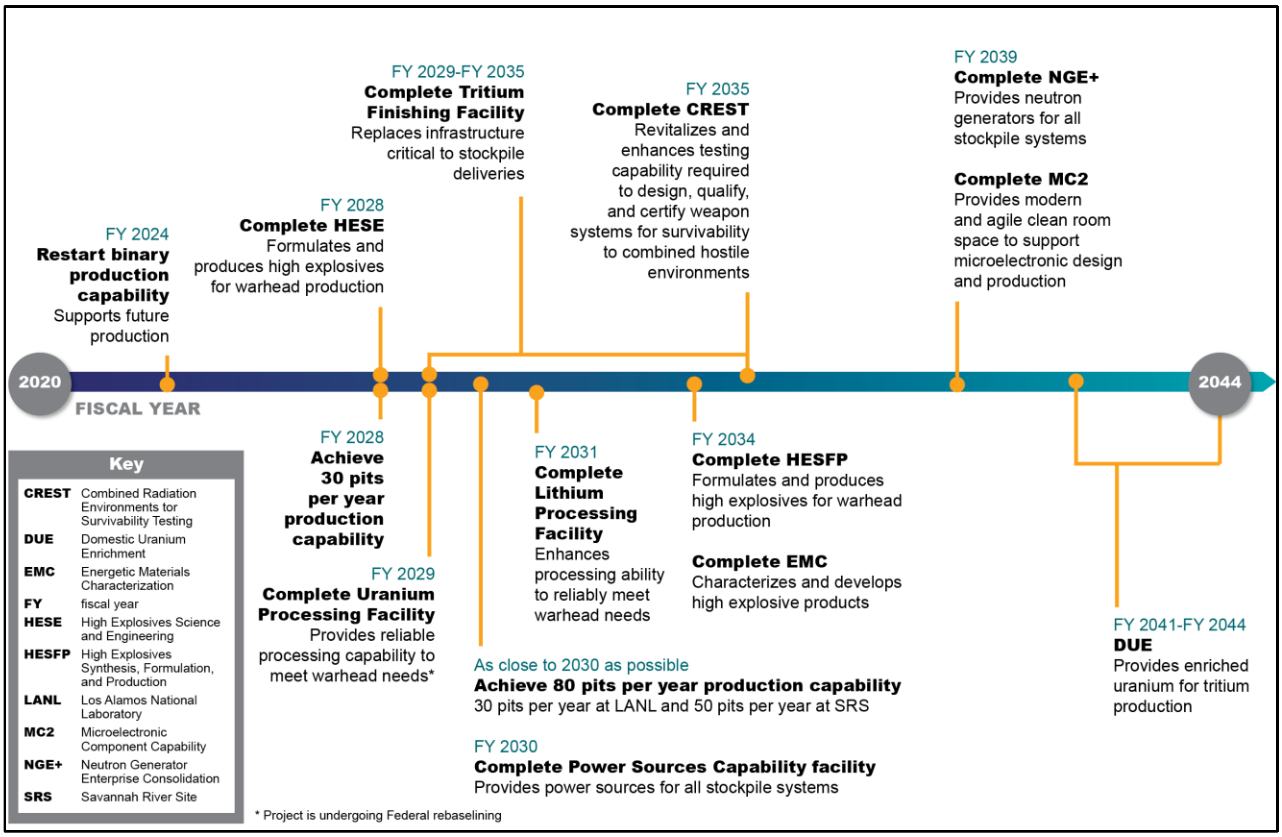


Figure 1–3. Timeline for key infrastructure and capability investments for future warheads

To support the above focus areas, other key considerations include:

- The nuclear weapons stockpile needs updated technologies that require investment in new processes, technologies, and tools for warhead design, qualification, certification, and production in accordance with stringent and evolving stockpile specifications and requirements. The increased number of concurrent weapon system builds entail three requirements:
  - Maturing new options with shortened development cycles
  - Advancing the ability to predict weapon performance in configurations that were not tested underground
  - Evaluating the impact of new materials and processes, reusing aging components in future systems, and enhancing production throughput
- Pursuing only the priority activities previously described does not exercise all phases and aspects of the joint nuclear weapons lifecycle. DOE/NNSA must devote some effort to less time-sensitive activities to transfer knowledge and skills to the newer generation of nuclear weapon designers and engineers, accelerate and enhance the weapon lifecycle, and strengthen integration between DoD and DOE/NNSA to sustain all required capabilities. This continued focus is reflected in the inclusion of Appendix D, which resubmits information on the programs, projects, and activities of the Stockpile Responsiveness Program.
- DOE/NNSA must sustain the nuclear weapons supply chain availability and trustworthiness to assure industrial base viability and guard against potential counterfeit and sabotage. DOE/NNSA has implemented several initiatives through the Nuclear Enterprise Assurance Program to protect the supply chain. For example, DOE/NNSA's nuclear security enterprise provides the tools and capabilities needed for trusted radiation-hardened silicon microelectronics. DOE/NNSA is installing new tooling and planning recapitalization efforts to extend the life of key and critical facilities to support continued capability. DOE/NNSA is also collaborating with partners to establish research and development efforts that could serve as future production capabilities.

Chapter 2
Stockpile Management

This chapter summarizes the activities the Department of Energy's National Nuclear Security Administration (DOE/NNSA) manages to maintain the Nation's nuclear weapons stockpile. These activities include sustaining, modernizing, and dismantling nuclear weapons; maintaining and modernizing production operations; and optimizing the scientific capabilities that underpin these efforts.

Figure 2–1 provides an overview schematic of the Stockpile Management major subprograms:

- **Stockpile Sustainment** performs single-system and multi-system sustainment activities for all warheads in the current stockpile to include limited life component (LLC) exchanges, surveillance activities, significant finding investigations (SFI), weapons reliability reporting, annual assessments that provide a comprehensive understanding of the stockpile's health, and warhead qualification and delivery system integration activities.
- **Stockpile Major Modernization** includes life extension programs (LEPs) to extend the lives of current stockpile weapons, modification programs (Mods) to change the operational capabilities of stockpile systems, major alterations (Alts), which alter stockpile systems without changing their operation capabilities, and warhead acquisition programs which provide modernized warhead capabilities designed to meet military requirements that cannot be met with other stockpile systems.
- **Weapons Dismantlement and Disposition (WDD)** manages dismantlement of retired weapons as well as disposition of weapon components, which can generate components and materials for Weapons Activities, including modernization programs, and other DOE/NNSA mission areas.
- **Production Operations** provides the base capabilities to enable weapon operations (i.e., assembly, disassembly, and production) planned for the warhead modernization, sustainment, and the WDD programs. Production Operations are not specific to one material stream. It coordinates closely with the Production Modernization program (see Chapter 3), which focuses on the special nuclear materials (such as plutonium and uranium) and components, as well as non-nuclear component modernization.
- **Nuclear Enterprise Assurance (NEA)** ensures the nuclear security enterprise actively manages subversion risks to the nuclear weapons stockpile and associated design, production, and testing capabilities.

Stockpile Management Accomplishments

- *Completed Annual Assessment Cycle 27*
- *Achieved First Production Unit on the B61-12 weapon and Joint Test Assembly (JTA)*
- *The Nuclear Weapons Council formally accepted the W88 Alt 370 and B61-12 into the stockpile and authorized entrance to Phase 6.6 in fiscal year (FY) 2022*
- *W80-4 received authorization to enter Phase 6.4*
- *Achieved last production unit delivery for W76-1 MC4700 arming, fuzing, and firing system*
- *Achieved first production unit for MC4972-1 Common High Efficiency Adaptable Telemetry Transmitter 1 month early, which is a multi-program JTA transmitter*
- *W87-1 received authorization to enter Phase 6.3*
- *W93 received authorization to enter Phase 2*

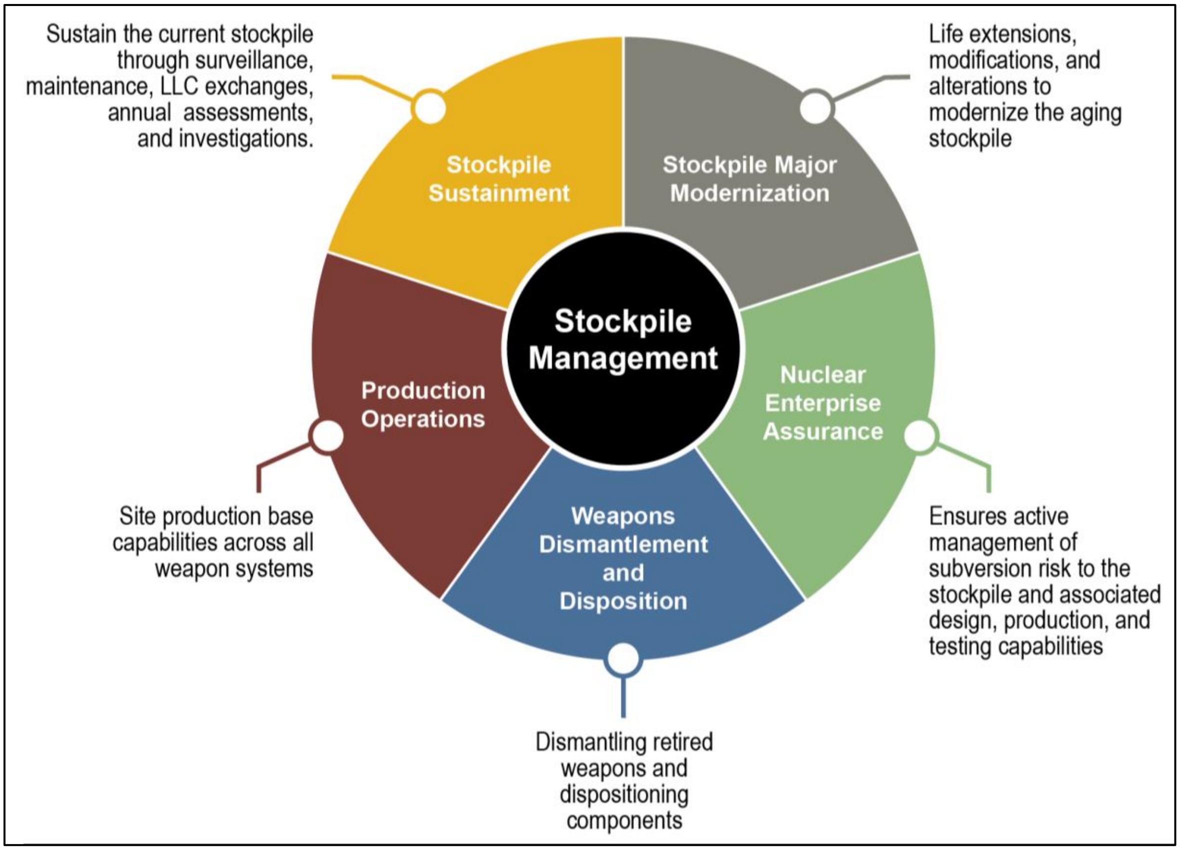


Figure 2–1. Stockpile Management major subprograms

The remainder of Chapter 2 is organized around these five major subprograms.

Managing the stockpile requires comprehensive planning for all stockpile elements to integrate these activities with each other and with production capabilities. However, these activities alone cannot sustain the nuclear deterrent. Managing the stockpile also depends on a strong set of enabling capabilities covering the necessary science, technology, design, production, materials, and processes, as well as a workforce with the requisite skill set to execute these activities. These individual capabilities and the linkages to stockpile management are described at length in Chapters 3 and 4. Chapters 6 and 7 of this report address two specific elements of these capabilities—infrastructure and workforce—across all capabilities at an enterprise level, further reinforcing the need to sustain the health of capabilities to support the stockpile mission work.

2.1 Stockpile Sustainment

Stockpile sustainment activities are responsible for the ongoing health of the stockpile, including surveillance; annual assessments; investigations; and ongoing maintenance such as LLC exchanges, code management, and surety operations to ensure weapons remain safe, secure, and effective over their lifecycles. Some weapons that remain in the stockpile are eventually updated or replaced through modernization programs to address aging issues, modified military requirements, and any anomalies, and to meet updated safety and security standards. These modernization activities (LEPs, Mods, Alts, and warhead acquisition programs) are addressed through the Stockpile Major Modernization activities discussed in Section 2.2.

2.1.1 Assessing the Stockpile

The status of the stockpile is evaluated through continual, multi-layered assessments of the safety, security, and military effectiveness of each U.S. nuclear weapon system. The annual stockpile assessment process evaluates the state of the stockpile by conducting physics and engineering analyses, experiments (such as hydrodynamic and subcritical experiments), and computer simulation/modeling. Assessments also evaluate the effects of aging on performance and quantify performance thresholds, uncertainties, and margins. Assessors gather a body of evidence to evaluate performance at the part, component, subsystem, and system levels to determine whether performance requirements are met. The processes combine data, analysis, and expert judgment with simulations and continually advancing capabilities to develop a final evaluation of the stockpile.

Stockpile Sustainment Accomplishments

- *Los Alamos National Laboratory, Sandia National Laboratories, and Lawrence Livermore National Laboratory completed annual assessment reviews for the deployed systems under their purview*
- *Completed planned LLC exchanges*
- *Delivered modernized components and technology to weapons modernization programs*
- *Surveilled the deployed stockpile*

2.1.1.1 Annual Assessment

The Annual Stockpile Assessment Reporting Process is codified in 50 U.S. Code § 2525—*Annual assessments and reports to the President and Congress regarding the condition of the United States nuclear weapons stockpile*. The code requires the directors of the three national security laboratories to conduct independent annual assessment reviews on the state of all stockpile systems for which they are responsible. It also requires the Commander of the U.S. Strategic Command (USSTRATCOM) to assess the stockpile each year based in part on inputs from the national security laboratories. This process is not a recertification of the weapons in the stockpile; it is an assessment of each system's existing certification basis. Each annual assessment builds on previous years' experience with each weapon system and incorporates new information, and state-of-the-art capabilities, from stockpile maintenance, surveillance, experiments, simulations, and other sources to update the technical basis of each weapon system.

The assessments and conclusions in the Annual Assessment Reports are subject to inter-laboratory peer review by subject matter experts appointed by each laboratory's director, program managers, and senior laboratory management. This effort culminates in a written summary and conclusion of the assessments from each laboratory director and the USSTRATCOM Commander. These findings are included as unabridged attachments to the statutorily required *Report on Stockpile Assessments*, prepared by the Nuclear Weapons Council for formal endorsement by the Secretaries of Energy and Defense and submitted to the President annually.

2.1.1.2 Weapon Reliability

DOE/NNSA publishes an annual *Weapons Reliability Report*, which provides an updated summary of reliability and yield characteristics of all weapons in the stockpile. The report's purpose is to communicate to stakeholders the assessed reliability, reliability risks, and effects of test limitations. This report is the principal DOE/NNSA report on weapon systems reliability that USSTRATCOM uses for strategic planning actions. The Annual Assessment Review process informs this report, which incorporates data from surveillance activities.

2.1.1.3 Advanced Certification and Qualification

Advanced Certification develops tools and methods to ensure the safety and reliability of the current stockpile and prospective systems for stockpile modernization without further underground nuclear explosive testing. This subprogram delivers assessment methods, diagnostic and experimental techniques, data analysis methods, and assessments of the certifiability of design options for future stockpile needs. Advanced Certification activities preserve and reanalyze legacy nuclear test data and validate simulation codes and models against improved physics models, and hydrotest and subcritical experimental data. These activities enhance DOE/NNSA's understanding of a weapon system's performance, improve the quantification of margins and uncertainties, and improve the fidelity and agility of certification methods.

DOE/NNSA qualifies nuclear weapons components, subsystems, and integrated systems to the military characteristics and stockpile-to-target sequence environmental requirements, including normal, abnormal, and hostile environments prior to their introduction into the stockpile. Qualification plans for each stockpile system specify the experimental data, modeling, simulation capabilities, and production data required to ensure system safety, security, reliability, and performance. While qualification is carried out by each warhead program, Advanced Qualification activities improve qualification methods by anticipating needs and developing the tools, capabilities, and material fabrication options that will enable qualification of replacement or new materials/components with a focus on increased responsiveness and enhanced analysis. These activities address the qualification challenges for advanced manufacturing methods, replacement materials, and new systems architectures. Additionally, these activities are focused on methods to streamline qualification processes to reduce costs, timescales, resources, floor space and testers, and to standardize methods and requirements across warhead systems. Advanced Certification and Qualification activities promote the close coordination between design and production agencies to capture qualification challenges early in the development process and design for easier manufacturing and relaxed specifications, where possible, without compromising certification needs.

2.1.1.4 Quantification of Margins and Uncertainties

Assessing weapon performance requires integrating many sources of data and expertise. One way performance is gauged is through the quantification of margins and uncertainties methodology, which evaluates the degree to which a weapon operates within the bounds of specified operating characteristics or requirements. This methodology supports nuclear stockpile decision-making and enables risk-informed decisions. A key metric is the confidence factor, or the ratio of margin (M) to uncertainty (U), M/U. Margin is the difference between the expected value and the minimum value of a parameter to ensure some aspect of warhead performance is met. Uncertainty is the degree to which these values are known, including the variation that exists due to design tolerances and manufacturing processes. Stockpile Research, Technology, and Engineering activities (also referred to as Stockpile Stewardship activities) evaluate approaches to increase margin when possible and to quantify uncertainties. These tasks are achieved by performing experiments in areas such as material properties to provide data for improving the reliability of the models used to simulate warhead operation. In summary, quantification of M/U provides an understanding of the basis for the assessed confidence in the weapons system performance and adds further confidence to the conclusions of the assessment process.

2.1.2 Stockpile Surveillance

Surveillance activities provide data to evaluate the safety, security, reliability, and performance of weapons in the current stockpile in support of annual assessments. The cumulative body of this data also supports future stockpile decisions based on the assessment activities described above. The surveillance program has six goals:

1. Identify manufacturing and design defects that could affect safety, security, reliability, or performance

2. Assess risks to the safety, security, reliability, and performance of the stockpile
3. Determine the margins between design requirements and performance at the system, component, and material levels
4. Identify aging-related changes and trends at the subsystem, component, and material levels
5. Further develop capabilities for predictive assessments and provide lifetime estimates of stockpile components and materials
6. Provide critical data for the annual *Weapons Reliability Report* and the *Report on Stockpile Assessments*

DOE/NNSA conducts stockpile surveillance through weapon disassembly and inspection, stockpile flight testing, stockpile laboratory testing, component testing, material evaluation, and test equipment. DOE/NNSA continually refines planning requirements for stockpile evaluation activities based on new surveillance information, new diagnostic tool deployment, annual assessment findings, and analysis of historical information using modern assessment methodologies and computational tools.

2.1.2.1 Disassembly and Inspection

Weapons sampled from the production lines or returned from Department of Defense (DoD) custody are inspected during disassembly. Weapon disassembly is conducted in a controlled manner to identify any abnormal conditions and preserve the components for subsequent evaluations. These inspections may detect anomalies that provide important clues about the health of the weapons, while also advancing knowledge and understanding of the stockpile.

2.1.2.2 System, Flight, Laboratory, and Component Testing

A subset of weapons that have undergone disassembly and inspection (D&I) are reassembled into joint test assembly (JTA) configurations to represent the original build to the greatest extent possible. Select non-nuclear components from weapon systems are used directly in the JTA, while nuclear materials are replaced with surrogate materials and custom diagnostic equipment. JTAs may contain extensive telemetry instrumentation to provide detailed information on component and subsystem performance during flight environments. JTA units are delivered to and flown by the DoD operational command responsible for the system. For each weapon system, JTAs are flown on delivery platforms to gather the information required to assess the effectiveness and reliability of the weapon, the launch or delivery platform, and the associated crews and procedures. System-level flight tests are conducted jointly with the Air Force and Navy.

After D&I, certain components of selected weapons are reassembled into test bed configurations using parent unit parts. Stockpile laboratory tests conducted at the subsystem, or component level, assess major assemblies and components and, ultimately, the materials that comprise the components. This surveillance process enables detection and evaluation of the onset of aging, trends, and anomalous changes at the component or material level.

Components and materials from the D&I process undergo further evaluations to assess component physical configuration, functionality, performance margins and trends, material behavior, and aging characteristics. The testing can involve nondestructive and destructive evaluation techniques and can be used to aid in developing predictive performance and aging models of components and materials.

2.1.2.3 Test Equipment

Custom sets of test equipment (i.e., testers) can be applied to systems, subsystems, major components, and processes. Testers perform two key functions. First, they provide the mechanical, electrical, and radiofrequency stimuli to the system in a specified sequence to evaluate component functionality relative to requirements. Second, they simultaneously collect data on the components and subsystems performance and for product acceptance. The data collected are used as input to assess the performance and assert the continued certification of the weapon system as safe, secure, reliable, and effective.

2.1.2.4 Anomaly Investigative Process

When anomalies that could adversely affect weapon safety, security, reliability, or performance are discovered in surveillance data or are identified and reported to DOE/NNSA by DoD, technical analyses are conducted to determine whether observations warrant an SFI. Investigations can include historical data modeling, focused materials experiments, research and studies, major system test replication, and subsystem and subcomponent tests. These SFIs can continue through several annual assessment cycles. SFIs are closed after the impacts to system performance, reliability, or safety have been assessed and follow-up actions are determined, if necessary. A tracking and reporting system monitors anomalies and SFIs as they progress from initial discovery, as well as the status of any corrective actions taken. This information is also reported in the annual assessment for the weapon system.

2.1.3 Maintaining the Stockpile

Maintaining the current stockpile involves many ongoing activities:

- Completing LLC exchanges of gas transfer systems (GTSs), power sources, and neutron generators, as required, to sustain system functionality
- Responding to emerging issues that do not rise to the level of a major Alt or LEP through maintenance, minor repairs and rebuilds, incorporation of surety features, and other changes
- Maintaining production authorization by conducting periodic nuclear explosives safety studies
- Maintaining specialized support equipment, such as custom tooling, for stockpile operations
- Provisioning for spare and replacement parts that are consumed in stockpile operations

2.1.3.1 Limited Life Components

Weapons contain LLCs that require periodic replacement to sustain system functionality and performance. Age-related changes affecting these components are predictable and well understood, and surveillance is conducted to ensure the components continue to meet performance requirements throughout their projected lifetime. Periodic LLC exchanges replace these components at defined intervals throughout a weapon's lifetime. DOE/NNSA produces LLCs and collaborates with DoD to jointly manage component delivery and installation. These components include GTSs, power sources, and neutron generators.

Gas Transfer Systems

GTSs are designed, produced, filled, and delivered to DoD for existing weapon systems. Compared to historical GTSs, modern GTS designs increase weapon performance margins, thereby improving maintenance efficiency and enhancing weapon safety and reliability. Function-testing life storage units and development hardware validates performance characteristics and provides research and development (R&D) to inform current and future GTS designs. New GTS designs are evaluated to verify the GTSs may be loaded in the production facilities and meet weapons systems performance characteristics. In parallel to these R&D efforts, production facilities are maintained for gas-loading operations, GTS surveillance, and tritium recovery from end-of-life GTSs.

Power Sources

Current and future planned nuclear weapons require specialized power sources that meet stringent reliability and performance requirements. Requirements for size, weight, active life, responsiveness, and output are unique to nuclear weapon applications, and are manufactured within the DOE/NNSA complex. This capability supports nuclear weapons and other national security missions, including prototyping and parts development, the full lifecycle requirements of power source components through early-stage R&D and modeling, technology maturation, design and development, production, surveillance, and disassembly.

Neutron Generators

Neutron generators are highly complex LLCs integral to nuclear weapon function. The DOE/NNSA neutron generator enterprise, which is an integrated design and production agency, manages the neutron generators' entire lifecycle to meet DOE/NNSA's requirements, including scientific understanding through design, development, qualification, production, surveillance, dismantlement, and disposal.

2.1.3.2 Integrated Surety Architecture

The Integrated Surety Architecture program enhances DOE/NNSA transportation surety for over-the-road shipments of nuclear weapons by developing enhanced capability shipping configurations to support transportation security. The program is implementing enhanced capability shipping configurations to address the maximum number of future shipments. Integrated Surety Architecture is a DOE/NNSA requirement for over-the-road shipment of any nuclear weapon planned to be in the active stockpile after 2025.[1]

2.1.3.3 Sentinel Integration

The W87-0 will be the first warhead deployed on the LGM-35A Sentinel, formerly known as the Ground Based Strategic Deterrent. This effort will require extensive qualification and integration activities to ensure the W87-0 will function as designed in the new Sentinel environments. In addition to ground and flight tests, warhead subsystem production will ramp up to replace hardware consumed in Sentinel qualification.

2.2 Stockpile Major Modernization

Stockpile major modernization activities are performed through a series of planned LEPs, Mods, Alts, and warhead acquisition programs enabled by a strong set of science, technology, engineering, and production capabilities. **Figure 2–2** displays these plans, which fully reflect the priorities established and formally authorized by the Nuclear Weapons Council. Some modernization programs do not yet have approved first production units but reflect notional first production units, coordinated with DoD, for planning purposes.

Stockpile Major Modernization Accomplishments

- *W80-4 completed the first flight test on the Long Range Standoff cruise missile.*

[1] Stated in 50 U.S. Code § 2538 (d).

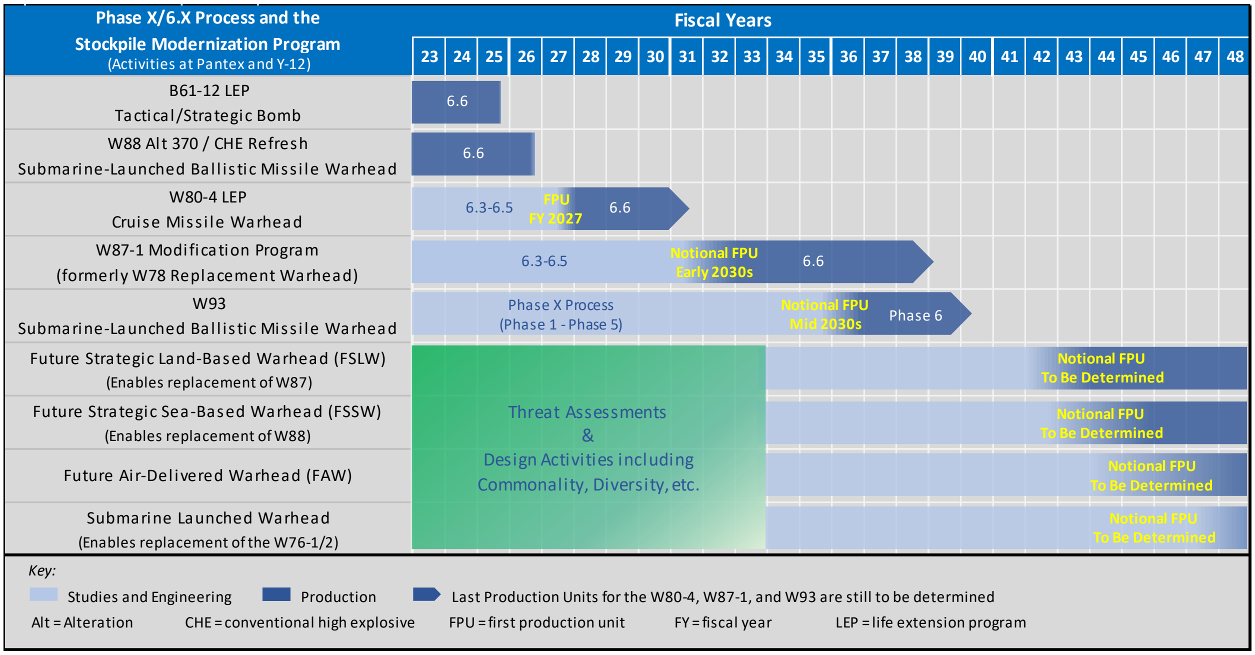


Figure 2–2. DOE/NNSA Warhead Activities

Currently, the long-term vision for the nuclear weapons stockpile seeks to build additional flexibility for the Nation to enable rapid response to unforeseen contingencies, while incorporating features and technologies that enhance safety and security, as appropriate and practicable. DOE/NNSA will incorporate flexibility-enabling design strategies and manufacturing, an advanced digital enterprise that promotes system modernization activities, and exercise capabilities through the Stockpile Responsiveness Program (see Appendix D). These improvements will enhance the Nation's ability to counter adversaries' capabilities, stockpile aging, and variables associated with supporting U.S. hedge capabilities.

Qualified options for materials, components, and systems must be developed to meet resilience requirements for the U.S. nuclear deterrent, and matured in advance to be viable for consideration and available when needed to support down-select decisions, development, and production. The activities that lead to this state of readiness depend on advanced scientific and engineering capabilities that enable design, qualification and certification processes, and improve the responsiveness of the nuclear security enterprise in terms of cycle time and digital design tools. These science-based enabling efforts are described in Chapter 4.

2.2.1 *Phase X Process* (Nuclear Weapons Life Cycle)

The responsibilities of DoD and DOE/NNSA for the development, testing, and production of proposed nuclear weapons were originally established through the 1953 joint agreement between the Atomic Energy Commission and DoD, which introduced the concept of weapon acquisition phases.

Nuclear weapons have been historically developed, produced, maintained, retired, and dismantled in a process known as the Nuclear Weapons Life Cycle (now known as the *Phase X Process*). The seven-phase process includes procedures for program study, development, production, sustainment, and nuclear weapons systems dismantlement and has not been exercised in its entirety since the end of the Cold War, with the United States executing only Phases 6 and 7 in recent decades. During this time, the Nuclear Weapons Council approved the *Phase 6.X Process* for non-routine Alts, Mods, and LEPs, which defines the framework for refurbishment activities of existing nuclear weapon systems. This process uses the same phases from the Nuclear Weapons Life Cycle, all occurring during Phase 6 of the weapon's lifecycle. Until recently, all DOE/NNSA's Major Stockpile Modernization activities have been guided by the *Phase 6.X Process*.

Emerging DoD requirements for future systems necessitated updated procedural guidelines defining the full seven-phase *Phase X Process*, which revised the original agreement and the joint DoD and DOE/NNSA procedures governing the full lifecycle for nuclear weapons. The new process is being used for the first time on the W93 program. These phases, and the relationship between the *Phase 6.X Process* and the Nuclear Weapons Life Cycle, are shown in **Figure 2–3**.

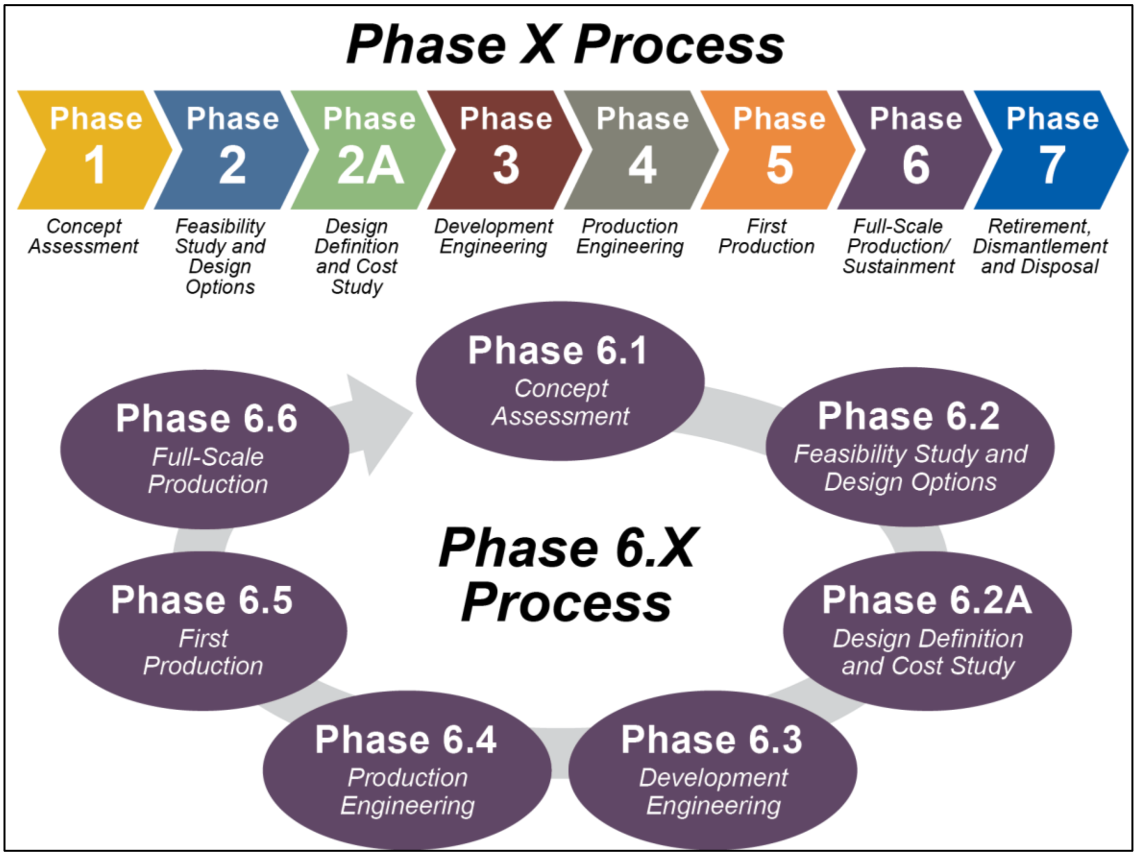


Figure 2–3. *Phase X* and *Phase 6.X Processes*

2.2.2 B61-12 Life Extension Program

The B61-12 LEP addresses multiple components that are nearing end-of-life, in addition to military requirements for reliability, service life, field maintenance, safety, and use control. The life extension scope includes refurbishment of nuclear and non-nuclear components and incorporates component reuse where possible. With the addition of an Air Force-procured tail kit assembly, the B61-12 LEP will consolidate and replace the B61-3, -4, and -7 bomb variants.

DOE/NNSA achieved the first production unit for the B61-12 LEP on November 23, 2021

2.2.2.1 Status

DOE/NNSA delivered the B61-12 LEP first production unit in November 2021, and received authorization to enter Phase 6.6, *Full-Scale Production*, in June 2022. The B61-12 LEP also reached the 50 percent completion milestone for all remaining components, including canned subassembly production in fiscal year (FY) 2023. The program met DoD shipment delivery requirements in 2022 and is projected to maintain all shipments in future years. The B61-12 LEP released an Aircraft Compatibility Control Document documenting compatibility certification with the F 15E, B-2A, F-35A, F 16, and PA-200 and is continuing certification activities for the B-21. The program is scheduled to complete production and close out in FY 2026.

2.2.3 W88 Alteration 370 Program

The W88 warhead has been deployed for more than three decades, and several updates are required to address aging issues and to maintain readiness. The W88 Alt 370 Program modernizes the arming, fuzing, and firing subsystem; improves surety; replaces the conventional high explosive and associated materials; and incorporates a lightning arrestor connector, trainers, joint test assemblies, and associated handling gear. The W88 Alt 370 conversion is scheduled to run concurrently with LLC exchanges of GTSs and neutron generators. This program does not extend the life of the warhead.

2.2.3.1 Status

The W88 Alt 370 completed the system-level first production unit in July 2021 and conducted the final review of the Design Review and Acceptance Group in October 2021. The Nuclear Weapons Council formally accepted the W88 Alt 370 into the stockpile in December 2021 and authorized entrance to Phase 6.6 in June 2022. In 2022, DOE/NNSA delivered an initial operational capability (quantity of re-entry Body Assemblies) of W88 Alt 370s to the Navy and continues to meet all scheduled deliveries.

2.2.4 W80-4 Life Extension Program

The W80-4 LEP will deploy with the Air Force's AGM-181 Long Range Standoff (LRSO) cruise missile. This integrated program will replace the aging AGM-86 air-launched cruise missile and the W80-1 warhead. The LRSO cruise missile will improve the Air Force's capability to defeat adversary Integrated Air Defense Systems by enhancing the bomber force's delivery and survivability capabilities.

2.2.4.1 Status

In FY 2024, the W80-4 LEP will be in Phase 6.4, *Production Engineering*, maturing to final design and transitioning the warhead design into the manufacturing process. A Nuclear Explosive Safety Design Review was completed, providing feedback to optimize nuclear safety aspects of the W80-4 design and operational concepts at the Pantex Plant. The W80-4 LEP is on track to meet a first production unit in FY 2027. FY 2024 deliverables include:

- Continuing joint flight tests with the Air Force LRSO program supporting the warhead design
- Updating military characteristics and stockpile-to-target sequence

2.2.5 W87-1 Modification Program

The W87-1 will be deployed on the LGM-35A Sentinel, formerly known as the Ground Based Strategic Deterrent, which will initially be fielded with the W87-0. The W87-1 will replace the aging W78 warhead by modifying the existing, legacy W87-0 design. After the B61-12 achieves initial operational capability, the W78 warhead will become the oldest weapon system in the stockpile and W78 components continue to age. The W87-1 Mod will meet DoD and DOE/NNSA requirements for performance, safety, reliability, and security and is slated to deploy on the Sentinel between FY 2031 and FY 2032.

2.2.5.1 Status

In FY 2022, the program completed the Weapon Development Cost Report as well as set the initial program baseline in October 2022. A Nuclear Explosive Safety Design Review was completed in FY 2022, providing feedback to optimize nuclear safety aspects of the W87-1 design. The program achieved Nuclear Weapons Council approval to enter Phase 6.3, *Development Engineering*, in May 2023 and the W87-1 system conceptual design review was completed in December 2022.

2.2.6 W93 Program

The W93 will address future Navy ballistic missile requirements. It will incorporate modern technologies to improve safety, security, and flexibility to address future threats and will be designed for ease of manufacturing, maintenance, and certification. All key nuclear components will be based on currently deployed and previously tested nuclear designs, and extensive stockpile component and materials experience. It will not require additional nuclear explosive testing to certify. The program will use the *Phase X Process* for integrated nuclear weapons system acquisition, rather than the *Phase 6.X Process* (see Section 2.2.1 for additional information regarding these lifecycle processes). The W93 program is currently in Phase 2, *Feasibility Study and Design Options*, which evaluates warhead architectures and available technologies against a potential range of desired attributes, draft military characteristics, and known constraints. It will also inform DoD's program activities for the associated Mk7 reentry body within which the W93 would be deployed.

2.2.6.1 Status

The W93 completed Phase 1, *Concept Assessment*, in FY 2022. The Nuclear Weapons Council authorized the program to proceed into Phase 2, *Feasibility Study and Design Options*, in May 2022.

2.2.7 Future Warheads

DOE/NNSA is coordinating with DoD to define the appropriate warheads to support anticipated future threats. These warheads currently include the Future Strategic Land-Based Warhead, the Future Strategic Sea-Based Warhead, the Future Air-Delivered Warhead, and a Submarine-Launched Warhead (to replace the W76-1/2).

2.3 Weapon Dismantlement and Disposition

WDD activities disassemble retired weapons into major components. Those components are then assigned for reuse, storage, surveillance, or for additional disassembly and subsequent disposition of constituent parts and materials. The dismantlement schedule for retired nuclear weapons is planned to provide the materials and components required for the stockpile (in particular, LEPs, Mods, and Alts), and considers the needs of other programs for these materials. WDD also maintains the proficiency of technicians and balances work scope at the production sites.

> ***Weapons Dismantlement and Disposition Accomplishments***
>
> - *Provided materials and components on schedule to meet stockpile sustainment and modernization requirements*
> - *Provided materials to meet commitments to Naval Reactors*
> - *Met or exceeded component characterization and disposition goals*

Dismantlement rates are affected by many factors including weapon system complexity, availability of qualified personnel, equipment, and facilities, logistics, policy and directives, and legislative requirements. DOE/NNSA's current 7-year Dismantlement Plan balances physical constraints with legislative, policy, and directive guidance. The WDD work scope includes management of retired nuclear weapon systems (e.g., managing safety concerns), characterization of weapon components, disassembly of weapons and components, and final component disposition (e.g., component reuse and material recycle and recovery). WDD activities occur across all sites in the nuclear security enterprise.

2.3.1 Status

DOE/NNSA continues to dismantle retired weapons and disposition resulting components and materials, supporting DoD return schedules, and meeting the needs of the LEPs and material demand requirements. As detailed in the FY 2024 SSMP's classified annex, the DOE/NNSA plans to dismantle several weapons systems to meet downstream requirements for material and/or weapon parts and DOE/NNSA is on-track to meet these responsibilities. Moreover, DOE/NNSA's disposition schedules are on-track and several disposition projects are ahead of schedule. DOE/NNSA also developed return schedules to remove additional retired weapons from DoD facilities, while still meeting DoD operational requirements. WDD continues to characterize components coming off the dismantlement line, and sites are eliminating excess component inventories.

2.4 Production Operations

Production Operations provides the base capabilities to enable weapon operations (assembly, disassembly, and production) planned for the warhead modernization, sustainment, and the WDD programs. Production Operations' goal is to maintain the base capability required to sustain the stockpile through robust management and production process engineering, manufacturing, production technology resources, and production equipment maintenance. The program accomplishes this goal by maintaining the tools and personnel necessary for supporting major manufacturing, assembly, disassembly, maintenance, and production data management for all nuclear weapons in the stockpile and modernization efforts.

Production Operations Accomplishments

- *Maintained production equipment at 98 percent availability*
- *Completed over 78,000 equipment and tooling calibrations*
- *Executed Tritium Process Computing maintenance in support of LLC exchange GTS production at 100 percent*

At individual enterprise sites, Production Operations sustains capabilities at required capacities for the nuclear security enterprise's production mission, mainly through the multifaceted skilled labor force. The program provides the base labor capacity that is essential for preventive and corrective production equipment maintenance, calibrations, quality assurance, qualification, production logistics, manufacturing execution systems, process flow, and scheduling activities.

Production Operations maintains critical multi-weapon system supporting equipment at certain sites and select programmatic infrastructure. Production Operations also provides the input for the modernization of production capabilities to improve efficiency and maintain manufacturing operations to meet future requirements. The program heavily depends on infrastructure modernization to ensure base capabilities with adequate capacities, space, and equipment are in place.

2.4.1 Status

Production Operations is expanding the nuclear security enterprise's base capability to provide the increased capacity necessary to meet the ramp up in stockpile modernization activities and Production Modernization projects. Production Operations has also assumed additional scope associated with enterprise capacity modeling and planning to ensure future capacities align with the increasing demand signal.

2.5 Nuclear Enterprise Assurance

NEA ensures the nuclear security enterprise actively manages subversion risks to the nuclear weapons stockpile and associated design, production, and testing capabilities. Through nuclear weapon digital assurance, NEA enables risk-managed adoption of leading-edge technologies to meet emerging military requirements and reduce modernization schedules and costs.

Nuclear Enterprise Assurance Accomplishments

- *Established formal program of record*

NEA focuses on technical and governance activities for the assurance of digital systems integral to weapon systems, operational technologies directly related to weapons, and capabilities that cross-cut multiple weapons programs. The NEA program has four major activities:

1. Assurance Evaluations
2. Tools and Capabilities
3. Policy, Requirements, and Oversight
4. Workforce Standards

2.5.1 Status

In FY 2022, NEA established the foundation for cross-site, multi-disciplinary assurance capability. Progress was made establishing, updating, and expanding NEA training as well as instituting cybersecurity of nuclear weapon policies, requirements, and oversight. For more information on NEA, see the classified annex of this SSMP.

Chapter 3
Production Modernization

The Production Modernization program is responsible for modernizing the facilities, infrastructure, technologies, and production methods to meet stockpile requirements. The program encompasses five major subprograms that sustain the Nation's nuclear weapons stockpile and deterrent:

1. The Primary Capability Modernization program consolidates management of primary stage material processing and component production capabilities in the Department of Energy's National Nuclear Security Administration's (DOE/NNSA) nuclear security enterprise. The program includes (1) Plutonium Modernization and (2) High Explosives and Energetics Modernization.
2. The Secondary Capability Modernization program restores and increases manufacturing capabilities for the secondary stage of nuclear weapons in the nuclear security enterprise. This program is modernizing facilities and operations to process the materials, fabricate components, and assemble components into subassemblies. The program includes (1) Uranium Modernization, (2) Depleted Uranium (DU) Modernization, and (3) Lithium Modernization.
3. The Tritium Modernization and Domestic Uranium Enrichment (DUE) Program consists of two parts: (1) Tritium Modernization produces, recovers, and recycles tritium to support national security requirements and (2) DUE ensures a reliable supply of enriched uranium to support U.S. national security needs.
4. The Non-Nuclear Capability Modernization program modernizes the capabilities needed for the design, development, qualification, production, and surveillance of non-nuclear components for multiple weapon systems.
5. The Capabilities-Based Investments (CBI) Program executes projects for equipment, tools, supporting facilities, and infrastructure directly related to enduring, multi-program weapon activity capabilities, mission deliverables, and management of programmatic risk across the nuclear security enterprise.

3.1 Primary Capability Modernization

The Primary Capability Modernization Program consolidates management of primary stage material processing and component production capabilities in the nuclear security enterprise. The program includes (1) Plutonium Modernization and (2) High Explosives and Energetics Modernization.

3.1.1 Plutonium Modernization

The United States is restoring the capability to produce new primaries for nuclear weapons, including plutonium subcomponents such as pits. In May 2018, the NNSA Administrator provided Congress with DOE/NNSA's course of action to produce no fewer than 80 pits per year (ppy) as required by the *National Defense Authorization Act for Fiscal Year 2018*. DOE/NNSA's strategy to meet pit production requirements, endorsed by the Nuclear Weapons Council, is twofold:

- Continue to invest in the Los Alamos National Laboratory (LANL) to produce 30 ppy
- Repurpose the former Mixed Oxide Fuel Fabrication Facility at the Savannah River Site (SRS) as the Savannah River Plutonium Processing Facility (SRPPF) to produce 50 ppy

This two-pronged approach will restore a critical production capability central to maintaining the Nation's nuclear deterrent. Operating two geographically separated plutonium pit production facilities provides resilience and adaptable options to mitigate against shutdowns, incidents, or other risks that may affect operations at a single site.

Recapitalizing the Nation's pit production capability to enable production of no fewer than 80 ppy addresses two major drivers:

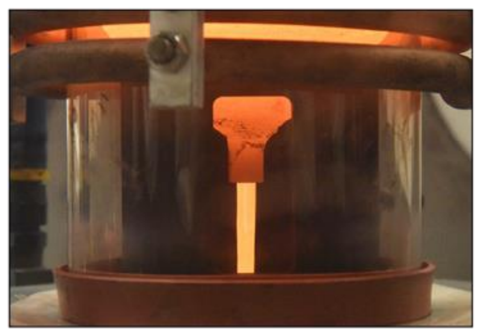
- Department of Defense (DoD) and DOE/NNSA requirements to enhance warhead safety and security
- Risk mitigation against plutonium aging through deliberate, methodical replacement of older plutonium pits with newly manufactured pits

Plutonium Modernization Major Accomplishments

- *Lawrence Livermore National Laboratory (LLNL) commenced certification testing on the LANL produced Certification 03 build.*
- *LANL completed seven developmental pit builds in 2022.*
- *SRPPF approved the Dismantle and Removal Critical Decision (CD)-3A package for the main process building to start critical activities to prepare the building for the construction needed to establish its new pit production mission.*
- *Kansas City National Security Campus (KCNSC) began providing War Reserve (WR) quality components to LANL to support the reestablishment of pit manufacturing in the United States.*

3.1.1.1 Status

In addition to dedicated pit production infrastructure efforts at LANL and SRS, DOE/NNSA is recapitalizing existing facilities throughout the nuclear security enterprise through a series of reinvestment projects, including several line-item projects, to replace the aging infrastructure that supports capabilities to process plutonium, fabricate plutonium components, perform experiments, and disposition transuranic waste. These projects include the Chemistry and Metallurgy Research Replacement project, which maintains continuity in analytical chemistry and material characterization capabilities by transitioning these activities from the Cold War-era Chemistry and Metallurgy Research facility to newer facilities. Programs are also conducting risk reduction activities in material recycle and recovery by removing the nuclear material inventory currently housed in the Chemistry and Metallurgy facility.



Molten Plutonium in Cast

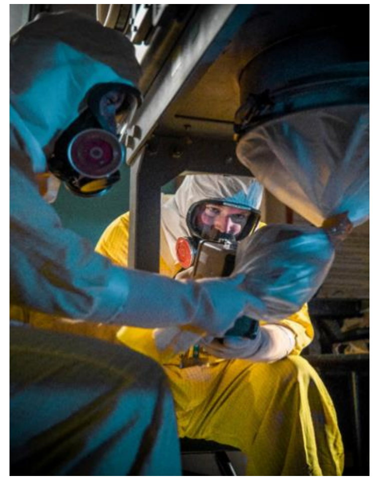
3.1.1.2 Los Alamos National Laboratory Plutonium Modernization

A modern, responsive, and resilient capability to handle, process, and characterize plutonium is essential to assess and maintain the nuclear weapons stockpile. A responsive plutonium infrastructure requires proper storage facilities, safe and secure disposal pathways, and unique facilities for research and development (R&D) and design realization activities. Manufacture and surveillance of plutonium components, as well as performance of experiments, analysis of plutonium, and plutonium processing for the nuclear weapons program (e.g., recovery, characterization, component fabrication, nondestructive analysis, and surveillance) currently occur at LANL's Plutonium Facility (PF-4). Modernization activities concentrate on initiatives within PF-4, such as recapitalization and modernization of the equipment needed to restore PF-4's ability to produce WR pits. Ongoing activities include projects funded by the

Plutonium Modernization Program and line-item programs, such as the Los Alamos Plutonium Pit Production Project, which will increase the pit manufacturing capability to 30 ppy and maintain LANL as the Nation's Plutonium Center of Excellence for R&D.

Primary infrastructure investment for the Plutonium Modernization program at LANL include:

- Los Alamos Plutonium Pit Production Project
- Technical Area (TA)-55 Reinvestments Project, Phase 3
- Transuranic Liquid Waste Facility
- Chemistry and Metallurgy Research Replacement Project



TA-55 Cold Lab Simulated Waste Removal

To meet rate production goals, workforce increases are needed. Therefore, DOE/NNSA must hire, train, qualify, and retain additional pit production personnel to meet the requirements. This increased workforce will need additional support, such as infrastructure investments for operations support, waste management, offices, parking, training, etc.

To support pit production and other vital plutonium missions, LANL has transitioned to 24/7 facility availability to enable enhanced execution of programmatic work, facility maintenance, equipment installation, and construction activities.

Plutonium Modernization also supports manufacturing of precision plutonium devices for scientific evaluation and experiments, including sub-critical experiments. The data collection and analysis from this evaluation supports sustaining an overall healthy feedstock supply chain that will support plutonium processing for the nuclear weapons program.

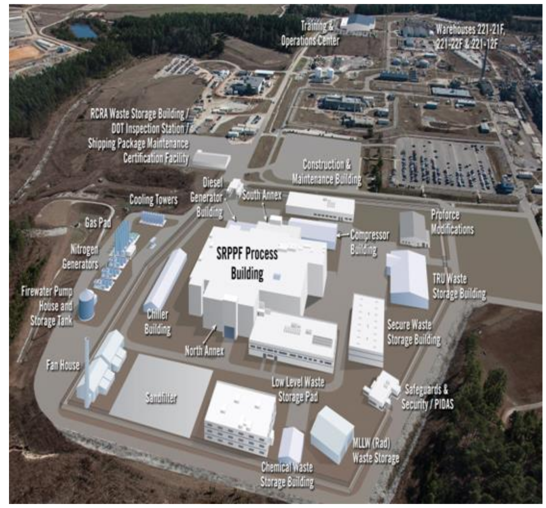
3.1.1.3 Savannah River Site Plutonium Modernization

SRS will establish a pit production capability in an existing facility that is already designed to meet stringent security and safety requirements for plutonium operations. Initial modernization activities include repurposing and transitioning into a safe, secure, compliant, and efficient pit production facility, the planned SRPPF. A new program office at SRS to sustain an enduring pit production goal of 50 WR ppy is being established. The Critical Decision (CD)-1 (*Approve Alternative Selection and Cost Range*) package detailing the conceptual design and estimated cost range was approved in fiscal year (FY) 2021. Following CD-1 approval, the project team has continued to finalize the specific conceptual design for process operations. In parallel, the team has continued to develop a detailed, more risk-informed design performance baseline, aligned to a Program Requirements Document. Based on information developed to support the CD-1 approval, DOE/NNSA determined that achieving the required 50 WR ppy production rate at SRS in 2030 was not feasible. Establishing the required SRPPF pit production capacity as close as possible to 2030 remains a high priority and is required for sustaining the effectiveness of the Nation's nuclear deterrent.

There are several key steps to completing the SRPPF project and establishing an enduring capability:

- Complete six inter-related construction subprojects
- Hire and train the workforce necessary to establish and sustain the SRS pit production mission
- Establish the institutional systems at SRS necessary to build WR pits
- Establish and manage SRS pit production interfaces across the nuclear security enterprise

- Maintain a secure supply chain to support the SRS pit production mission
- Modernize SRS site-wide infrastructure that supports the pit production mission



SRPPF 3D Aerial with New Buildings

The following upcoming activities will allow DOE/NNSA to define timelines for 50 WR ppy at SRPPF:

1. Completion and approval of SRPPF's CD-2 (*Approve Performance Baseline*) acquisition milestone. This indicates that the project's design is 90 percent complete and will identify when fully operational capability (CD-4) can be achieved.
2. Lawrence Livermore National Laboratory (LLNL), LANL, Kansas City National Security Campus (KCNSC), and the ongoing W87-1 Modification Program's Pit Product Realization Team to find ways to reduce the time needed to produce the first WR pit at SRPPF after CD-4, based on knowledge gained at LANL from parallel production efforts at PF-4.
3. Capture efficiencies and use lessons from production experience at LANL to apply at SRPPF.

Further activities conducted in support of CD-2 have identified opportunities to accelerate achieving the required production capacity.

Essential to this process will be the transition of an existing facility into the SRS High Fidelity Training and Operations Center, which began with design work in FY 2021. The High Fidelity Training and Operations Center will enable training in a safe environment, as well as high-fidelity surrogate materials training aimed to qualify the personnel and procedures ultimately used to build and handle pits in the SRPPF. The High Fidelity Training and Operations Center will also support final design by serving as a test bed for selected engineering equipment and to demonstrate systems integration. LANL and LLNL are supporting the training rotation pipeline for the SRS pit production mission through a knowledge transfer program initiated in FY 2020 with Savannah River National Laboratory. Additionally, a CD-3A package for dismantlement, removal, and site preparation was approved in August 2022 to begin removal of unnecessary equipment, commodities, and coatings from the existing facility and procurement of temporary support equipment, which will maximize beneficial use of the inventory turned over from Mixed Oxide Fuel Fabrication Facility materials and equipment.

3.1.1.4 Enterprise Plutonium Support

DOE/NNSA manages numerous facilities that house plutonium handling, processing, R&D, characterization, experimentation, and storage facilities that must be sustained. A responsive plutonium infrastructure requires proper storage facilities, safe and secure disposal pathways, and unique equipment and facilities for R&D and design realization activities.

Enterprise Plutonium Support includes activities that enable programmatic objectives across the enterprise, including production of non-nuclear components, certification activities, management of the Product Realization Team, material management activities, radioisotope thermoelectric generator production and surveillance, subcritical plutonium experiments, and pit certification.

3.1.1.5 Challenges and Strategies

Table 3–1 provides a high-level summary of Plutonium Modernization challenges and the strategies to address them.

Table 3–1. Summary of Plutonium Modernization challenges and strategies

Challenges	Strategies	
	Current Strategy Being Implemented	*Future Strategies Needed*
Reestablishing required pit production capabilities and capacity with timely integration of infrastructure and workforce investments in alignment with W87-1 program needs.	Continue to invest in LANL plutonium facilities and workforce needs to meet pit production milestones—achieving the first production unit milestone, then completing the Los Alamos Plutonium Pit Production Project to increase production capacity to 30 WR ppy.	Drive continued improvement in executing equipment installation projects and workforce investments to support future pit production needs.
Repurposing the former Mixed Oxide Fuel Fabrication Facility at SRS to achieve a production rate of 50 WR ppy.	• Implement a tailored approach for the SRPPF project to achieve CD-2/-3 and execute engineering, procurement, and construction activities through multiple subprojects to support producing 50 WR ppy. • Use knowledge transfer from LANL and LLNL SMEs to support workforce development at SRS to achieve pit production mission objectives.	Maintain a supply chain for weapons-related components and commodities needed to support the 50 WR ppy mission.
Executing environmental testing/surety/qualification of plutonium pits without nuclear explosive testing.	• Use and expand chemical, thermal, and mechanical characterization capabilities to evaluate newly manufactured and legacy pits. • Expand and establish new equipment and experimental platforms to evaluate normal and abnormal environments that pits could experience. • Leverage scientific capabilities described in Chapter 4 to evaluate newly manufactured material.	Leverage ongoing investment in the Enhanced Capabilities for Subcritical Experiments Program to support estimates of the certification uncertainty achieved with single and multi-point safety.
Managing glovebox fabrication and deliveries to support enterprise needs.	• Establish a working group to analyze demand and current industrial capacity and work with national lab partners to prioritize procurements. • Examine current procurement methods to streamline processes.	Work with interagency and industry partners to communicate growing need for gloveboxes and increase capacity.

CD = Critical Decision
ppy = pits per year
SMEs = subject matter experts
SRPPF = Savannah River Plutonium Processing Facility
WR = War Reserve

3.1.2 High Explosives and Energetics Modernization

The High Explosives and Energetics Modernization program addresses nuclear security enterprise modernization of high explosives (HE) science and production facilities and the qualification of energetic materials (energetics) such as HE, pyrotechnics, and propellants. This program is not only responsible for energetic materials, but also the network of associated activities, such as the HE and Energetics business processes, infrastructure, production, and supply chain. This program scope spans five management and operating sites: the Pantex Plant (Pantex), Sandia National Laboratories (SNL), LANL, LLNL, and the Nevada

National Security Site (NNSS). Each site maintains multiple dispersed facilities engaged in Stockpile Research, Technology, and Engineering and Production Operations.

Energetic materials are an essential component for each weapon system in the existing stockpile. In addition to existing stockpile sustainment needs, currently planned warhead modernization activities (such as limited life component exchanges) and future modernization activities will continue to have a substantial demand for energetics. DOE/NNSA meets energetic material demands for nuclear weapon sustainment and modernization through investments in developing reliable production capabilities such as: safe and secure facilities, integrated infrastructure, effective logistics (handling, storage, and delivery), and ensuring a reliable supplier base.

3.1.2.1 Status

Most of the current facilities in the energetics enterprise were built over 70 years ago. These aging facilities require extensive infrastructure and process modernization to meet future mission requirements.

DOE/NNSA is currently planning three major programmatic line-item construction projects for HE along with additional ongoing investments across the HE and energetics enterprise:

High Explosives and Energetics Modernization Accomplishments

- *Implemented projects to modernize HE qualification and production facilities (HE Science and Engineering; and Light Initiated High Explosives facility).*
- *Achieved qualification of development lot 1 for the W87-1 toward main charge production.*
- *Completed pressing and machining operations in advance of the W87-1 qualification of legacy LX-17.*
- *Established HE and energetic requirements to meet W93 development and qualification requirements.*
- *Developed supply chain continuity of operations models and risk registers to inform risk mitigation decisions.*
- *Enhanced safety and viability of storage and shipping energetic materials, including testing to characterize hazards for Department of Transportation compliance.*
- *Completed our Energetics Industrial Base Assessment to identify available vendors and map their supply chains to determine vendor capability to convert to domestic production.*
- *Re-establishing production capability and processes for critical energetic materials.*
- *Sponsored an Other Transaction Agreement to construct a TATB (triaminotrinitrobenzene) production facility at the Naval Surface Warfare Center, Indian Head Division, to manufacture insensitive HE for NNSA.*

- The HE Science and Engineering (HESE) Facility at Pantex will consolidate 15 aging facilities into three new, efficient facilities to conduct science, technology, engineering, and production activities in weapons assembly/disassembly and HE. This will mitigate against current HE production and testing capability risks.
- The HE Synthesis, Formulation, and Production project at Pantex will address explosive and mock formulation operations to support multiple weapon programs; technology development for future programs; and support for strategic partners that will hedge against current HE production and testing capability gaps.
- The Energetic Materials Characterization Facility at LANL will consolidate 18 inadequate and outdated facilities to analyze, test, and periodically qualify HE parts going into or coming from stockpile systems. Once built, program activities at this facility will identify solutions to advance predictive capabilities for safety and performance assessments, qualification, and surveillance; evaluate material responses to all phases of the stockpile-to-target sequence; resolve significant finding investigations (SFIs) involving

HESE HE Lab Blast Tank Pit Concrete Forming energetic materials; provide technical data on which to base annual weapon assessments; and develop new/replacement materials to support evolving HE technical requirements. It will also provide support in the design and testing of new detonators, as well as the development of HE formulation and explosive components for the future stockpile. This facility will create a consolidated set of capabilities for the development of components and materials from early concept and prototype design to high-volume production within a single location and provide internal production capability for WR energetic material and components (such as actuators, drivers, detonators, timers, and rocket motors) to augment the commercial supplier base.

- Additionally, ongoing investment in Light-Initiated High Explosive capabilities at SNL will provide the ability to conduct testing of full-scale mockup devices with live main charges in safe and effective modern facilities. These investments provide HE qualification capability to hostile impulse requirements.

Future infrastructure investments may include consolidation and modernization of existing facilities critical to providing required HE capabilities for main charges, boosters, and detonators in a modern, enhanced safety and security environment. DOE/NNSA will continue to pursue projects to mitigate known issues with the limited commercial component supplier base and provide onsite production of energetic materials and components for the stockpile.

HE and Energetics Modernization activities will also include the following:

- Manage the HE and energetics supply chain risk portfolio to ensure a healthy infrastructure exists to maintain, manufacture, and deploy WR HE and energetics in support of weapons production
- Provide guidance for energetics surveillance, weapon response, transportation, containers, and explosive/electrical environments
- Define and monitor the qualification standards of HE and energetic material
- Support the future of HE and energetics development, production, component design, and manufacturing, testing, and qualification

Experienced and knowledgeable personnel are needed for the proper care and handling of hazardous components. Recruitment of skilled professionals and extensive safety training are imperative for safe operations. With an increased workload and the attrition or retirement of senior personnel, DOE/NNSA must actively develop a sustainable workforce to perform these operations competently and safely in the future. More detail on DOE/NNSA's workforce strategies can be found in Chapter 7 of this report.

3.1.2.2 Challenges and Strategies

Table 3–2 provides a high-level summary of HE and Energetics Modernization challenges and the strategies to address them.

Table 3–2. Summary of High Explosives and Energetics Modernization challenges and strategies

Challenges	*Strategies*	
	Current Strategy Being Implemented	*Future Strategies Needed*
Nuclear security enterprise infrastructure for energetic materials science, production, and development located within aging critical facilities and equipment (many past their life expectancies).	• Coordinate with the Office of Infrastructure and the Programmatic Recapitalization Working Group to improve energetic readiness. • Keep aging equipment available for warhead modernization and current stockpile systems through rigorous maintenance programs and integrated	• Transfer manufacturing and qualification of energetic and HE materials to the HE Synthesis, Formulation, and Production Facility, the HESE Facility, and the Energetic Materials Characterization Facility.

	Strategies	
Challenges	***Current Strategy Being Implemented***	***Future Strategies Needed***
	equipment modernization planning across the nuclear security enterprise. • Find creative solutions to modernize facilities past their useful life until current modernization efforts are complete. • Make short- to medium-term investments where reasonable. • Engage and enable sites to reduce dependency or better enable external suppliers.	• With inputs from sites, define requirements, risks, and capability gaps to inform future investments. • Employ creative methods to mitigate obsolescence issues, such as using additive manufacturing to produce parts. • Stand up production enclaves, as DA-PA partnerships, to enable more efficient response to the emerging deterrent.
Depending on a small and shrinking vendor base to supply the explosives, constituent components, and specialized equipment needed to produce its energetic end products.	• When necessary, use in-house capabilities to restore mission schedules at risk. • Respond to situations by collaborating with relevant stakeholders to develop innovative solutions that may stabilize suppliers or qualify new materials/supplies. • Support cooperative arrangements with DoD and Holston Army Ammunition Plant (Holston) to improve Holston's ability to deliver product requirements.	• Sponsor capital acquisition projects and coordinate efforts among sites and HQ elements to shepherd projects from business case to beneficial use. • Construct the HE Synthesis, Formulation, and Production Facility for a nuclear security enterprise capability and capacity to supply HE for WR energetics. • Enable Naval Surface Warfare Center Indian Head Division to supply HE in the near term and operate as a second source to Holston for insensitive high explosive.
Developing sufficient supply chain capacity for energetic materials in current and future life extension programs and alterations.	• Exercise initiatives within the Defense Programs for Energetic Materials. • Refresh HE formulation, synthesis, and machining capabilities at Pantex. • Identify, assess, and perform risk-informed activities to understand, characterize, and develop better methods to produce and qualify materials more fully.	• Analyze and apply lessons learned from Defense Programs initiatives for energetic materials for broader implementation across the enterprise along lines of effort, such as at-risk materials, and requirements and capacity integration. • Continue to build on external collaboration activities with external DoD stakeholders that further partnerships with industry to ensure supply chain opportunities are identified and assessed.
Ensuring requirements for energetic materials are adequately identified, preserved, and documented.	Document the detailed processes necessary for the synthesis and formulation of energetic materials for a repeatable material specification that yields the required engineering and performance requirements through efforts with the NNSA Energetics Coordinating Committee.	• Document the technical basis for future process parameter choices and rationale for specific requirements in the specifications. • Improve understanding and control over material specifications and manufacturing to improve reliability and repeatability and increase lot acceptance. Develop techniques to computationally assess manufacturing with computational fluid dynamics, computational chemistry, machine learning, and artificial intelligence. • Develop techniques to reprocess out-of-spec material to meet requirements.

Challenges	Strategies	
	Current Strategy Being Implemented	Future Strategies Needed
Mitigating material shortfalls for legacy WR HE due to a lack of robust plans and processes to control inventories.	• Collaborate with DoD and industrial partners to institute a more routine process to exercise synthesis and formulation of energetic materials. • Complete triaminotrinitrobenzene/PBX-9502 specifications to improve plans and processes and enhance inventory control.	Preserve and enhance in-house production for items such as WR detonator powder production.
Maintaining a trained and qualified a workforce for HE operations.	• Develop staffing plan for multi-year training operations. • Transfer knowledge from SMEs near retirement age to new SMEs.	Implement additional strategies to maximize knowledge retention and minimize workforce turnover.

DA-PA = design agency-production agency
HE = high explosives
HESE = High Explosive Science and Engineering Facility
SME = subject matter expert
WR = War Reserve

3.2 Secondary Stage Capability Modernization

The Secondary Capability Modernization Program is responsible for restoring and increasing manufacturing capabilities for the secondary stage to required levels in the nuclear security enterprise. This includes ensuring the availability of strategic materials and other sub-component streams necessary for the secondary stage, as well as modernizing the facilities and operations required to process these materials, fabricate them into parts, and assemble the final components. The areas of focus include (1) Uranium Modernization; (2) DU Modernization; and (3) Lithium Modernization.

3.2.1 Uranium Modernization

Highly enriched uranium (HEU) is needed to support stockpile programs, Naval Reactors, and Nonproliferation programs. Uranium Modernization supports these efforts through investments in the infrastructure surrounding HEU processing, purification, machining, and other operations. To execute this mission, Uranium Modernization is working to phase out mission dependency on Building 9212 at the Y-12 National Security Complex (Y-12) by the end of FY 2029, but the project is undergoing a federal rebaseline. To support the success of this transition, the program is working to:

- Relocate Building 9212's HEU capabilities into the Uranium Processing Facility and other enduring facilities
- Leverage these relocations to develop and deploy new technologies to reduce cost, improve worker safety, and enhance manufacturing processes to meet future needs
- Invest in key production systems to sustain casting, machining, metal purification systems, assembly, and analytical chemistry capabilities to support long-term reliability

Uranium Modernization Accomplishments

- *Demonstrated the technical readiness of electrorefining to purify HEU.*
- *Completed a years-long effort to remove more than 59 metric tons of material-at-risk from Y-12's enriched uranium operations area and secured it in the modern HEU Material Facility.*

3.2.1.1 Status

Y-12 is home to the Nation's primary uranium processing and storage infrastructure, including laboratory capabilities that supports uranium activities. Building 9212 contains the most hazardous HEU operations but does not meet modern nuclear safety and security standards because it is nearly 80 years old. As part of the relocation strategy, modern capabilities will be deployed and existing processes will be simplified or phased out to increase the overall safety and efficiency of HEU operations. During the transition period, efforts to maintain a reduced level of material-at-risk will continue.

The Uranium Processing Facility will replace Building 9212 capabilities for HEU casting, special oxide production, chemical recovery, and decontamination. HEU casting and special oxide production will be housed in the Uranium Processing Facility's Main Process Building, while chemical recovery, decontamination, and assay will take place in the Uranium Processing Facility's Salvage and Accountability Building. A third building, the Uranium Processing Facility's Mechanical/Electrical Equipment Building, will provide utilities and other support systems. Uranium Modernization is working with Y-12, the design laboratories, and other NNSA Offices within Defense Programs to reduce schedule and cost risk associated with the Uranium Processing Facility by demonstrating the effectiveness of microwave casting using a full-scale prototype system.

DOE/NNSA will relocate other Building 9212 capabilities, like HEU purification and machine chip processing, into an enduring facility—Building 9215. Ongoing projects, such as HEU electrorefining and direct chip melt, will relocate, reduce costs, and improve material processing technologies. The calciner technology being deployed in Building 9212 will allow for safe and efficient transition out of this facility. These capabilities will also improve existing operations by reducing the number of production processes, reducing risks, and improving personnel safety.

Uranium Modernization also funds Technology Maturation efforts to develop and deploy improved manufacturing processes for nuclear weapon materials. When the technology is sufficiently mature, the development and deployment of equipment is pursued through capital line-item acquisition or major item of equipment processes, as appropriate. This technology development and maturation process has generated three current major items of equipment acquisitions. The major items of equipment include:

The Electrorefining Development Area

- Electrorefining—an electrochemical HEU purification system designed to replace portions of the current HEU purification process. This capability, located in Building 9215, along with the calciner process in Building 9212, will allow for the shutdown of the current high-hazard wet chemistry process located in Building 9212. The program has already initiated the shutdown of the oxide conversion and reduction processes in Building 9212. The remaining portions of the hazardous purification process in Building 9212 will continue to operate at least until the completion of the Building 9212 Calciner. The program will perform its HEU metal purification using the electrorefining process after it achieves operational release in 2024.
- Building 9212 Calciner—a dry thermal treatment process to convert low-equity HEU liquids to a dry stable form for storage. This capability will process material remaining in Building 9212 during the final clean-out of the facility. The calciner, along with the electrorefining capability (see above), will allow for the shutdown of the current high-hazard wet chemistry process in Building 9212.
- Direct Chip Melt—a process by which HEU machine tool chips (i.e., turnings) are recovered by collecting and remelting them in furnaces. This capability, located in Building 9215, will replace the current high-hazard practices of transferring chips to Building 9212 for cleaning, briquetting, and storing.

Uranium Modernization continues to optimize Building 9212 resources to supply the current stockpile with purified HEU metal. The program provides a comprehensive storage capability to support a steady supply of material through peak production periods. It also enables HEU material de-inventory activities to increase safety, establish target working inventory levels for the production facilities, and optimize composition of the inventory. The program, partnering with DOE/NNSA's Office of Environment, Safety, and Health, is also managing the sustainment of enduring facilities with an Extended Life Program, which implements risk-based infrastructure improvements on production facilities. This enables the safe and secure continuation of operations, including those relocated from Building 9212, through 2040 and into the future.

Uranium Modernization is proactively removing equipment that is no longer operationally necessary from these enduring facilities through its Flexible Production Capacity Initiative to improve Y-12's responsiveness and resilience to meet future production needs.

3.2.1.2 Challenges and Strategies

Table 3–3 provides a high-level summary of uranium modernization challenges and the strategies to address them.

Table 3–3. Summary of Uranium Modernization challenges and strategies

	Strategies	
Challenges	***Current Strategy Being Implemented***	***Future Strategies Needed***
Integrating new technologies into operations.	Develop and operate full-scale prototype systems to mitigate risks associated with technology maturation.	Use Operational Release Plans to identify issues and streamline the transition to operations.
Executing process relocations with multiple timelines without interruption to operations.	Develop integrated schedule, risk plan, and lifecycle cost estimate. Relocate existing (radiography) and upgraded (direct chip melt, electrorefining) technologies in Building 9212 to enduring facilities, and install a calciner in Building 9212.	Bridge key capability gaps through partnership with commercial vendors and partnerships with other DOE laboratories.
Preparing Building 9212 for disposition and demolition in the shortest achievable timetable.	• Begin deactivating systems and removing material immediately and maintain a 15+ year schedule. • Reduce material-at-risk and overall uranium inventory to minimize the safety and security risks associated with aged facilities and invest in upgrades (e.g., the LEP) for mid-term capabilities in enduring facilities.	Update plan regularly to ensure opportunities are taken over the lengthy timeline.
Current component manufacturing capabilities relying on aging equipment and having limited capacity to meet future stockpile needs.	Execute the extended life plan strategy to reduce bottlenecks, improve space utilization of existing facilities, and increase capacity and reliability of existing processes to fulfill near-term mission requirements.	Build and equip a manufacturing facility dedicated to EU machining as well as material storage to meet future stockpile needs.
Current EU facilities experiencing age-related failures and having insufficient floor space to support future stockpile demand.	Complete the transition to Uranium Processing Facility and establish capabilities for HEU casting, special oxide production, chemical recovery, decontamination, and assay.	• Evaluate long-term EU machining facility options to meet future stockpile demands. • Sustain existing EU facilities with an EU LEP strategy to ensure safe and secure operations in existing facilities until the beneficial occupancy of the EU Manufacturing Complex Capability.

Challenges	Strategies	
	Current Strategy Being Implemented	Future Strategies Needed
Maintaining a trained and qualified workforce for EU operations.	• Develop a staffing plan for multi-year training. • Transfer knowledge from SMEs near retirement age to new SMEs.	Implement additional strategies to maximize knowledge retention and minimize workforce turnover.
Completing modernization strategy for all HEU operations.	Implement extended life replacements in 9215 and 9204-02E.	Initiate acquisition processes for remaining EU replacements, including EU Manufacturing Capability and Assembly and Disassembly Capability.

EU = enriched uranium
HEU = highly enriched uranium
LEP = life extension program
SMEs = subject matter experts

3.2.2 Depleted Uranium Modernization

DU is a byproduct of the HEU enrichment process and has a lower concentration of the fissile isotope uranium-235 and a higher concentration of the fissionable isotope uranium-238 than natural uranium.

High Purity DU (HPDU) and DU Niobium alloy (binary) are required for nuclear component production to maintain and modernize the stockpile through life extension, modification, limited life component (LLC) exchange programs, and future nuclear weapons. HPDU and binary are made into precision components through complex processes that must meet stringent requirements. Key processes include alloying, casting, forging, rolling, swaging, forming, machining, assembly, welding, and inspection. Many of these processes are currently operable.

The DU Modernization Program is responsible for restarting and maintaining lapsed processes to meet imminent weapons delivery mission requirements. These capabilities lapsed in the early 2000s due to the reuse of materials, low demand signals, and prioritization of other activities. To resume full-rate production, the DU Modernization Program needs to execute HPDU and niobium feedstock procurements, restart and maintain DU and DU alloying and manufacturing capabilities, invest in key new technologies and execute its bridging strategy to meet enterprise demand until 2035, when a new DU manufacturing facility is anticipated.

Depleted Uranium Modernization Accomplishments

- *Produced recycled and alloyed binary ingots from the Cold Hearth Melter for rolling and forming trials.*
- *Completed 20 validation castings to achieve Technology Readiness Level 7 for the Direct Cast technology.*
- *Executed Analysis of Alternatives activities for the DOE Order 413.4B depleted uranium hexafluoride (DUF_6) to HPDU conversion project to produce a reliable supply of HPDU metal feedstock.*
- *Completed Depleted Uranium Viability Study.*

The NNSA has a long-term requirement to reestablish a reliable supply of HPDU before the current inventory is exhausted in the 2030 timeframe. To address this need, the DU Modernization Program is pursuing the establishment of a capability that converts depleted uranium hexafluoride (DUF_6) to depleted uranium tetrafluoride (DUF_4), which can then be converted to HPDU. To mitigate risks associated with the aggressive schedule of this project, the program has been working with DoD to determine the viability of recycling DU munitions and invested in procuring DU material to supplement existing supplies of HPDU at Y-12.

The DU Modernization Program also supports restarting and maintenance of existing DU operations and DU alloying capabilities to meet current and future weapon component needs. To produce new binary, Y-12 will restart the alloying process for production of binary ingots. Y-12 has successfully restored the Vacuum Induction Melt (VIM) capability and is working to do the same with the Vacuum Arc Melt (VAR).

The program will also modernize the wrought manufacturing and machining capabilities needed for component manufacturing to increase reliability and capacity. Lastly DU Modernization will train operators, develop procedures, and provide DU and binary components for qualification activities at LANL and LLNL.

The program is also investing in new technologies to modernize production and meet future demands. Direct Casting would improve the existing component manufacturing process by significantly reducing the risks of current equipment failure, decreasing material waste, and improving process efficiency. Cold Hearth Melting provides an opportunity to alloy ingots more efficiently and introduces a material recycling capability by alloying certified ingots.

Cold Hearth Melt

These new technologies could both improve the DU alloying process and augment production of DU and binary components. As shown in **Figure 3–1**, the implementation of these capabilities provides alternative processes that reduce the risk of single-point failure in DU and binary component production.

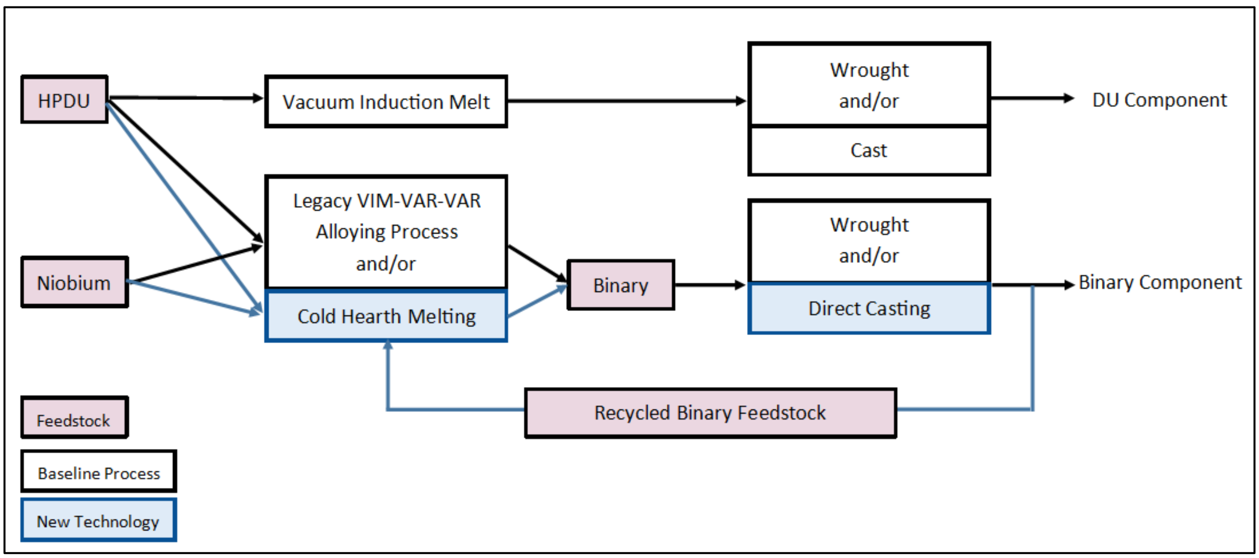


Figure 3–1. Potential production process with new technology insertion

The DU Modernization Program must ensure an enduring capability to manufacture DU and binary components. Without additional capacity for creating binary feedstock and manufacturing components, the existing DU facilities at Y-12 will reach component production limits and will be unable to meet component deliveries in support of required weapons modernization programs beginning in 2035 based on the demand detailed in the 2022 Production and Planning Directive. The DU mission currently performed at Y-12 has capability gaps in aging infrastructure, facility constraints, obsolescence of equipment, and capacity constraints.

The DU Modernization Program is implementing a bridging strategy to increase capacity and reliability to meet future enterprise demand. This strategy includes the continued support of planned investments in maturing and deploying Direct Casting and Cold Hearth Melting, while addressing the growing NNSA-mission related production needs using existing capabilities. Strategic planned investments in the current equipment set to increase capacity and reliability, shifts, and load-leveling of future mission-related requirements are also being pursued to augment this strategy.

The Development Vacuum Arc Remelt Furnace at the Testing and Development Facility

Furthermore, the DU Modernization Program will evaluate on and offsite solutions to address capacity gaps in the mid-2030s, to include alternative acquisition approaches to supplement onsite production. Additionally, the program has established a task force to prioritize infrastructure projects across Y-12, which will allow the NNSA to focus infrastructure investments on capabilities that have nearer term capacity bottlenecks, beyond just the DU modernization program.

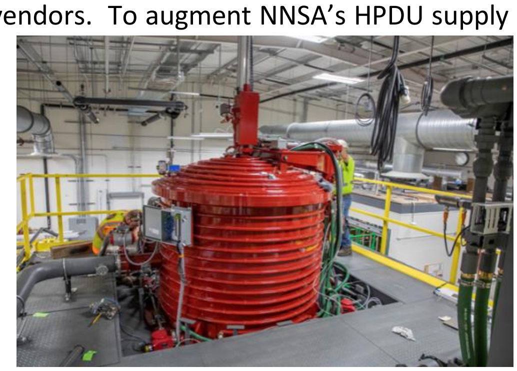
DU Modernization activities include the following:

1. Supply new HPDU metal feedstock by establishing a DUF_6 to HPDU conversion capability
2. Restart and maintain the VIM-VAR-VAR and component manufacturing processes at Y-12
3. Develop, mature, and deploy key new technologies for insertion into production to augment existing processes, improve material use efficiency, and reduce reliance on the existing and aging processes
4. Modernize existing component manufacturing processes to improve reliability, meet capacity and throughput demands, and reduce risk to future life extension programs (LEPs)
5. Execute a bridging strategy to meet weapons deliverables through the Production and Planning Directive and increase component capacity with a mixture of modernized existing capabilities and new technologies.

3.2.2.1 Status

The DU Modernization Program is currently engaged in many activities to meet imminent weapons delivery mission requirements, which include establishing a reliable supply of HPDU by 2030, executing a bridging strategy, and restarting and modernizing DU alloying and manufacturing capabilities.

The DU Modernization Program's goal is to reestablish a reliable supply of HPDU before the current inventory is exhausted in 2030. To obtain the large quantities required, the NNSA will need to establish a supply chain to convert DUF_6 to HPDU. The program completed an Analysis of Alternatives (AoA) to identify a solution that addresses the long-term need for HPDU by leveraging existing and potential capabilities within the DOE enterprise and through qualified vendors. To augment NNSA's HPDU supply until a long-term capability is established, Y-12 has engaged with a vendor to establish a process to convert recycled DU oxide from Y-12 and decommissioned DU projectiles from the DoD into HPDU.


The Multi-Zone Direct Cast Vacuum Induction Melt Furnace at the Testing and Demonstration Facility

The DU Modernization program is also restarting DU alloying capabilities and maintaining existing manufacturing processes. This includes restarting alloying production equipment at Y-12, modernizing component and machining capabilities, training operators, developing procedures, and supporting LANL and LLNL with process qualification activities. Collectively, these activities allow for successful manufacturing of binary components. Additionally, the program has developed modernization plans for the facilities that increase their reliability and capacity by determining which equipment to replace and/or update and how to use the available space more efficiently. These plans include schedules for equipment removal and installation, floor plans that demonstrate the optimized machine layout for each building, and waste management plans for the removal of large equipment.

Along with the wrought and machining capability issues, Y-12's current alloying process has proven reliable but inefficient and leads to significant material waste and excessive costs. DOE/NNSA is developing new technologies to replace these aging capabilities and provide a more efficient and cost-effective means of producing binary components and allowing DOE/NNSA to meet future production demands. The DU Modernization program is accelerating technologies, such as Direct Cast and Cold Hearth Melting, by establishing technology readiness teams with stakeholders from production, development, design agencies, and technical subject matter experts (SMEs). By including the relevant stakeholders in the development and testing phases using high fidelity prototypes, technology transfer between development and production is facilitated to insert new technologies into the production process.

DOE/NNSA's Manhattan Project-era facilities continue to experience age-related failures that present significant risk to mission delivery and personnel safety. According to the 2021 Major Asset Plan for Y-12 facilities associated with DU, those facilities will on average be over 80 years old by 2035. Restarting and sustaining DU processing capabilities requires targeted resources to address the risk associated with aging equipment and continued training and development of SMEs to produce components and resolve technical issues associated with complex processes. Furthermore, these challenges require the establishment of the Agile Radiation Case and Component Capability to address the capability gaps caused by aging equipment and infrastructure. The Agile Radiation Case and Component Capability will enable the DU program to meet increased demand for radiation cases and other DU and binary components, which will exceed Y-12's current production capabilities by 2035.

3.2.2.2 Challenges and Strategies

Table 3–4 provides a high-level summary of DU Modernization challenges and the strategies to address them.

Table 3–4. Summary of Depleted Uranium Modernization challenges and strategies

Challenges	*Strategies*	
	Current Strategy Being Implemented	*Future Strategies Needed*
HPDU metal inventory is insufficient to meet long-term demands.	• Execute multiple mitigation efforts that include procuring HPDU from limited commercial entities, recycling DU oxide from Y-12, and converting DU projectiles into HPDU. Invest in cold hearth melting and direct casting to increase material use efficiency and reduce overall HPDU demand.	• Stand up a long-term HPDU conversion capability. • Bolster the supply chain for HPDU and other uranium materials by seeking additional vendor solutions for conversion processes from DUF_6 to HPDU.
DOE/NNSA needs to restart, modernize, and maintain lapsed DU alloying capabilities to support future stockpile needs.	• Invest in the restart and maintenance of the legacy VIM-VAR-VAR alloying processes. • Purchase additional equipment to reduce the strain on legacy equipment and processes. • Coordinate across production and design agencies to expedite qualification of binary with joint qualification plans.	• Deploy cold hearth melting alloying production technologies to improve efficiency and recycling capabilities. • Integrate direct cast technology into production to reduce binary material demands and waste due to increased efficiencies and decrease process risk.

Challenges	*Strategies*	
	Current Strategy Being Implemented	***Future Strategies Needed***
Current component manufacturing capabilities rely on aging equipment and have limited capacity to meet future stockpile needs.	• Execute the DU bridging strategy to reduce bottlenecks, improve space utilization of existing facilities, and increase capacity and reliability of existing processes to fulfill near-term mission requirements. • Purchase wrought critical spare parts to sustain the process. • Invest in direct casting technology to produce components more efficiently and reliably.	Establish a DU/Binary manufacturing capability to meet future stockpile needs. Mature new technologies to reduce reliance on aging equipment and outdated technologies.
Current DU facilities experience age-related failures and have insufficient floor space to support future stockpile demand.	• Identify opportunities to meet capacity within existing space by co-locating key pieces of equipment, improving existing processes, upgrading equipment with modern controllers, and continuously improving strategic material models. • Invest to recapitalize the aging physical infrastructure, reducing risk to produce strategic materials and components. • Establish a combination of on and off-site storage capabilities to store required quantities of HPDU feedstock to meet future mission demand.	Evaluate long-term DU facility options to meet future stockpile demands.
Maintain a trained and qualified workforce for DU operations.	Develop staffing plan for multi-year training. Transfer knowledge from SMEs near retirement age to new SMEs.	Implement additional strategies to maximize knowledge retention and minimize workforce turnover.

DU = depleted uranium
DUF_6 = depleted uranium hexafluoride
HPDU = high purity depleted uranium
SMEs = subject matter experts
VIM = Vacuum Induction Melt
VAR = Vacuum Arc Remelt

3.2.3 Lithium Modernization

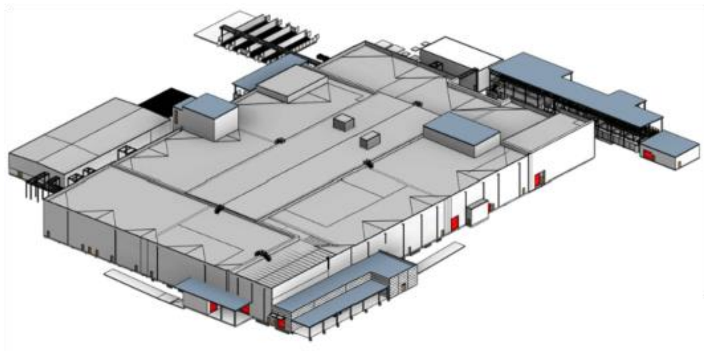
The Lithium Modernization Program maintains the processes that ensure the Nation's enriched lithium materials are supplied to support Defense Programs, DOE's Office of Science, the Department of Homeland Security, and other customers.

> ***Lithium Modernization Accomplishment (2022 and 2023)***
>
> *The team completed the Material Conversion Equipment Refurbishment project at Y-12, which refurbished and re-started equipment that had been idle for nearly a decade. Within a few production runs, it is now producing 140 percent of program expectation in FY 2023.*

Lithium materials for the nuclear weapons stockpile and other customers are currently processed in Y-12's Building 9204-2 (a Manhattan Project-era building that has housed lithium processing since the 1950s) and in Building 9202. The historical processes are very corrosive in nature and have caused accelerated degradation to Building 9204-02. Additionally, the facility and its processes are oversized for today's mission, do not meet current codes/standards, and are well beyond their designed operational life. The program is responsible for the design and construction of a new Lithium Processing Facility that uses improved processes.

Until that effort is complete, the Lithium Modernization Program also supports operations for processing lithium materials to meet current and near-term mission requirements. Lithium is currently provided via a recycling process that relies on retired weapons dismantlement feedstock purified through the wet chemistry process. As part of stockpile surveillance data collection, nondestructive and destructive testing is performed on lithium components in full assembly and part forms.

The program also works with multiple DOE/NNSA stakeholders to plan and execute recapitalization projects and risk reduction activities to sustain the current lithium processing capability until the Lithium Processing Facility is operational in the 2030s. Additionally, the program is developing the operational release plan for startup and transition to full Lithium Processing Facility operations.



Current Engineering Design of the Lithium Processing Facility

The Lithium Modernization Program also supports the maturation of technologies and development of process improvements that make lithium processing more efficient, safer for workers, and less impactful to surrounding infrastructure. In FY 2023, the program continued to expand lithium processing expertise to develop future lithium material SMEs across the enterprise, with key partnerships at LANL, LLNL, and the Pacific Northwest National Laboratory.

Lithium Modernization activities include the following:

- Produce and maintain the lithium material inventory to meet current mission requirements and customer deliverables
- Purify and convert lithium materials to lithium hydride and/or lithium deuteride, which are the two types of lithium materials used for component production
- Recapitalize lithium purification and powder production process equipment and perform risk reduction activities to sustain process capabilities until the Lithium Processing Facility comes online
- Develop, mature, and deploy lithium purification and production technologies in support of the Lithium Processing Facility baseline and beyond

DOE/NNSA created a lithium strategy to ensure sufficient lithium processing capabilities (raw materials to finished assemblies) are available to meet near- and long-term requirements. The strategy includes:

- Sustaining the current Manhattan Project-era infrastructure and equipment until transition to the Lithium Processing Facility
- Increasing the usable supply of lithium by dismantling and recycling lithium components with direct material manufacturing
- Using small-scale technologies to purify and convert lithium
- Designing and constructing the Lithium Processing Facility to house lithium processing capabilities by 2031

3.2.3.1 Status

A new facility is critical to the long-term strategy for lithium supply. Currently, aging infrastructure and antiquated equipment present risks to mission delivery that could affect the ability to meet stockpile requirements. The current lithium facility has housed lithium processing for more than 75 years. The

Beta-2 Workers Harvest Lithium Metal from Electrolytic Cell

historical processes are very corrosive in nature and have accelerated degradation of the facility. Structural issues due to chemical contamination pose safety and environmental concerns, and the facility must be replaced.

The Lithium Modernization Program will execute recapitalization projects and risk reduction activities to sustain the current lithium processing capability until the Lithium Processing Facility is operational. Modernization activities include developing the plan for bridging operations and transitioning from the existing facility to the new Lithium Processing Facility. DOE/NNSA periodically updates the Lithium Strategy Document and has also developed the Lithium Technology Maturation Plan. DOE/NNSA is maturing technologies that will make lithium purification and processing safer for workers, more efficient, and less impactful to surrounding infrastructure. For example, the next-generation Lithium Electrolytic Cell will improve lithium metal processing efficiency and drastically reduce worker hazards by a closed cell design with automated processes for remote salt feed and remote metal harvesting. Other technologies being pursued include Near Net Shape, Homogenization, Low Temperature Chlorine-Free Lithium Production, and Advanced Lithium Purification. Technology Readiness Assessments will be conducted as needed to assess the strengths and weaknesses of identified technologies.

DOE/NNSA will continue to work with management and operating partners to develop tailored, long-term staffing plans that anticipate critical skills shortfalls within this capability and properly forecast staffing levels based on the current program of record. Sustainment of capabilities will necessitate continued training and development of SMEs to produce lithium components and resolve technical issues associated with complex production processes.

3.2.3.2 Challenges and Strategies

Table 3–5 provides a high-level summary of Lithium Modernization challenges and the strategies to address them.

Table 3–5. Summary of Lithium Modernization challenges and strategies

Challenges	*Strategies*	
	Current Strategy Being Implemented	*Future Strategies Needed*
Insufficient lithium materials.	• Restart a small-scale purification capability and legacy processing capabilities in the legacy lithium facility to provide additional feedstock material. • Deploy a production cleaning station to provide additional capacity. • Complete the Material Conversion Equipment Refurbishment project to recapitalize equipment that processes salvage solutions, converts lithium chloride to lithium metal, and converts the metal to lithium hydride. • Monitor and optimize weapons dismantlement schedule to provide feedstock as needed. • Construct the modern Lithium Processing Facility on schedule to replace infrastructure critical to stockpile deliverables at Y-12 by 2031.	• Implement additional strategies to increase capacity for purification of current Li6 material not suitable/ eligible for Direct Material Manufacturing • Continually monitor supply chain risks and opportunities.

Challenges	Strategies: Current Strategy Being Implemented	Strategies: Future Strategies Needed
Sustaining lithium production in aging facilities until the transition to the Lithium Processing Facility.	• Implement short- to medium-term recapitalization investments as appropriate. • Construct the modern Lithium Processing Facility on schedule to replace infrastructure critical to stockpile deliverables at Y-12 by 2031. • Identify and prioritize future projects to include electrical, utility upgrades, and other structural life extending efforts.	• Monitor emerging needs and implement strategies and actions to mitigate risks. • Implement additional strategies to maintain facilities past their useful lives.
Delay in transition to conducting lithium operations in the Lithium Processing Facility beyond 2031.	• Prioritize recapitalization projects, process qualifications, and coordination with the Design Agencies to sustain current infrastructure to set the conditions for transition of operations from legacy facilities to the future Lithium Processing Facility. • Continually monitor integrated schedules to identify opportunities for Lithium Processing Facility project acceleration. • Deploy rapid response projects in the legacy lithium facility to mitigate aging infrastructure risks and prevent interruptions to production.	• Qualify additional systems for Direct Material Manufacturing to increase the quantities of LiH/LiD available for reuse. • Identify and prioritize future projects to include heating, ventilation, and air conditioning; electrical; utility upgrades; and other identified structural life extending efforts.
Inability to balance right-sized inventories of material with ongoing mission priorities and manufacturing capacities.	• Optimize small-scale purification capability and legacy processing capabilities through lean improvement methods. • Add additional lithium drying capacity. • Develop and mature strategic lithium process technologies (e.g., Homogenization, next-generation Lithium Electrolysis Cell) to introduce efficiencies into the Lithium Processing Facility. • Develop sustainment lithium process technologies (e.g., near-net shape forming) to introduce efficiencies into the current process and prepare for insertion in existing process facilities.	• Optimize design of the front-end wet chemistry process for the Lithium Processing Facility. • Monitor evolving technologies and invest in existing or new technologies as appropriate.
Maintaining a trained and qualified workforce for lithium operations.	Develop staffing plan for multi-year training. Transfer knowledge from SMEs near retirement age to new SMEs.	Implement additional strategies to maximize knowledge retention and minimize workforce turnover.

Li6 = Lithium 6 (isotope) LiH = Lithium Hydride
LiD = Lithium Deuteride SME = subject matter expert

3.3 Tritium Modernization and Domestic Uranium Enrichment

Tritium Modernization and Domestic Uranium Enrichment is responsible for producing tritium and supplying unobligated low-enriched uranium (LEU) to support national security needs.

3.3.1 Tritium Modernization

The Tritium Modernization Program maintains and operates the national capability for producing tritium. The tritium supply chain's capacity is increasing as part of a multiyear plan to reliably meet national security requirements. Since FY 2003, DOE/NNSA has produced tritium by irradiating tritium-producing burnable absorber rods (TPBARs) in the Watts Bar Nuclear Plant Unit 1 (WBN1) and Unit 2 (WBN2) (nuclear power reactor) operated by the Tennessee Valley Authority (TVA) during normal 18-month operating cycles. The tritium inventory is required to meet national security requirements, including support for limited-life component exchanges of tritium reservoirs that are deployed in the stockpile. The program establishes tritium production schedules, which are based on detailed computational models and annual tritium reconciliations, to maintain required tritium inventories, including reserve quantities. Production planning takes into consideration the material that is constantly being recovered and recycled from deployed reservoirs, including those from weapon dismantlements.

Tritium Modernization Accomplishments (2022 and 2023)

- *In FY 2022 WBN2 completed irradiation of 544 TPBARs (Cycle 4) and commenced irradiation of 1,104 TPBARs (Cycle 5).*
- *TVA completed eight shipments of TPBARs to SRS in calendar year 2022 (a total of 2,400 TPBARs), including six shipments from November to December.*
- *The final design for the thermal cycling absorption process column A isotopic separation equipment was completed in December 2022 in preparation for calendar year 2025 installation, in addition to awarding long-lead equipment procurements.*
- *CD-2/3 for the Tritium Finishing Facility site prep and warehouse subproject was completed and approved in December 2022.*
- *In March 2023, TVA submitted a License Amendment Request to NRC to raise the maximum allowable TPBAR numbers by 39 percent per reactor cycle in support of Tritium Modernization Program goals.*
- *In FY 2023, SRS completed six tritium extractions.*

3.3.1.1 Status

Tritium Production

The Tritium Modernization Program must increase capacity to confidently meet national security requirements.

The tritium production goal, independently certified by the Nuclear Weapons Council in 2015 as requested by Congress, established a requirement to ramp up tritium production capacity at TVA by 2025. This production requirement necessitated the use of two reactors with 18-month operating cycles, as well as an increase to the previously established maximum number of TPBARs allowed per reactor cycle. WBN1 has produced tritium since 2003 and is loading the maximum number of TPBARs currently licensed by the Nuclear Regulatory Commission (NRC). In November 2020, WBN2 began its first-ever 18-month tritium production cycle and is expected to reach the established maximum allowable number of TPBARs by mid-FY 2025. In March 2023, TVA submitted a License Amendment Request to NRC to raise the maximum allowable TPBAR numbers by 39 percent per reactor cycle in support of the Tritium Modernization Program goals. The Tritium Modernization Program anticipates a 12-month review and approval period for the License Amendment Request by NRC.

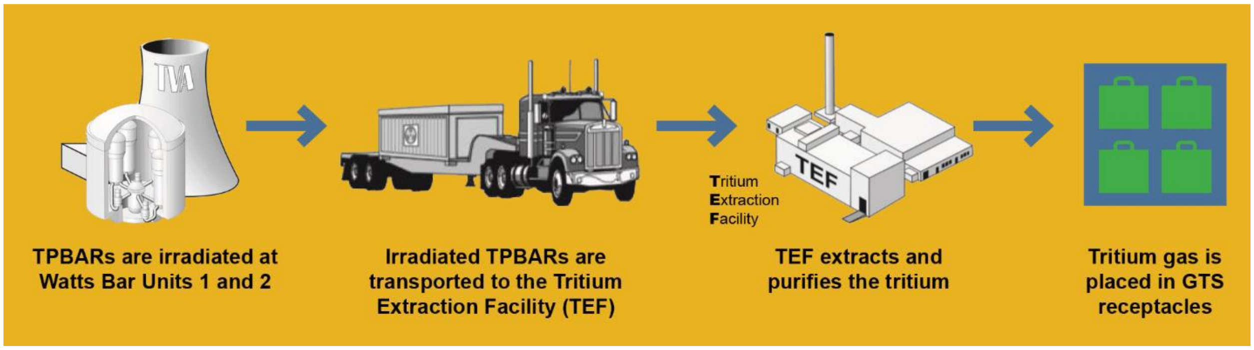
To support DOE/NNSA's long-term tritium needs, TVA plans to prepare 20-year Subsequent License Renewal applications for submission to NRC to ensure WBN1 and 2 reactors continue production operations through 2055 and 2075, respectively. While DOE/NNSA is confident that the TVA reactors will meet or exceed tritium production needs throughout their operating lifetime, the Tritium Modernization Program is actively monitoring viable production alternatives, as well as trends in the civilian nuclear regulatory environment, to ensure supplies will continue to meet long-term needs.

As the demand for tritium continues to rise, DOE/NNSA must increase efforts to mitigate risk to production plans.

Tritium Processing at SRS

DOE/NNSA operates numerous facilities at SRS that support tritium handling, processing, and storage functions, including recovery, nondestructive analysis, and surveillance. In addition, DOE/NNSA is implementing a plan to replace or recapitalize aging facilities. This plan focuses on maintenance of facilities as well as the need for supply chain management (e.g., vendors, tritium R&D capabilities, etc.).

After being irradiated, TPBARs are transported to the Tritium Extraction Facility at SRS, where tritium is extracted by cutting and heating the TPBARs using unique, specialized equipment. The extracted tritium is processed and added to the tritium inventory at SRS. Tritium is used to meet several national security needs. One such need is to fill gas transfer system (GTS) reservoirs that meet design agency specifications.



To recycle tritium from returned GTS reservoirs, or other bulk containers, the gas content is unloaded and then processed to remove any impurities. Helium-3, a byproduct resulting from the naturally occurring radioactive decay of tritium, is separated from the remaining tritium contents. The recycled tritium gas partially replenishes tritium inventory and can be reused in future reservoir fills.

Various tritium extraction and purification processes, along with supporting functions, are performed in the H-Area New Manufacturing facility and the Tritium Extraction Facility at SRS. While DOE/NNSA has the tritium processing capabilities and capacity to meet foreseeable workload requirements, several of the facilities that house these processes were built in the 1990s. DOE/NNSA is currently monitoring the health of equipment, infrastructure, waste gas processing, and other facility attributes and is developing a plan to maintain and recapitalize the facilities and equipment needed to meet processing requirements and other delivery schedules. The plan focuses on both the need to maintain the facilities and the need to ensure maintenance of the supply chain, which includes unique equipment, vendors, and tritium R&D capabilities. A major part of the plan is the maintenance and repair of aged isotopic separation equipment and its supporting infrastructure in the H-Area New Manufacturing facility. This effort (comprising six projects) will bring equipment/processes back up to original design capacity and reduce age-related maintenance. Long-lead procurement and design activities are currently underway, which will culminate in a reservoir loading system partial outage in calendar year 2025. This outage is being closely coordinated within DOE/NNSA and with DoD to mitigate impacts to the tritium mission and deployed weapons.

Tritium Extraction Facility Personnel Receive Irradiated TPBARs Shipped from Watts Bar in Preparation for Extracting Tritium for the Nation's Nuclear Deterrent

The Tritium Finishing Facility (TFF) project, along with several minor construction projects, will replace the critical capabilities of the existing 65-year-old manufacturing building that operates 24/7 for GTS operations. The H-Area Old Manufacturing Facility building was designed and built prior to modern construction standards and is beyond its expected operational service life. The new facilities within the TFF Project will adhere to new and more stringent DOE/NNSA design and construction standards. For example, the TFF design is based on analyses of accidents/impacts from natural phenomena, such as earthquakes and high-wind events. TFF achieved CD-1 in 2019, initiated design activities in 2020, and achieved CD-2/3 for the site preparation and warehouse subproject in December 2022. While 30 percent design completion was authorized for the overall project, the project is paused from FY 2024–2026 to prioritize workforce requirements for the SRPPF project. Funding carried over from FY 2023 will be used to complete site preparation work and 30 percent of overall project design, as well as 60 percent of classified process design, to better position the project for resumption in FY 2027. The project was scheduled to be completed by FY 2031, but will now likely be completed in FY 2034. The existing manufacturing building will remain operational, supplying tritium-filled GTS reservoirs to DoD until TFF is operational. Some of the facility's electrical systems have been upgraded to reduce the risk of failure in the short-term until critical capabilities can be relocated to new facilities.

Tritium extraction operations at SRS are keeping up with the growing demand for tritium. DOE/NNSA has the workforce capability to meet planned workload and mission deliverables.

3.3.1.2 Challenges and Strategies

Table 3–6 provides a high-level summary of Tritium Modernization Program challenges and the strategies to address them.

Table 3–6. Summary of Tritium Modernization challenges and strategies

Challenges	*Strategies*	
	Current Strategy Being Implemented	***Future Strategies Needed***
Maintaining a reliable tritium supply chain to meet inventory, availability, and GTS loading schedule requirements.	Assess supply chain risks and opportunities. Investments are being made that will provide a high level of reliability, flexibility, and resiliency to the program.	Continue to monitor risks and opportunities to identify cost-effective solutions and maintain high reliability.
Evaluating alternative tritium production technologies or methods due to the uncertainties associated with NRC approval of operating license renewal application submissions in 2055 and 2075 for Watts Bar Units 1 and 2, respectively.	• Invest in studies that identify and monitor viable and emerging replacement methods and technologies as risk mitigation for long-term tritium production needs. • Plan for and invest in reactor vessel fluence mitigation strategies to protect current production infrastructure and improve reactor longevity.	• Monitor evolving technologies and invest in existing or new replacement technologies as appropriate. • Implement developed core design strategies to protect current reactor vessels from excess fluence that would reduce reactor lifetime estimates.
Acquiring replacement limited-life facility components and equipment from foreign sources opposed to the Tritium Modernization Program mission.	• When appropriate, provide assurances to foreign governments that desired components/equipment are not in direct support of the Tritium Modernization Program mission. • When appropriate and possible, identify alternative sources unopposed to the Tritium Modernization Program mission.	Develop a supply chain of all critical limited-life components and equipment that is U.S.-based and sourced.
Maintaining facilities and equipment to support stockpile deliverables and future Alts, Mods, and LEPs, and reduce GTS delivery risks.	Construct the modern Tritium Finishing Facility to replace infrastructure critical to stockpile deliverables at SRS in approximately FY 2034. Continue long-lead procurements and other activities needed to support replacement of aged tritium isotopic equipment and support systems in calendar year 2025.	Monitor emerging needs and implement strategies and actions to mitigate risks.
Developing technologies that further enhance stockpile maintenance, evaluation, and efficiency of processes throughout the tritium production lifecycle.	Invest in fundamental tritium science to include material property interactions and scientific research into the material properties and behaviors of TPBARs, GTSs, and tritium gas processing technologies.	Develop a strategy to acquire dedicated radiological tritium capabilities to address future technology needs without compromising mission schedule.

Alts = alterations
GTS = gas transfer system
LEPs = life extension programs
Mods = modifications
NRC = Nuclear Regulatory Commission
TPBARs = tritium-producing burnable absorber rod

3.3.2 Domestic Uranium Enrichment

The DUE Program is responsible for ensuring a reliable and economic supply of enriched uranium to support U.S. national security needs. Since the closure of the Paducah Gaseous Diffusion Plant in 2013, the United States has lacked the capability to produce enriched uranium free of peaceful use obligations (i.e., unobligated). DOE/NNSA requires unobligated enriched uranium to fuel reactors that produce tritium for nuclear weapons and to power the nuclear Navy. The DUE program is implementing a three-pronged strategy to meet current enriched uranium needs and re-establish an enduring supply of enriched uranium to meet long-term needs. First, DOE/NNSA seeks to ensure and extend availability of its unobligated LEU fuel supply through 2044 by down-blending excess HEU. Second, DUE is preserving and advancing uranium enrichment expertise and technology. Third, DUE is executing the acquisition process to re-establish a long-term supply of enriched uranium to support future U.S. national security needs.

Domestic Uranium Enrichment Accomplishments (2022 and 2023)

- *Oak Ridge National Laboratory (ORNL) completed lab-scale cascade testing of the first deployable centrifuge design platform as part of the Domestic Uranium Enrichment Centrifuge Experiment (DUECE) project.*
- *ORNL broke ground on the facility extension to house the engineering-scale Demonstration Cascade 2 that will evaluate DUECE centrifuge enrichment performance in a representative cascade configuration.*

3.3.2.1 Status

The status of each element of the program are as follows:

- **Downblend HEU to LEU to extend the tritium fuel need date to 2044.** DOE/NNSA has identified existing unobligated enriched uranium to power the TVA reactors through 2044. Much of the material is HEU "scrap," which is unattractive for use by other programs. DOE/NNSA is engaged in an Interagency Agreement with TVA to manage downblending activities through FY 2025. This effort maintains continuous operations at the only commercial downblender, which would otherwise close in the absence of feed material. However, because the HEU inventory is finite and, at present, irreplaceable, downblending is a temporary solution.
- **Develop enrichment technology options.** Following an analysis of available enrichment technologies, DOE/NNSA determined that centrifuge technologies have the highest technical maturity and lowest risk. DOE/NNSA is funding centrifuge R&D efforts at Oak Ridge National centrifuge design platform and will continue to mature multiple centrifuge designs. In FY 2024, ORNL plans to complete a facility extension project to house the engineering-scale Demonstration Cascade 2, which will evaluate centrifuge enrichment performance in a representative cascade configuration.

Rendering of Demonstration Cascade 2 Facility Extension at ORNL

- **Execute an acquisition process to deploy an enrichment technology.** Because of the finite nature of the HEU inventory, the United States will eventually need a new unobligated uranium enrichment capability. DOE/NNSA approved CD-0 for this capability in December 2016. DOE/NNSA expects to conclude an AoA and make a final technology downselect in the mid-2020s.

3.3.2.2 Challenges and Strategies

Table 3–7 provides a high-level summary of Domestic Uranium Enrichment challenges and the strategies to address them.

Table 3–7. Summary of Domestic Uranium Enrichment challenges and strategies

Challenges	Strategies	
	Current Strategy Being Implemented	*Future Strategies Needed*
Enrichment technologies are complex and difficult to develop and deploy.	• Continue to invest in two centrifuge technologies to provide optionality and contingency. • Continue to work with ORNL to increase confidence that centrifuge technologies are sufficiently matured in time for the LEU need date.	Continue developing centrifuge technology options to provide additional operational data and reduce long-term deployment risks.
Sources of unobligated LEU are finite.	Continuously assess inventory to identify any additional unobligated enriched uranium to extend the LEU need date.	Establish a reliable and enduring supply of unobligated enriched uranium.

DUE = domestic uranium enrichment
LEU = low-enriched uranium

3.4 Non-Nuclear Capability Modernization

The Non-Nuclear Capability Modernization program executes projects to ensure enduring availability of non-nuclear component capabilities for all weapon systems. The program is responsible for modernization efforts related to all non-nuclear components external to the primary or secondary stage in the nuclear explosive package. Non-nuclear components enable critical functionality in the warhead, including arming, fuzing, and firing, key safety and use control features, and other vital functions. Providing these functions requires a wide range of components encompassing radiation-hardened microelectronics, neutron generators, GTSs, power sources, electrical assemblies (e.g., radars, weapon control units, sensors), cable assemblies, connectors, mechanisms, structural elements, pads/cushions, and a multitude of other parts that are incorporated into the systems that support or weaponize the nuclear explosive package. The Non-Nuclear Capability Modernization program modernizes the extensive suite of infrastructure and equipment required to support the non-nuclear component lifecycle, including design, development, qualification, production, and surveillance.

Non-Nuclear Capability Modernization Accomplishments

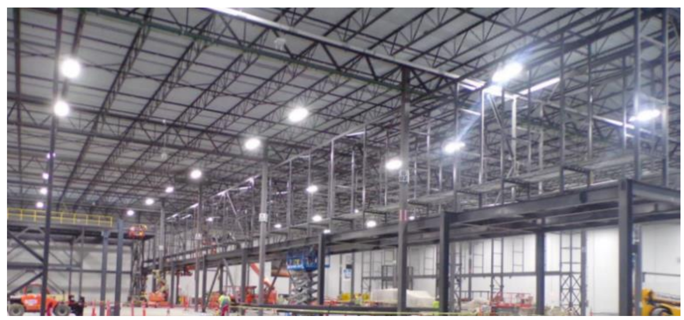
- *Polymer Enclave parts production at LLNL*
- *Established an Electronic Parts Program working group that created the funding model for the program*
- *Power Sources Capability achieved CD-1 at SNL*
- *Agile Facility build out contract awarded in September 2022 with build out completion expected in the second quarter of FY 2024 at SNL*
- *Saturn Facility outage preparations completed to allow for an effective outage for system upgrades at SNL*
- *Pantex production modernization studies awarded to include Bays/Cells of the future and Material Staging Facility alternative options*
- *Product Realization Infrastructure for Stockpile Modernization (PRISM) project completed the combined Mission Need Statement/Program Requirements Document at LLNL*
- *KCNSC's Strategic Sourcing saved $2.4 million in long-term contracting win*
- *Kansas City Short-Term Expansion Plan (KC STEP) executed capital equipment procurements totaling $25 million to support production and development*

Non-Nuclear Capability Modernization activities include the following:

- Procure equipment to meet non-nuclear component manufacturing capacity requirements
- Provide equipment and infrastructure to enable new technology insertion
- Sustain DOE/NNSA's capability to produce trusted microelectronics
- Recapitalize and conduct equipment maintenance on critical environmental test and accelerator capabilities that support lifecycle activities (such as components qualification or surveillance) for weapon electrical and mechanical systems
- Procure equipment that supports the bridging strategy for power sources production capabilities
- Introduce new processes and technologies that increase efficiency in component manufacturing
- Mitigate industrial base and supply chain risks for non-nuclear parts
- Modernize production capabilities for non-nuclear components through long range planning activities and line-item construction projects

3.4.1 Status

KCNSC is the center for non-nuclear component production, delivering the majority of DOE/NNSA's non-nuclear components for weapon modernization and sustainment. Completed in 2012 and designed to support fewer and less complex weapon modernization programs, the KCNSC is challenged to support the current program of record. Meeting this growing demand involves additional equipment procurements to outfit Building 23, which NNSA purchased in February 2023. Additional equipment will also be needed to support the future campus being planned. Improved collaboration with design agencies using Design for Manufacturing tools will also enhance use of existing space by increasing producibility and yield of components. Manufacturing and space needs beyond the Future-Years Nuclear Security Program will be addressed thru KCNExT, a multi-year phased campus approach that will also allow the exit of leased facilities. Non-Nuclear Capability Modernization will validate program requirements and provide capital equipment to fit out the new additional manufacturing space provided from KCNExT.



KC STEP Construction Initiated, and Occupancy Contracts Awarded

The primary design agency for non-nuclear component research, development, testing, and evaluation is SNL. SNL also plays a critical role in the production of non-nuclear components and subsystems. Many of the SNL facilities supporting these capabilities are beyond life expectancy and critically need upgrading and recapitalizing. The primary Power Sources facility was originally built as a shipping/receiving warehouse in 1949 and then converted to manufacturing space. Due to severe degradation of this facility, a new facility is in design, which will provide a long-term solution for the development and production of power sources needed for all weapon programs. The Power Sources Capability is

Rendering of the Power Sources Capability Project Currently Under Design, SNL currently in the preliminary design phase (post CD-1) with an anticipated CD-4 occurring in FY 2030. As an interim bridging solution, an agile facility at SNL has been constructed and is being outfitted to accommodate a critical portion of the power sources thermal and lithium primary production mission.

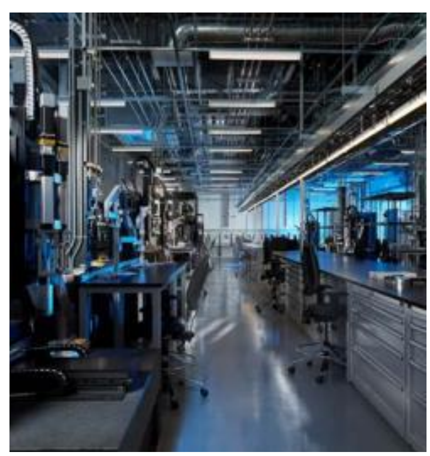
The aging facilities and equipment in SNL's Microsystems Engineering, Science, and Applications (MESA) complex also pose challenges. MESA has an ongoing extended life program to sustain its capabilities through at least 2040, and plans are underway to evaluate future capability gaps and develop long-term solutions to provide microelectronics when existing facilities are no longer viable.

Aging equipment and capabilities are an issue throughout the enterprise. At SNL, this is impacting major testing facilities used to qualify and assess non-nuclear components. These facilities test components in extreme environments and ensure they meet high reliability requirements. Most of these facilities, including the Major Environmental Test Facilities, the Saturn facility, the High-Energy Radiation Megavolt Electron Sources III accelerator, and the Annular Core Research Reactor, are decades old and have deferred maintenance over the years. Presently, the Saturn facility provides deliverables about 30 percent of the time due to planned and unplanned maintenance and shot-to-shot irreproducibility, causing the need to schedule additional tests. The High-Energy Radiation Megavolt Electron Sources can only accommodate about 85 percent of requested qualification tests, of which only 75 percent are executed due to unplanned outages and data acquisition inadequacies. These facilities must remain operational to ensure that non-nuclear components can be qualified as required by the program of record. DOE/NNSA is developing a model and methodology to prioritize recapitalization efforts for the environmental test facilities.

New Centrifuge Cooling System, Major Environmental Test Facilities, SNL

High Speed Camera, Major Environmental Test Facilities, SNL

To assist in developing non-nuclear components in a rapid and agile environment, LLNL has begun part development at the Polymer Enclave, including pads and cushions to support new polymer designs and enable an increased pace of technology development and deployment with increased production yield. The Polymer Enclave is expected to speed the transition from current manufacturing and to be used with other technologies in the future. Leveraging the success of the Polymer Enclave, proposed projects such as the Product Realization Infrastructure for Stockpile Modernization (PRISM, previously called the next-generation LEP R&D facility) are intended to provide increased agility for manufacturing responsiveness for other non-nuclear components. Other design agency laboratories are also looking into similar or complementary facilities to advance early technologies and improve manufacturing yield.



Polymer Enclave, LLNL

3.4.2 Challenges and Strategies

Table 3–8 provides a high-level summary of Non-Nuclear Capability Modernization challenges and the strategies to address them.

Table 3–8. Summary of Non-Nuclear Capability Modernization challenges and strategies

Challenges	Strategies	
	Current Strategy Being Implemented	Future Strategies Needed
Increased scope and complexity: Workload projections to produce non-nuclear components for the program of record exceed existing equipment and infrastructure capacity. Manufacturing space was sized for fewer, less-complex weapon systems.	• NNSA purchased Building 23 in February 2023, which will provide 450,000 square feet of manufacturing space through modifications referred to as KC STEP. Of this new space, 250,000 square feet is currently undergoing modifications, equipment purchases, and installations. The remainder of the building will begin modifications in FY 2024. The KC STEP is intended to meet the non-nuclear component production through FY 2028. • KCNExT is the long-term initiative to provide additional manufacturing and office space to meet projected mission requirements. This will enable NNSA to terminate current office space leases.	Determine the most prudent long-term solutions to provide increased production capacity at SNL and KCNSC to meet the Program of Record.
Integration of New Technologies: As new manufacturing techniques are developed, qualified, and accepted, new production capabilities are required to support manufacturing methods involving materials, multi-function machines, additive manufacturing, and other new approaches.	Provide relief for critical equipment needs related to these key product lines. Investments in non-nuclear capabilities enable new manufacturing techniques to transition smoothly to production by encouraging early DA-PA collaborations.	Identify promising technologies that may be committed to future modernization programs if sufficiently mature. These technologies may enable improvements to stockpile safety, use control, and reliability, while minimizing the schedule, performance, and risk to the enterprise.
With integration of new technologies on modernization programs (e.g., direct ink write polymer cushions and pads), KCNSC must maintain capabilities for legacy programs consuming significant manufacturing space.	Add additional manufacturing space to support select legacy technologies as well as development work for modernization programs through its KC STEP plan.	DOE/NNSA is in the planning stage to add manufacturing space to support new and legacy technologies.
Material availability: Some material supplies are limited and remaining quantities continue to be in high demand by modernization programs.	Continue to use a central material data management system to track and monitor at-risk materials and provide a transparent supply chain network and associated risks by industry experts.	• Continue monitoring supplier network risks for non-nuclear materials unavailability and provide recommended policy actions, production options, and material mitigation solutions to improve supply chain resiliency. • Coordinate across DOE/NNSA to prioritize material risks, develop enterprise-wide mitigation strategies, and leverage available policy tools.
Limited availability of qualified vendors has led to an increase in cost, in-house production, and an increased reliance on the remaining vendors.	Continue third party market and vendor assessments and increased investment into the qualification of additional vendors.	Early engagement with design requirements to research potential new qualified sources.

DA-PA = design agency-production agency
KC STEP = Kansas City Short-Term Expansion Plan

3.5 Capabilities-Based Investments

The CBI program manages and executes projects to modernize and sustain equipment, tools, supporting facilities, and infrastructure. CBI addresses enduring, multi-program requirements through discrete, short-duration projects usually lasting from 1 to 3 years. These capital investments sustain or replace core nuclear and non-nuclear enterprise capabilities for weapons assessment, design, production, and certification. Such projects include recapitalization of high risk-of-failure test, measurement, and production equipment. The CBI portfolio reduces programmatic risk to missions across the nuclear security enterprise and ensures needed capabilities are available for stockpile stewardship, sustainment, and modernization, while providing the enterprise with increased agility and flexibility to respond to emerging requirements and mitigate evolving risks.

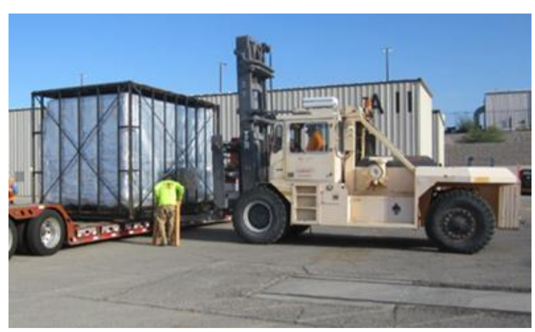
Capabilities-Based Investments Accomplishments

- *Upgraded digitizers for the U1a Complex (U1a) Z-pinch Experimental Underground System Testbed at NNSS.*
- *Established a new capability to certify the Zeus Dense Plasma Focused U1a tritium operations at NNSS.*
- *Provided an enclosure for operating highly sensitive Coordinate Measuring Machines at NNSS.*
- *Replaced the Lujan Target for Los Alamos Neutron Science Center at LANL.*
- *Modernized the Multiplexed Photonic Doppler Velocimetry - Gen 4 used at Dual-Axis Radiographic Hydrodynamic Test at LANL.*
- *Established a debonding capability for Assembly/Disassembly Operations at Y-12.*
- *Installed a new 5-axis ultrasonic mill at Y-12.*

The CBI program funds projects for total replacement of equipment or tools, including minor building modifications required to install and operate new equipment. The projects are predominantly capital acquisition projects, requiring CBI to fully fund equipment and installation costs the first year of execution. CBI funds activities at all eight NNSA sites, and coordinates closely with production operations, science campaigns, other production modernization offices, and additional stakeholders to reduce programmatic gaps and align funding sources.

The Programmatic Recapitalization Working Group was established to better understand current and future equipment needs across the nuclear security enterprise for all aspects of the nuclear weapons mission. This working group includes a combination of participants from the NNSA Office of Defense Programs and Office of Infrastructure, as well as full participation from each of the DOE/NNSA sites. The Programmatic Recapitalization Working Group helps programs assess equipment risks across the enterprise and deconflict planning and programming for activities to address those risks.

Improving experiment capability, Lujan Target



Machining parts that support JASPER and U1a Complex, High-Torque Mill

3.5.1 Status

CBI fulfills equipment capability recapitalization needs that do not fit under any specific program. DOE/NNSA's nuclear security enterprise includes numerous laboratory and production capabilities whose roles are critical to the success of multiple programs, but whose outputs make up a relatively small portion of each program's activities. Historically, programs prioritized equipment investments on specific, near- and mid-term program of record deliverables. In such cases, risks to multi-program capabilities were often overlooked. CBI provides a dedicated program office to address those cross-program risks.

Through the Programmatic Recapitalization Working Group efforts, DOE/NNSA conducts analyses of programmatic capital equipment to identify targets of opportunity for investment to reduce mission and performance risk. For example, as equipment ages through and past its expected useful life, it may pose increased risk of performance degradation and/or failure. **Figure 3–2** depicts the useful life status of enterprise programmatic capital equipment as of September 2022. The specific pieces of equipment and capabilities within the Programmatic Recapitalization Working Group data set also help inform CBI investment decisions.

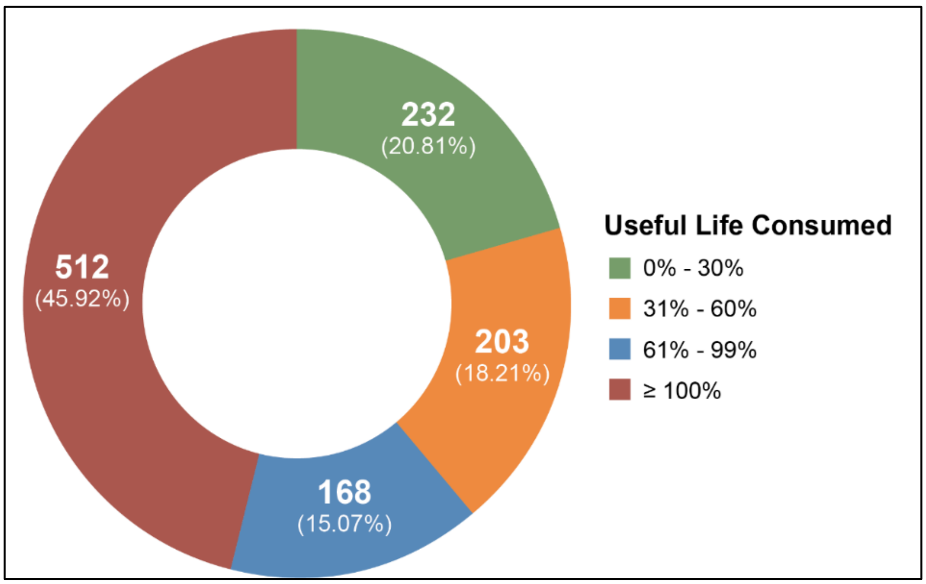


Figure 3–2. Count of equipment by useful life consumed

3.5.2 Challenges and Strategies

Table 3–9 provides a high-level summary of CBI challenges and the strategies to address them.

Table 3–9. Summary of Capabilities-Based Investments challenges and strategies

Challenges	*Strategies*	
	Current Strategy Being Implemented	*Future Strategies Needed*
Limited ability to accurately and precisely forecast equipment failure dates for a diverse collection of technologies used to enable a wide range of capabilities for developing, testing, and producing weapon systems and subsystems.	Emphasize recapitalization of single points of failure, bottlenecks, and equipment no longer supported by vendor base. Recapitalize before equipment begins to fail, to the greatest extent possible.	Develop advanced measures of effectiveness for equipment recapitalization planning to effectively capture and analyze data currently obscured by relatively long feedback loops.

Challenges	Strategies	
	Current Strategy Being Implemented	Future Strategies Needed
Sites have limited internal resources available to execute planned projects, limiting the amount of equipment recapitalization achievable in a single fiscal year.	Coordinate work scope that is challenging yet achievable based on past performance and forecast site capabilities.	Continue to grow capacity of key resources at NNSA sites, including engineering and craft labor.
Unforeseen equipment failures and emerging risks.	Maintain flexibility to adapt equipment replacement priority list by committing to short term projects and through frequent updates coordinated with other Federal program offices.	Evaluate ways to leverage advanced machine diagnostics for more accurate failure forecasts.

Chapter 4
Stockpile Research, Technology, and Engineering

The Stockpile Research, Technology, and Engineering (SRT&E) Program is central to maintaining a credible deterrent and ensuring the safety, security, and effectiveness of the Nation's nuclear stockpile. SRT&E is responsible for research, development, qualification, certification, testing, and evaluation support to stockpile sustainment, stockpile modernization, warhead production, and the future nuclear security enterprise. The program also works to sustain the science, technology, and engineering proficiency of the Department of Energy's National Nuclear Security Administration (DOE/NNSA) workforce for the future and helps maintain the readiness of its infrastructure to support near-term and future workloads. Innovations and development of advanced capabilities in SRT&E are key to a resilient and responsive nuclear security enterprise.

The drivers for SRT&E include (1) sustaining the deployed stockpile; (2) enabling the future nuclear deterrent; (3) assessing and mitigating threats to the deterrent; and (4) developing modern materials, design and manufacturing options, and qualification/ certification techniques for the nuclear security enterprise. The science-based SRT&E Program advances DOE/NNSA's understanding of nuclear weapon functionality through science, technology, and engineering research in the absence of underground nuclear explosive testing.

Key activities—such as advanced modeling and simulation capabilities, subcritical and hydrodynamic experiments, high energy density (HED) physics experiments, focused experiments, and experiments that reproduce the environment U.S. nuclear weapons are expected to encounter—provide the capabilities to support current and future nuclear stockpiles. Enhanced experimental and simulation capabilities are required to recreate, interrogate, and provide data on materials and physics at weapon-like conditions to address these focus

SRT&E Accomplishments

- *Achieved at the National Ignition Facility (NIF) a chain-reaction fusion burn in the laboratory that generated more energy than was used to drive it. This is a milestone not only for the NNSA, but for the United States and our dedication to the pursuit of grand scientific challenges.*
- *Completed eleven hydrodynamic and static experiments at the Dual Axis Radiographic Hydrodynamic Test Facility (DARHT) and the Contained Firing Facility to support SRT&E programs and weapons activities.*
- *Bounded changes in plutonium properties with age using a combination of data from JASPER, Z, diamond anvil cell, and benchtop experiments, with supporting modeling and theory work.*
- *Completed plutonium compressibility experiments on the Z and NIF, including shots to evaluate changes with manufacturing variations and aging.*
- *Used capabilities at the NNSA-supported Dynamic Compression Sector at the Advanced Photon Source at Argonne National Laboratory to measure the dynamic response of materials, with relevance to manufacturing considerations in support of life extension program (LEP) and modification (Mod) activities.*
- *Predicted changes in high-pressure plutonium strength with age using large-scale molecular dynamics simulations on the Sierra supercomputer.*
- *Developed and delivered a method for rapid connector prototyping using advanced manufacturing, reducing connector lead times for development and Test Engineering applications from 6–12 months to 7–14 days at a fraction of the cost.*
- *Completed the Exascale Computing Facility Modernization project ahead of schedule and under budget, upgrading the Livermore Computing Complex to be capable of housing two exascale-class systems simultaneously with 85 MW of power and 28,000 tons of cooling.*

areas. Capabilities developed under SRT&E drive innovation, provide data essential to stockpile modernization and production, and help recruit, train, and retain the next generation of the stockpile workforce.

The SRT&E program continues to pioneer, develop, and deploy capabilities to provide DOE/NNSA with important, high-fidelity data and capabilities to maintain and modernize the stockpile and associated workforce. SRT&E's world-class capabilities provide a hedge against prospective and unanticipated risks, prevent technological surprise, and are critical to enabling technical assessment of the stockpile without underground nuclear explosive testing.

4.1 Strategic Program Goals

The initial Stockpile Stewardship Program established more than 20 years ago to maintain a safe, secure, and reliable nuclear stockpile without underground nuclear explosive testing. The program emphasized experimental science and simulation for existing nuclear explosive packages, namely HED science modeling and simulation (making use of the experimental data), and high-performance computing (HPC) (to run the weapon models in the timeframes and detail needed). This approach has been successfully applied to the future needs of the nuclear security enterprise in warhead component production and timely weapon component design and certification. While the Stockpile Stewardship Program has made great advances in nuclear weapon science, experimental capabilities, technology maturation, engineering, simulation, and computing, challenges remain and grow with an uncertain geopolitical future, enduring and emerging threats, and the aging of the stockpile.

The strategic program goals of SRT&E are still applicable as DOE/NNSA embarks on the next 20 years of Stockpile Stewardship. SRT&E continues to address present needs and prepare for the requirements associated with an uncertain future. SRT&E advances DOE/NNSA's understanding of weapon performance and demonstrates new component and production technologies as viable options for support of the future stockpile. Development of these technologies well before their use in support of the stockpile is required to understand the risks that such use would introduce due to aging, changing legacy processes, and evolving threats. These technologies enable NNSA to adapt its legacy processes to updated workforce and environmental regulations. Moreover, these capabilities add value to the program because they:

- Drive program plans within SRT&E (Section 4.3).
- Align with the 10-year program outlook in the Stewardship Capability Delivery Schedule (Section 4.1.1).
- Provide requirements for new or recapitalized capabilities that will be realized via the Weapons Activities Line-Item Planning (formerly capital acquisition planning) process (Chapter 6, Section 6.2.2).

Looking to the future, SRT&E will continue to develop and implement technologies to address issues facing the nuclear security enterprise. As part of an enterprise-wide strategy, SRT&E will take leadership in:

- Fostering innovation aimed at improving our understanding of the stockpile and serving as the proving grounds for new ideas to meet current and future strategic challenges.
- Applying SRT&E capabilities to enable a more modern and efficient production complex.

SRT&E will employ internal and external outreach, communicate the common vision for the future of the enterprise more effectively, codify strategies and plans, enable appropriate risk-taking, and foster a diverse and skilled workforce.

4.1.1 Stewardship Capability Delivery Schedule

The Stewardship Capability Delivery Schedule aligns SRT&E programs with mission objectives, coordinates efforts across Defense Programs, and serves as a communication framework for internal and external stakeholders. DOE/NNSA and the national security laboratories, plants, and sites use the Stewardship Capability Delivery Schedule to guide experimental and simulation capability development (**Figure 4–1**) in four key areas:

- **Stockpile Sustainment** guides the efforts that support the needs of the current U.S. nuclear stockpile, such as material aging studies and improving warhead system assessment and surveillance with experimental, modeling, and simulation capabilities.
- **Future Deterrent** develops responsive technologies, architectures, and processes designed to address emergent threats, increase agility, improve certification processes, and reduce cycle times for future weapon development.
- **Threat Mitigation** develops and matures technologies and experimental capabilities to simulate, assess, and mitigate combined and emerging reentry and hostile environments that current and future weapons may encounter.
- **Modern Materials and Manufacturing** develops advanced materials and manufacturing of materials and components that are robust to full stockpile-to-target sequence (STS) environments, extend lifetimes, minimize risk of material obsolescence, improve efficiency, and reduce production lifecycle, time, and cost.

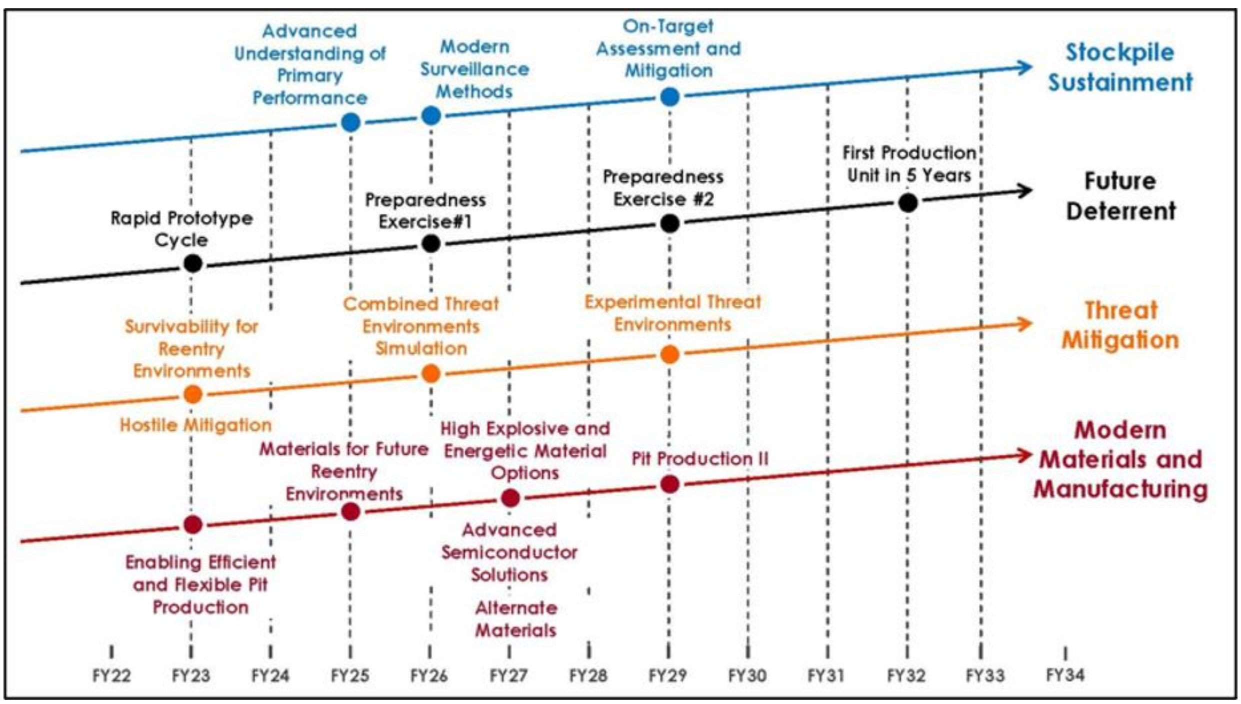


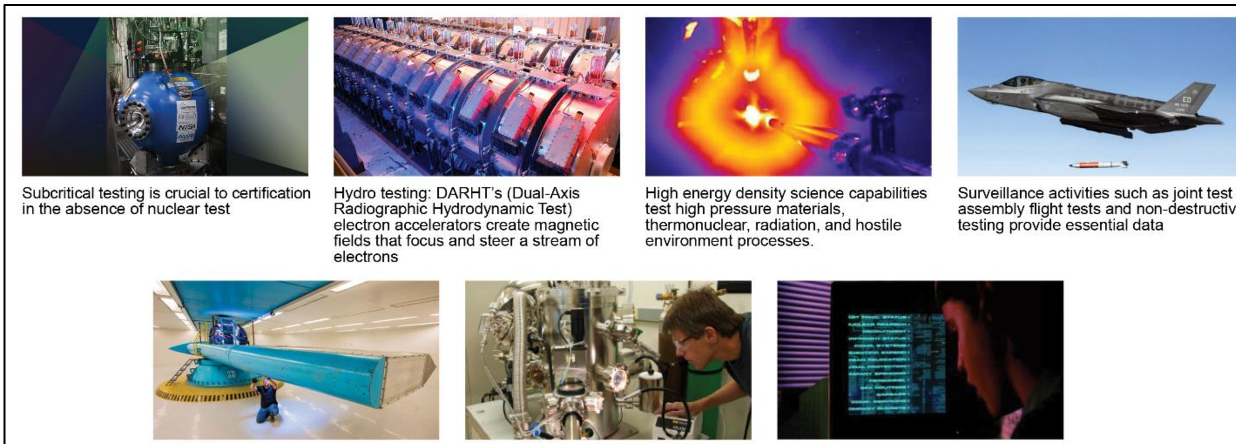
Figure 4–1. Stewardship Capability Delivery Schedule – the four key focus areas needed to address mission delivery

4.2 Enduring Drivers for Stockpile Research, Technology, and Engineering

Responsible stockpile stewardship demands computational, experimental, and testing capabilities, as well as continuous development of a qualified workforce to implement these capabilities. These capabilities are essential for stewardship of the current stockpile and must be enhanced to improve understanding of nuclear weapons performance to support the effectiveness of our nuclear deterrent into the future. Enhancing capabilities to prepare for the future also allows the nuclear security enterprise to remain responsive with an ability to adapt to changing geopolitical environments as needed, as well as attract, train, and retain the requisite stockpile expertise in the workforce.

4.2.1 Sustaining and Assessing the Current Stockpile

Understanding the status of the stockpile is essential to planning for its sustainment. The status of the current stockpile is monitored through continuous, multi-layered assessments of the safety, security, and effectiveness of each U.S. nuclear weapon system. As explained in Section 2.1.2.1, the annual stockpile assessment process evaluates the safety, performance, and reliability of weapons based on physics and engineering analyses, experiments, and computer simulations. Assessments further evaluate the effect of aging on performance and quantify performance thresholds, uncertainties, and margins. These evaluations depend on all available sources of information, including surveillance, non-nuclear hydrodynamic tests, subcritical experiments, HED science, materials evaluation, modeling and simulation, and enhanced surveillance techniques. Continuous assessment involves assembling a body of evidence to assess performance at the part, component, subsystem, and system levels to determine whether all required performance characteristics are met, and relies on new advances in tools, including computational and experimental advances. DOE/NNSA uses expert judgment to combine data, theory, experiment, and simulation, and arrive at conclusions that are underwritten by extensive peer review. SRT&E delivers experimental and modeling tools to evaluate current performance and study uncertainties around those baselines. Some of the many sources of information derived from SRT&E activities are depicted in **Figure 4–2**.



Subcritical testing is crucial to certification in the absence of nuclear test

Hydro testing: DARHT's (Dual-Axis Radiographic Hydrodynamic Test) electron accelerators create magnetic fields that focus and steer a stream of electrons

High energy density science capabilities test high pressure materials, thermonuclear, radiation, and hostile environment processes.

Surveillance activities such as joint test assembly flight tests and non-destructive testing provide essential data

Superfuge, a 29-foot arm centrifuge used for assessment of combined environments

Materials testing and evaluation including methods providing rapid chemical and mechanical analyses.

Testing complements modeling and simulation

Figure 4–2. Weapon assessments rely on many sources of information from Stockpile Research, Technology, and Engineering

Weapons scientists and engineers are crucial to every aspect of the assessment process. The overall assessment philosophy and approach involves quantification of weapon characteristics and a deep understanding of the multi-physics mechanisms driving weapons performance under a variety of conditions. The laboratory teams responsible for each weapon system and its assessment are comprised of scientists and engineers who are deep technical experts in multiple areas relevant to weapons assessments and who review historical and new data. Several mechanisms exist to ensure each national security laboratory has full and complete access to all relevant weapons data to support these assessments. These mechanisms include regular exchanges of electronic documents and databases between sites and several peer-to-peer data-sharing options. In addition, DOE/NNSA sites are consolidating and digitizing historical weapon data to ensure it is available to future weapon designers. The assessments and conclusions in the Annual Assessment Reports are reviewed by independent reviewers, federally mandated Red Teams (i.e., subject matter experts from other national security laboratories who are appointed by their laboratory directors), program managers, senior laboratory management, and the laboratory directors. Specific results related to the stockpile systems are included in the latest *Report on Stockpile Assessments*.

4.2.2 Ensuring the Resiliency of the Future Stockpile

Evolving security environments, as well as the aging of the stockpile, create requirements for LEPs and modern replacements for existing stockpile systems. Ensuring the resiliency of the U.S. nuclear deterrent requires qualification- and certification-ready options, from materials through components to systems, to be matured and available when needed for down-select decisions, development, and production. This "readiness for use" demands advances in design, manufacture, qualification, and certification methodologies, improvements to the responsiveness of the nuclear security enterprise, improved integration with the Department of Defense (DoD), and development of new and emergent capabilities for the qualification and certification processes.

4.2.3 Assessing and Qualifying the Deterrent

SRT&E collaborates with the Stockpile Management Program to steward, advance, and qualify nuclear weapons components, subassemblies, and integrated systems to meet the military characteristics across the STS environment requirements (e.g., normal, abnormal, and hostile environments specified in the STS). These qualification activities are defined in qualification plans and use experimental and modeling/simulation capabilities. Experimental capabilities include flight tests, shock and vibration tests, thermal environment tests, and exposure to various forms of radiation. Modeling and simulation are used to interpolate and extrapolate into regions not addressed by testing and experiments.

4.2.4 Developing Modern Materials and Manufacturing Methods

Thus far, with some notable exceptions, the nuclear security enterprise has continued to rely on legacy infrastructure, materials, and manufacturing methods established decades ago that were geared toward the mass production of weapons components. Robust manufacturing maturation efforts are key to meeting new stockpile and enterprise modernization requirements by developing innovative solutions to reduce schedule, cost, and improve weapons components' reliability over the weapon's lifecycle.

Efforts are underway to improve communication and collaboration between the design and production agencies with investments in tools that allow the sharing of design data. Flexible architectures that enable model-based system engineering approaches should accelerate qualification and certification activities and overall lead to the DOE/NNSA being more responsive.

As new manufacturing technologies are inserted into the production enterprise, qualification of complex components and materials produced will present new challenges. Therefore, the SRT&E Program is developing new inspection technologies, such as in-line metrology, which can help detect defects during manufacturing earlier in the process and on the same machine, potentially reducing manufacturing times and accelerating the acceptance process. In addition, new measurement techniques are being developed and deployed to more fully characterize products to enable predictive assessments of stockpile performance over time.

4.3 Stockpile Research, Technology, and Engineering Elements and Status

The five major elements that enable Stockpile Stewardship are the Assessment Science Program, the Inertial Confinement Fusion (ICF) Ignition and High Yield Program, the Advanced Simulation and Computing (ASC) Program, the Engineering and Integrated Assessments Program, and the Weapon Technology and Manufacturing Maturation (WTMM) Program. These elements are illustrated in **Figure 4–3**.

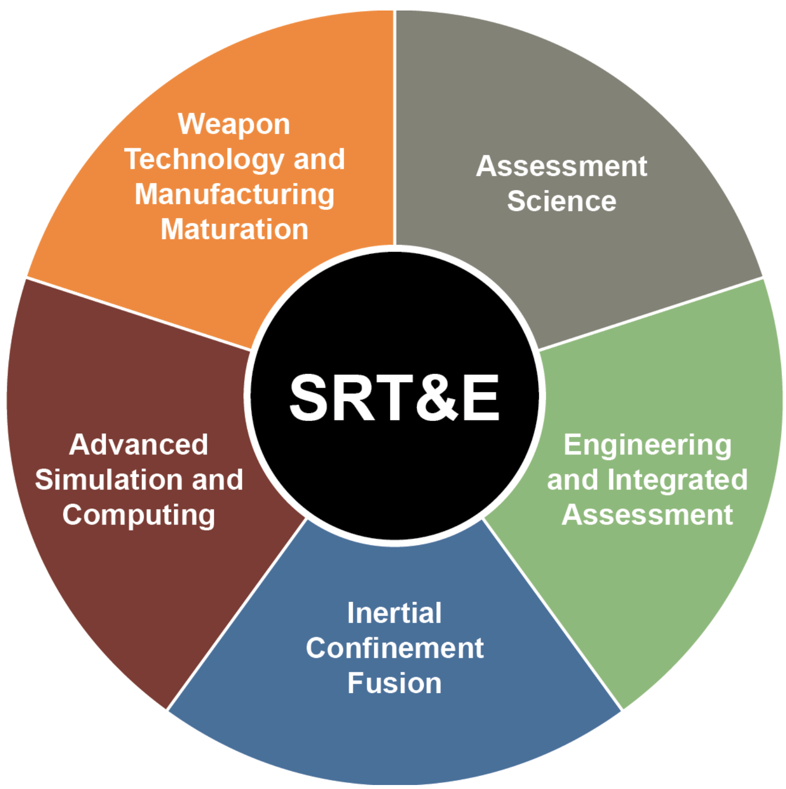


Figure 4–3. Subprograms in Science, Research, Technology, and Engineering

4.3.1 Assessment Science

The Assessment Science Program provides the knowledge and expertise needed to maintain confidence in the nuclear stockpile in the absence of underground nuclear explosive testing, ensuring weapons will perform as required by DoD plans. Capabilities developed and maintained in the Assessment Science Program support the entire nuclear security enterprise by providing (1) the scientific knowledge required to conduct annual assessments of weapon performance and certification of modernization programs; (2) the scientific insight to discern the impacts of surveillance findings to ensure that the nuclear stockpile remains safe, secure, and effective; and (3) the core technical expertise required to respond to technical developments and geopolitical drivers. Assessment Science also facilitates the assessment of current weapon and weapon component lifetimes, the development and qualification of modern materials and manufacturing processes, the exploration of concepts for component reuse, and the development of modern safety concepts for sustainment.

Assessment Science performs experiments to obtain the materials and nuclear data required to validate and understand the physics of nuclear weapons performance. These experiments include hydrodynamic and subcritical experiments to obtain data on the dynamic behavior of plutonium and surrogate materials in integral geometries. Science program experiments and data analyses also facilitate evaluation of safety, security, and sustainment concepts without the need for additional underground nuclear explosive testing. These activities develop, exercise, and strengthen the expertise and competence of the nuclear weapon design, engineering, and assessment community. This collection of weapons-relevant data is acquired using unique, small- and large-scale experimental facilities throughout the DOE nuclear security enterprise. In some cases, Assessment Science also stewards the relevant facilities.

The Assessment Science Program is made up of six subprograms:

Primary Assessment Technologies provides foundational capabilities for annual assessment of stockpile primaries, certification of future modernization programs, improvements in primary safety and security, and resolution of significant finding investigations (SFIs). It also designs and analyzes subcritical experiments that provide essential data to underwrite the performance of the evolving stockpile. This subprogram improves predictive ability by developing common models to quantify uncertainties; supports experimental platforms to validate weapons physics models; incorporates experimental data to improve modeling of boost, plutonium aging, and manufacturing processes; and enables threat-informed design and assessment advances.

Dynamic Materials Properties develops and maintains the experimental capabilities needed to describe and predict the behavior of weapon materials in extreme environments and ensure weapons perform as required by DoD plans. The subprogram provides experimental assessment of special nuclear material (SNM), metals, conventional and insensitive high explosives (HE), polymers, and foams under dynamic conditions. It furthers understanding of how fundamental material behavior affects nuclear weapon performance. The subprogram advances understanding of how plutonium aging and different plutonium and HE manufacturing methods impact weapon performance. It also maintains and expands capabilities to access pressure, temperature, and strain rate regimes of interest, and advances characterization methodologies of these high-interest materials, leading to reduced uncertainties in performance models.

Advanced Diagnostics establishes next-generation tools for delivering stockpile data by developing revolutionary diagnostics, novel methodologies, and advanced drivers for future hydrodynamic, subcritical, and other dynamic experiments. It matures leading-edge driver technologies that can create and diagnose dynamic experimental conditions relevant to the stockpile. It also advances innovative data analysis techniques that enhance and expand the results of dynamic experiments.

Secondary Assessment Technologies provides capabilities that assure confidence in the assessment of secondaries. This is achieved by using experimental results to validate and improve weapons physics models and to evaluate new manufacturing processes, replacement materials, and aged materials in the stockpile. This subprogram supports the prioritized development, design, and execution of experiments to qualify experimental platforms designed to meet the needs of current and future modernization programs, as well as modern investigation of historical underground test data. Through this work, Secondary Assessment Technologies provides foundational capabilities for conducting an annual assessment of the current stockpile, certifying future modernization programs, and resolving SFIs.

Hydrodynamic and Subcritical Experiment Execution Support provides the services required to maintain a robust integrated weapon testing capability that supplies critical data to weapon physicists and design engineers. This subprogram enables execution of prioritized experiments through the *National Hydrodynamic Test Plan* and the *National Subcritical Experiments Plan* to deliver critical data in support of modernization programs, stockpile maintenance, experimental science, and global security. The subprogram enables assessments of potential impacts on weapon performance and safety due to design changes, material substitutions, or component changes associated with LEPs, alterations, or modifications.

Enhanced Capabilities for Subcritical Experiments (ECSE) establishes two new underground test beds outfitted with modern diagnostics capabilities that will evaluate the response of plutonium to aging and changes in manufacturing techniques, materials, and design. Plutonium data obtained from planned subcritical experiments in the ECSE test beds will enable design certification of nuclear systems without the need for explosive nuclear testing. For example, ECSE data from will help underwrite certification of the W87-1 Modification Program. A major capital investment element of ECSE is the Advanced Sources and Detectors “Scorpius” accelerator; the U1a Complex (U1a) Enhancements Project line item is preparing the underground U1a to receive this equipment.

4.3.1.1 Status

The Assessment Science Program is executing four major initiatives to advance our understanding of weapons physics and improve the capabilities that DOE/NNSA leverages to execute its assessment, certification, and qualification missions. The first major initiative is the completion of the Enhanced Capabilities for Subcritical Experiments capital acquisition program that will be at the center of DOE/NNSA’s modernization programs for the next three decades. This initiative includes investing in the workforce and manufacturing needed to support the expected three-fold increase in experimental cadence over the coming decade from the traditional, one subcritical experiment per year. The second major initiative is the execution of focused experiments that advance the physics and engineering models used in weapons simulations. The highest priority of these is the execution of the congressionally requested *Plutonium Aging Plan* to inform future assessments of pit lifetimes and eventually enduring pit production requirements. The third major initiative is a concentrated effort to execute experiments in support of NNSA’s Production Agency. These experiments are required to implement new, more efficient manufacturing techniques as part of the nuclear security enterprise’s extensive production modernization efforts. The fourth and final initiative is the development of an integrated plan to revitalize our experimental science base in accordance with the *Enhanced Mission Delivery Initiative* report. In coordination with data customers, Assessment Science has embarked on a plan for maintenance and recapitalization of experimental infrastructure, covering everything from light laboratory and general experimental infrastructure to major new science and engineering capabilities and facilities.

4.3.1.2 Challenges and Strategies

Table 4–1 provides a high-level summary of Assessment Science challenges and the strategies to address them.

Table 4–1. Summary of Assessment Science challenges and strategies

Challenges	***Strategies***	
	Current Strategy Being Implemented	***Future Strategies Needed***
Enable delivery and sustainment of future weapon systems.	Achieve a robust understanding of weapons' physics, including boost; radiation transport; hydrodynamics; plasma, nuclear, and material properties; and platform and diagnostics development supported by a full range of experiments. Conduct subcritical experiments to inform modernization program decisions, assess aging effects, improve safety, provide needed data on the hydrodynamics of implosions, and underwrite stockpile performance. Understand the effects of aging (in particular, aging plutonium) on weapon performance through execution of the 10-year Plutonium Aging Research Program Plan, studies on aging, canned subassemblies, and evaluations of new materials and processes through Production Science partnerships on plutonium, uranium, HE, and non-nuclear materials. Deliver data on materials properties at high-pressure, weapon-relevant regimes to understand how the manufacturing process and the resulting material structure and properties affect performance, safety, reliability, ang aging to enable new technologies and appropriate material tolerances to increase efficiency of production.	Conduct experiments and analyses to resolve principal remaining uncertainties, improve predictive capability, and expand the certification envelope for future weapon systems. Enhance efficiencies in experimental operations to reduce fielding time and the number of experiments required for assessment and certification. Establish domestic and global partnerships to leverage strategic scientific investments to realize capabilities.
Provide capabilities to support stockpile assessments, modernization options, and surety decisions	Deliver world-class experimental capabilities to support hydrodynamic testing, dynamic plutonium experiments including subcritical experiments, nuclear science, materials' characterization, and HED physics.	Invest in a core suite of flexible experimental capabilities that enable access to weapons-relevant environments at a variety of scales, from small, focused experiments to large integrated experiments that provide weapon designers with the capabilities required to respond to a rapidly evolving threat environment.
Meet the future stockpile need for science-informed analysis and evaluation of systems, processes, and threats.	Invest in production-oriented R&D test beds to accelerate evaluation of cutting-edge technologies for the production mission.	Deliver certification-ready options for LEPs and the future stockpile to inform down-select decisions. Enable assessment and certification of these options via a sufficient range of experiments. Increase coordination with other Government stakeholders to consider how potential new technologies would affect strategic deterrence.

HE = high explosive
HED = high energy density
LEPs = life extension programs
R&D = research and development

4.3.2 Engineering and Integrated Assessments

The Engineering and Integrated Assessments Program is responsible for developing modeling, simulation, and experimental capabilities to evaluate weapon technologies in present and future STS and ensuring a responsive nuclear deterrent through collaborative partnerships, proactive integration, and assessments. This program supports four key mission areas: (1) strengthening the science, technology, and engineering base by maturing advanced technologies to improve future weapon systems; (2) providing tools for qualifying weapon components and certifying weapons without underground nuclear explosive testing; (3) supporting annual stockpile assessments through improved weapons surveillance technologies and warhead component and materials aging assessments; and (4) providing capabilities that accelerate the nuclear weapons acquisition process and strengthen the United States' ability to respond to unexpected developments that could threaten nuclear security.

The Engineering and Integrated Assessments Program is made up of seven subprograms:

Archiving and Support preserves and maintains historic knowledge, records, and data related to U.S. nuclear weapons testing and Stockpile Stewardship and provides targeted studies, multi-system assessments, and independent reviews that support the annual assessment of the stockpile.

Delivery Environments supports experimental and modeling capabilities, diagnostics, and data used to evaluate system survivability through normal and abnormal environments in current and future STS.

Weapons Survivability builds the advanced tools, models, and experimental platforms needed to ensure U.S. weapons will survive and operate as intended through all hostile environments.

Studies and Assessments supports pre-Phase 1/6.1 assessments, studies, and other activities; and conducts program technical, cost, and feasibility assessments. These assessments inform Nuclear Weapons Council decision-makers of the strategic impacts of the pursuit of various nuclear security enterprise and weapon capabilities in coordination with U.S. Strategic Command and the Military Services.

Aging and Lifetimes supports research and development (R&D) to understand and mitigate the impacts of aging on materials and components in the stockpile, and develops diagnostics used to assess age-induced impacts on weapon systems.

Stockpile Responsiveness sustains, enhances, and exercises innovative techniques and capabilities required to conceptualize, study, design, develop, engineer, certify, produce, and deploy nuclear weapons. These efforts do not include the actual production or deployment of a stockpile weapon system, nor do they engage in the acquisition of nuclear weapons for the U.S. stockpile.

Advanced Certification and Qualification ensures the feasibility of certification or qualification paths for stockpile systems and new components in the absence of additional underground nuclear explosive testing. This is achieved by integrating computing, science, technology, and engineering advancements to facilitate certification of future life extensions and other warhead needs.

4.3.2.1 Status

The tools, technologies, methods, and data developed within the Engineering and Integrated Assessments Program ensure the viability and success of ongoing modernization programs and the rapid certification and qualification of future weapon systems. Success depends on diverse, highly qualified staff throughout the complex; close coordination and cooperation between weapon designers, weapon engineers and production agencies; partnerships with ongoing modernization and surveillance programs; and close coordination with the programmatic and technical efforts ongoing throughout the SRT&E portfolio.

The program routinely reviews historical records and data to understand how new weapon designs will depart from their tested configuration. Without underground nuclear explosive testing, indexing and digitizing existing records is an important task to certification. In concert, the program continues to expand experimental and diagnostic capabilities to collect data that inform models being developed for lifetime predictions and ensure the survivability of weapon systems.

To ensure the success of new acquisition programs and reduce the associated time and cost, the Engineering and Integrated Assessments Program is developing methodologies, computational tools, and technology development capabilities to advance the technical readiness and manufacturability of weapon systems and components. These include ground and flight-testing capabilities; tools to improve combined environment testing; facilities to evaluate hostile radiation exposures; quantification of uncertainties for engineering models; digital design; engineering and manufacturing tools; embedded sensing; and diagnostics.

4.3.2.2 Challenges and Strategies

Table 4–2 provides a high-level summary of Engineering and Integrated Assessments challenges and the strategies to address them.

Table 4–2. Summary of Engineering and Integrated Assessments challenges and strategies

	Strategies	
Challenges	***Current Strategy Being Implemented***	***Future Strategies Needed***
Ensuring weapon survivability in a dynamic worldwide nuclear environment	Investing in improvements to sustain current radiation environment testing (e.g., ACRR sustainment and Saturn refurbishment).	Additional combined environments testing and simulation capabilities prioritized.
Anticipating the future needs of the enterprise	Accelerating technology design and deployment process: the Agile Processes and Technologies initiative was developed for a rapid clean-sheet design to prototype, including DA-PAs working together to streamline the development. Engaging with current advisory panels and DoD partners	Recurring engagements and workshops focused on future need; additional emphasis on pre-phase 1 efforts; and approaches to enhance nuclear deterrence.
The highest fidelity aging experiments often take years to complete.	Providing tools and diagnostics to assess the aging and lifetime of the current stockpile, understanding age-related phenomena, and advancing age-aware models.	Use results of targeted experiments to inform bounds and validate models. Invest, implement, and maintain multifactor testing and analyses rooted in a strong foundation that enable optimized accelerated aging.
Making the most of legacy data through digital preservation and accessibility of pre-computer era nuclear testing data	Rapid digitization laboratories continue to be established to process physical media. A specialized workforce in filmography, history, library sciences, and archiving is being recruited.	AI/ML tools required for metadata tagging and database linkage.
Storing and connecting current data streams for future use	Build a Knowledge Management framework to assure critical knowledge capture, search, and retrieval using AI/ML.	Enterprise-wide integration of data and resources needed for stockpile modernization.
Having flexibility to rapidly adapt to changing threat environments	The Stockpile Responsiveness Program explores disrupting technologies and processes.	Apply innovative approaches to programs of record.
Certification of stockpile warheads in post-underground nuclear explosive testing era	Expand understanding of margins and uncertainties; revisit archived information from underutilized underground test data; use results of AGEX experiments to inform models.	Use AI/ML driven analysis to uncover new causal relationships in existing test data.

ACRR = Annual Core Research Reactor
AI/ML = Artificial Intelligence/Machine Learning
DA-PA = design agency-production agency
AGEX = above ground experiments

4.3.3 Inertial Confinement Fusion

The ICF Program studies the effects of the extreme conditions produced inside a detonating nuclear weapon. Its twofold mission is to meet immediate and emerging needs for HED data on materials and properties under HED conditions to support the present deterrent and to advance the R&D capabilities necessary to meet those needs for the deterrent of the future. The ICF Program enables access to and data delivery from the HED regime through (1) the design and execution of complex physics experiments to improve fundamental and integrated understanding of properties and processes in the HED regime; (2) the development of instrumentation to diagnose physics phenomena at the extreme temperature, pressure, and density conditions relevant to nuclear weapons performance; and (3) the development, operation, and sustainment of experimental facilities capable of reaching those conditions.

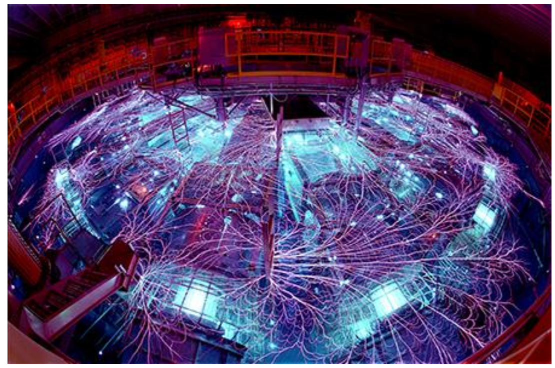
The ICF Program leverages its experimental design expertise, computational modeling capabilities, diagnostic technology, target engineering and fabrication infrastructure, and national HED facilities to ensure high-fidelity experimental capabilities and data are available to support a range of DOE/NNSA missions. Its capabilities are used by program partners to assess the existing stockpile, inform design decisions for current LEPs, investigate hostile nuclear environments, and support DoD research.

The ICF Program supports DOE/NNSA's long-term R&D mission by developing the knowledge and capabilities necessary to reach controlled thermonuclear fusion in the laboratory. Developing a robust burning plasma[1] platform and eventually producing high fusion yield[2] opens the door to a range of important weapons physics that has been unreachable since the end of underground nuclear explosive testing, with significant knowledge and capability development at each step along the path from burning plasma to ignition and high yield. Not only does the ICF Program attract, train, and challenge some of the Nation's best physicists and engineers, it also represents an important component of DOE/NNSA's preparation to meet the stockpile science challenges of the 2030s and beyond. The ICF Program consists of three subprograms.

HED and Ignition Science for Stockpile Applications supports R&D in HED physics and maintains global preeminence in HED science by identifying, maturing, and delivering next-generation tools and experimental platforms to enable weapons science studies. By supporting data delivery and advanced platform development to meet future needs, this area supports nuclear survivability work and certification and qualification activities in Assessment Science in partnership with the ASC Program. It pursues thermonuclear fusion and eventual high yield to provide access to weapons phenomena and energy densities that have been inaccessible since the cessation of underground nuclear explosive testing. The subprogram develops expertise and tools for partner programs to experimentally measure dynamic material properties; fluid and plasma hydrodynamics, hydrodynamic instability-induced mix, burn, boost; and radiation transport. It produces unique environments relevant to nuclear weapon outputs and hostile radiation conditions.

[1] A burning plasma is one in which most of the plasma heating comes from fusion reactions involving thermal plasma ions. A plasma enters what scientists call the *burning plasma regime* when the self-heating power exceeds any external heating (DOE Office of Science website).

[2] High fusion yield is a release of fusion energy in excess of 200 megajoules (MJ) from an ICF target. This is two orders of magnitude greater than today's best performing experiments.



Sandia National Laboratories' (SNL) pulsed power facility provides experimental data that support weapons designers in creating effective models without underground nuclear explosive testing

ICF Diagnostics and Instrumentation establishes new diagnostics capabilities and experimental support systems for use at the three national HED facilities—NIF, the Omega Laser Facility, and the Z pulsed power facility (Z) to execute experiments studying matter under extreme HED conditions. It develops and deploys transformational diagnostics using specialized technologies necessary for acquiring high-fidelity data during HED experiments. It also leverages diagnostic advancements from NIF, engineering them to enhance capabilities within the Z environment. Diagnostics are often coordinated with Assessment Science to meet priority data requirements.

ICF Facility Operations operates and maintains national flagship HED facilities and conducts R&D for long-term sustainment of facilities and capabilities. Sustainment of NIF and Z is essential to maintain capabilities for stockpile assessment, and demand for HED experiments for modernization programs is increasing.

4.3.3.1 Status

ICF remains a critical scientific pursuit of the Stockpile Stewardship Program. In December 2022, the ICF Program achieved a historic milestone when a deuterium and tritium-filled capsule ignited at the NIF, generating more fusion energy out (3.15 megajoules [MJ]) than laser energy used to drive the experiment (2.05 MJ). Secretary of Energy Jennifer M. Granholm hailed this milestone as a "landmark achievement" and reaffirmed the Department's commitment to supporting this world-class scientific effort to both combat climate change and maintain the nuclear deterrent without underground nuclear explosive testing. Confident in its ability to advance the understanding of the physics of thermonuclear burn, the ICF Program has defined goals to accelerate progress toward a robust fusion platform for Stockpile Stewardship Program experiments and is investigating the fundamental scientific questions that govern the HED processes in ICF capsules and nuclear weapons. These goals also support development of the technologies required for future pulsed-power and laser-driven ICF facilities. Such investments are necessary to go beyond the recent scientific breakthrough of achieving ignition and realize the goal of generating high-yield (200+ MJ) experimental capabilities in the laboratory. A true high-yield platform would provide a scientific capability unique in the world and allow the investigation of weapons physics regimes that have been out of reach since the end of the underground nuclear explosive testing era, realizing the full potential of ICF for nuclear modernization, assessment, and survivability missions.

4.3.3.2 Challenges and Strategies

Table 4–3 provides a high-level summary of ICF challenges and the strategies to address them.

Table 4–3. Summary of Inertial Confinement Fusion challenges and strategies

Challenges	*Strategies*	
	Current Strategy Being Implemented	*Future Strategies Needed*
Understand the fundamental physical phenomena that govern the HED processes in ICF capsules and nuclear weapons.	Execute experiments targeting key aspects of material properties and complex hydrodynamic flows in the HED regime using novel diagnostics to acquire data that benchmarks our models of the interactions between radiation and materials. Use HED facilities to provide precision data at regimes that were previously only accessible by theory or models to enable future assessments and certification of device performance in the absence of underground nuclear explosive tests. Coordinate as appropriate with Assessment Science and provide timely access to experimental data.	Develop and pursue an integrated investment strategy to sustain existing HED capabilities and provide ongoing and timely access to experimental HED needs by the program of record.
Accelerate progress toward a robust fusion platform for Stockpile Stewardship Program experiments.	Develop an ignition platform to achieve controlled thermonuclear fusion in the laboratory that accesses a range of important weapons physics phenomena that have been unreachable since the end of underground nuclear explosive testing to enable new design and certification capabilities.	Generate the full range of nuclear weapon environments within experimental facilities via sustainment and development of existing Office of Experimental Sciences facilities to reach the critical portions of the weapons physics parameter space, investment in next-generation facilities to reach weapons physics regimes beyond current capabilities, and development of novel facility instrumentation and advanced diagnostics to measure within these regimes with high fidelity.
Access energy and density regimes required to support work on future systems.	Pioneer new experimental platforms, diagnostic technologies, and data science and analytical tools to meet emerging assessment needs by making new and higher fidelity data available in HED regimes of interest. Provide intense X-ray and neutron sources that can be used to support the design and qualification of components of U.S. systems in partnership with the Assessment Science and ASC Programs to meet nuclear survivability requirements.	Develop new driver technologies and facility capabilities to provide access to energy densities necessary for emerging radiation effects and assessment science needs. Develop HED capabilities to address potential changes in STS environments (i.e., outputs and effects, thermal and mechanical environments), including development of experimental capabilities required for assessments, with increasingly more realistic source environments.

ASC = Advanced Simulation and Computing
HED = high energy density
ICF = Inertial Confinement Fusion
STS = stockpile-to-target sequence

4.3.4 Advanced Simulation and Computing

The ASC Program provides high-end simulation capabilities (e.g., modeling codes, computing platforms, and supporting infrastructure) to meet the requirements of the Stockpile Stewardship Program. Modeling the complexity of nuclear weapons systems is essential to maintaining confidence in the performance of our stockpile without underground nuclear explosive testing. The ASC Program develops the weapon codes that provide the integrated assessment capability supporting annual assessment and future qualification and certification needs for the stockpile. ASC is integral to the execution of the Stewardship

Capability Delivery Schedule and provides critical capabilities that help inform decision-making related to the sustainment of the nuclear stockpile in support of U.S. national security objectives. The program also coordinates within NNSA and with other government agencies, including the intelligence community, to support nonproliferation, emergency response, nuclear forensics, adversary capability assessments, and attribution activities.

The ASC simulation capabilities are the key integrating mechanism across the nuclear weapons program through the integrated design codes (IDCs), which contain mathematical descriptions of the physical processes of nuclear weapons systems and functions. Combined with weapon-specific data, these IDCs support high-fidelity, physical models used to carry out design studies, maintenance analyses, annual assessment reports, sustainment programs, SFIs, and weapons dismantlement activities, all without additional underground nuclear explosive testing. The IDCs currently perform well for general mission-related activities. However, issues such as aging, potential new threats, and new manufacturing techniques require IDCs with new, enhanced-fidelity physical models that use HPC resources more effectively. For the past 28 years, ASC capabilities that support the stockpile stewardship mission were built on the relatively stable, commercially available computing technologies and associated programming models. To provide increased computing power for both ASC and general consumer markets, the computing industry has evolved to more specialized accelerator-based hardware designs that provide large potential performance gain. However, that can require codes to be modified or even completely rewritten. ASC must stay current with, and continue to influence, the computing industry to ensure continued performance of the IDCs on the next-generation compute platforms, as required to maintain a credible nuclear deterrent and address potential additional mission needs in non-proliferation, emergency response, nuclear forensics, and attribution programs. ASC also develops weapons science (single-physics) codes and makes significant use of those codes to underwrite model development and to deliver key physical data. Therefore, ASC continues to invest in the portability and improved performance of its IDCs to run on next-generation computing platforms. The ASC program consists of five subprograms:

Integrated Codes subprogram produces and maintains large-scale IDCs that allow the performance of detailed nuclear weapons assessments without the need for additional underground nuclear explosive testing. IDCs and science codes are used for physics and engineering stockpile assessments to support concept studies, certification, maintenance analyses, LEPs, alterations, SFIs, and weapons dismantlement activities. The IDCs represents a repository of knowledge gained from experiments on DOE/NNSA's wide range of facilities, legacy nuclear explosive tests, and enhancements made to support the Stockpile Management Program. These codes enable nuclear forensics, assessments of foreign capabilities, and device disablement techniques related to nuclear counter-terrorism efforts and the study of nuclear weapons behavior in normal, abnormal, and hostile environments.

The Integrated Codes subprogram also maintains select legacy codes and is responsible for ancillary tools that support the weapons mission. These specialized codes enable simulation workflow, generate models or information used by the IDCs, and validate the IDCs by comparison with experimental data obtained from facilities, such as Z and NIF. In this way, the Integrated Codes subprogram serves as an integrating tool for activities across SRT&E.

Physics and Engineering Models subprogram develops and provides the models and databases used in simulations supporting the U.S. stockpile. These models and databases describe a wide variety of physical, engineering, and manufacturing processes occurring in a nuclear weapon lifecycle, such as equation of state (EOS) tables of critical materials such as plutonium, uranium, and various HE formulations. The capability to accurately simulate these processes is required for annual assessment; design, qualification, and certification of warheads; resolution of SFIs; and development and evaluation of future stockpile technologies. The Physics and Engineering Models subprogram is closely linked to the Assessment Science

Program within the SRT&E, which provides the experimental data that informs development of new models used in simulation codes.

Verification and Validation subprogram provides evidence that the models in the codes produce mathematically credible answers that reflect physical reality. The verification and validation subprogram focuses on establishing soundness in integrated simulation capabilities by collecting evidence that the numerical methods and simulation models are being solved correctly and establishing that the simulation results from mathematical and computational models implemented into the codes are in alignment with real-world observations. The verification and validation subprogram funds the critical skills needed to systematically measure, document, and demonstrate that the models and codes predict physical behavior.

The Verification and Validation subprogram bridges the Integrated Codes and Physics and Engineering Models subprograms together with other SRT&E activities to evaluate the capability and accuracy of the IDCs. Verification activities demonstrate that the codes and models are correctly solving their respective governing equations. Validation activities ensure that both science codes and IDCs are solving the equations accurately, and that the models themselves are sufficiently precise for the intended application. Together, these subprogram activities provide a technically rigorous, credible, and sensible foundation for computational science and engineering calculations by developing, exercising, and implementing tools that provide confidence in the simulations of high-consequence nuclear stockpile problems.

Computational Systems and Software Environment subprogram builds a portfolio of integrated, balanced, and scalable computational capabilities to provide the needed computing environment to protect DOE/NNSA's investment in IDCs. In addition to the Commodity Technology and Advanced Technology systems that the program fields, the supporting software infrastructure deployed on these platforms includes many critical components, ranging from system software to input/output services, storage and networking, post-processing (visualization and data analysis tools), and next-generation computing technologies. The Computational Systems and Software Environment subprogram also examines possible future technologies beyond exascale, such as quantum, neuromorphic, and non-complementary metal-oxide-semiconductor based computing techniques.

Facility Operations and User Support subprogram provides and manages the facilities and services required to provide nuclear weapons simulation, including physical space, power, cooling, and other utility infrastructure; local area/wide area networking for local and remote access; system administration; cybersecurity; and operations services. The subprogram also provides computer center hotline and help desk services, account management, web-based system documentation, system status information tools, user training, trouble-ticketing systems, common computing environment, and application analyst support.

4.3.4.1 Status

With the conclusion of the ASC Advanced Technology Development and Mitigation (ATDM) subprogram at the end of fiscal year (FY) 2023, all next-generation code development, production readiness, user engagement, and next generation hardware and software development activities will continue to mature within the Integrated Codes and Computational Systems and Software Environment subprograms.

The ASC program is also advancing several internal initiatives, or special projects, to leverage developing technologies and capabilities to support the sustainment of the nuclear stockpile. The Large-Scale Calculations Initiative was initiated to determine the limitations and scaling potential of our current assessment capabilities. It assesses what is achievable with current ASC platforms, codes, and qualified personnel, along with what cannot be achieved with those capabilities. "Large-scale calculations," as defined by this initiative, are impractical to perform on available capacity computing platforms due to size, run length, or a combination of the two. The initiative directs the national security laboratories to look beyond current computing abilities and ask how calculations on this scale enhance delivery of our mission.

HPC platforms are also evolving in response to the computer industry's movement toward heterogeneous computing, in which accelerators such as graphics processing units, are combined with traditional central processing units to increase computing capacity. Recognizing the challenge that this evolution presents to use of current IDCs, DOE/NNSA has developed next-generation application codes, which contain new capabilities in numerical methods, software technologies, and programming models to optimize the use of these emerging HPC technologies. The ASC program continues this work in preparation for DOE/NNSA's first exascale system, El Capitan, to be deployed at Lawrence Livermore National Laboratory (LLNL) by end of FY 2024. DOE/NNSA continues to collaborate with the U.S. computer industry to manage the expected effects of technological disruptions while continuing to deliver productive compute cycles for Defense Programs mission workloads.

In addition to using heterogeneous architectures, the computing industry has evolved new technology paradigms that are more energy efficient and has developed artificial intelligence/machine learning (AI/ML) capabilities and infrastructure that greatly magnify the capabilities of traditional high-performance, physics-based simulation. In response, the ASC program has introduced an Advanced Machine Learning Initiative to expand the use of AI/ML capabilities to better manage complexity in physics-informed simulations. This initiative will significantly increase efficiency, improve models to better match experimental data, and tighten the integration of multi-scale and multi-dimensional models, while addressing concerns with validation of these techniques and improving understanding of when new errors are introduced. Finally, the ASC Program is driving efficiencies into the manufacturing process through the new Production Simulation Initiative. Efforts such as the Simulation First initiative, or "SimFirst," incorporate physics-based simulation into production operations to optimize solutions prior to full-scale manufacture.

As the fidelity of the simulation codes increase, especially those with three-dimensional features, run times to reach solution increase dramatically. This presents an increasing challenge in providing timely support for mission and experimental needs. To address this challenge, DOE/NNSA continues to follow its clearly defined strategy of re-capitalizing its HPC infrastructure at regular intervals; however, evolution of these platforms creates increased demand on supporting infrastructure. Power, cooling, and mechanical requirements have grown dramatically with the introduction of exascale computing and are being addressed through minor construction projects and construction line items. The Exascale Computing Facility Modernization project was completed in FY 2022 to upgrade the LLNL HPC facility to 85 megawatt of power and 2,000 tons of cooling. The nuclear security enterprise will continue to manage and coordinate code development and facility upgrades with HPC system acquisitions to provide the necessary modeling and simulation services in support of DOE/NNSA stockpile stewardship management and production missions.

4.3.4.2 Challenges and Strategies for Advanced Simulation and Computing Program

Table 4–4 provides a high-level summary of ASC challenges and the strategies to address them.

Table 4–4. Summary of Advanced Simulation and Computing challenges and strategies

	Strategies	
Challenges	***Current Strategy Being Implemented***	***Future Strategies Needed***
New physics, engineering, and materials applications are needed to support the evolving stockpile.	Work with the Stockpile Management, Assessment Science, Engineering and Integrated Assessments, and Weapons Technology and Manufacturing Maturation programs to understand the physics of these changes, establish requirements, and continue to improve modeling.	Higher-fidelity modeling of nuclear and non-nuclear components will be needed to address interactions in new cross-domain environments.
The evolving threat space requires new ways for weapons to be certified.	Coordinate through the *Nuclear Posture Review* implementation to understand the new needs for threat response and to respond with credible simulation capabilities.	Modeling of combined threats, including those identified in coordination with *Nuclear Posture Review* implementation.
Next generation code adoption by the Stockpile Modernization and Production programs and the ability to mechanistically simulate the material response of weapons effects, aging, and changes to production and manufacturing.	Develop and implement a broader range of tools for rapid design, evaluation, and qualification of new materials. Develop models and databases in conjunction with experiments to improve the performance, reliability, and safety of weapons. Adapt weapon science codes to the most advanced computing architectures to reach time and spatial scales of greatest interest. Ensure performance of IDCs and supporting codes on increasingly powerful platforms to allow quicker time-to-solution for applications of simulation enhancements.	Apply agile approaches to code development, increasing the rate of new capability development. Engage Defense Programs mission programs early and often to fold their requirements into design and development of new code features. Place a high priority on code usability and user experience.
Performing rapid evaluations of new materials and modeling additive manufacturing techniques.	Continue current efforts to model additive manufacturing processes and couple these with molecular dynamics and mesoscale modeling to enhance their use. Develop machine-learned techniques that can capture these effects efficiently for routine use in part-scale simulations	Develop and mature production simulation capabilities with built-in capabilities to provide quantitative risk assessment.
Maintaining current IDC operations to deliver on near-term needs, while preparing the IDCs for future computing architectures	Optimize current codes for advanced technology hardware. Develop programming model abstractions that allow architecture-specific programming to be insulated from the code developer	Evolve HPC tools for next-generation IDCs to achieve sophisticated programming models, software designs, and numerical algorithms.
Respond to more specialized hardware designs from industry to avoid large code modifications or mitigate the need for wholesale rewrites.	ASC must stay current with, and continue to influence, the computing industry to ensure continued performance of the IDCs on the next-generation compute platforms.	None needed.
More complex facility and infrastructure needs (power and cooling) to support exascale platforms.	Continue to execute the ASC strategy. Continually survey HPC vendors' facility requirements, identify gaps, and proceed with modernization or new infrastructure solutions to meet HPC utility demands.	None needed.

ASC = Advanced Simulation and Computing
HPC = high-performance computing
IDC = integrated design code

4.3.5 Weapon Technology and Manufacturing Maturation

The WTMM Program is responsible for developing agile, affordable, assured, and responsive technologies and capabilities for nuclear stockpile sustainment and modernization.

Primary responsibilities of this program include:

- Developing innovative technologies that minimize the probability of unauthorized use and meet reliability requirements.
- Leading technology and system demonstration efforts, with various mission partners, to speed development, improve acceptance of advanced technologies and processes into the stockpile, develop system integration technical basis, and reduce risk for future programs of record.
- Improving agility, effectiveness, safety, and efficiency in the design and manufacture of war reserve components using advanced technologies and manufacturing processes.

Direct Ink Write (DIW) silicone pad and cushion technology is a polymer Additive Manufacturing technique jointly developed by LLNL, SNL, and the Kansas City National Security Campus (KCNSC). DIW is a digital process and is one of the advanced manufacturing technologies pushing the nuclear security enterprise into the digital manufacturing realm. Technology development has progressed from multiple Plant Directed Research and Development funded projects at KCNSC to the establishment of a highly innovative Polymer Production Enclave with parallel, nearly identical capabilities at LLNL and KCSNC focused on DIW technology. The Enclave is expected to speed the transition from manufacturing to production and the enclave model is expected to be used with other technologies in the future. The use of DIW on modernization programs is a high priority at both LLNL and KCNSC because the technology enables performance that would cost hundreds of millions of dollars and could not be achieved within the time frame to support the programs if attempted with any other approach.

The WTMM Program comprises three subprograms, whose elements are described below.

Surety Technologies Program is dedicated to simultaneously minimizing the probability of unauthorized use and maximizing the reliability of authorized use of a U.S. nuclear weapon while maintaining the highest levels of safety. Surety Technologies creates, develops, and matures advanced safety, security, and use-control or denial technologies to minimize the probability of an accidental nuclear explosion, and in the unlikely event that security fails and unauthorized access is gained, reduces the risk of an unauthorized nuclear yield to the lowest practical level.

Weapon Technology Development is responsible for developing technology options that are responsive to changing global security environments and for activities that reduce risk and increase the likelihood of insertion of those technologies into the stockpile. The focus of Weapon Technology Development is to improve existing capabilities, provide solutions for addressing capability gaps and shortfalls, evolve capabilities to meet emerging threats and changing policy, and use improved technologies and methods to reduce lifecycle costs.

Advanced Manufacturing Development designs, develops, demonstrates, and transitions improved production processes, including tools, fixtures, parts, and materials designed to ensure the safety, security, and performance of the nuclear weapons stockpile. This development enables the nuclear security enterprise to respond to emerging issues with the current stockpile and adapt new processes for follow-on use, with the objective to provide significant reductions in production time, material waste, and floor space. In accomplishing its mission, this program enables DOE/NNSA to meet DoD requirements while enhancing safety and security and remaining vigilant and responsive to evolving national security requirements.

4.3.5.1 Status

WTMM continues to focus on its core areas of work:

Improved Performance. WTMM seeks to innovate existing capabilities and technologies by improving existing performance margins. This ensures stockpile and production technologies can survive long lifecycles and continue to be an effective deterrent in emerging threat environments.

Improve Producibility. WTMM engages in innovation of technologies and capabilities that result in reduction of production costs. This includes but is not limited to developing technologies that are more time and resource efficient to produce technologies that require fewer process steps or less infrastructure to produce; and technologies that leverage systems engineering principles for seamless transitions from weapon component designers to weapon component manufacturers.

Agile, Assured, and Affordable Technologies. WTMM strives to add flexibility to the stockpile by developing and modernizing technologies and processes to be more agile, assured, and responsive to change, as well as shortening design qualification, certification, and manufacturing cycles and timelines to improve future affordability.

Skilled Technical Workforce and Enhanced Capabilities. WTMM works to maintain a qualified technical workforce and enhanced capabilities by transferring knowledge, skills, and direct experience with respect to all stockpile technologies and processes.

4.4 Nuclear Test Readiness

The United States continues to observe its 1992 nuclear test moratorium and has not conducted a nuclear explosive test in over three decades. While President Biden most recently issued test readiness guidance in January 2022, readiness requirements have existed across multiple Administrations and the United States has no plans to conduct a nuclear explosive test. DOE/NNSA maintains the readiness to conduct an underground nuclear explosive test, if required, to ensure the safety and effectiveness of the Nation's stockpile or if otherwise directed by the President. DOE/NNSA's evaluation of the response time has changed over the years, and the fundamental approach taken to achieve test readiness has also changed.

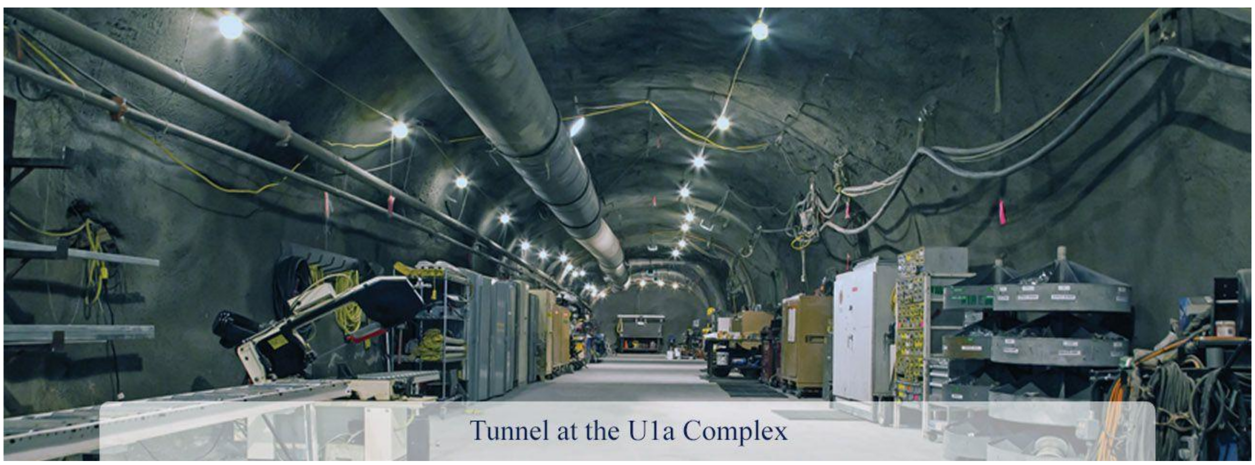
Nuclear test readiness covers a broad range of potential activities. Assessments of nuclear test readiness require a clearly defined technical basis and well-understood assumptions. Key considerations include:

- DOE/NNSA is required to maintain the capability to conduct a nuclear test. National Security Memorandum-7 establishes as U.S. policy an expectation that the United States must be ready to perform an underground nuclear explosive test using a test article drawn from the existing stockpile and limited diagnostics within 36 months, assuming current barriers to achieving this timeline in relevant laws and regulations will be overcome. Nuclear test timeline and cost would depend on the specific details of the test.
- Assuring full compliance with domestic regulations, agreements, and laws related to worker and public safety and the environment, as well as international treaties, would significantly extend the time required to execute a nuclear test.
- DOE/NNSA assumes that a test would be conducted only when the President has declared a national emergency or other similar contingency and only after any necessary waiver of applicable statutory and regulatory restrictions.

Since FY 2010, there has been no funding specific to nuclear test readiness as a separate program. DOE/NNSA maintains test readiness by exercising capabilities and workforce at the national security laboratories and the Nevada National Security Site (NNSS) through the Stockpile Stewardship Program and other NNSA programs. Test readiness is a product of a robust, technically challenging science-based Stockpile Stewardship Program that exercises essential underground testing elements at NNSS, such as mining, as well as investments in the personnel and infrastructure of the nuclear security enterprise.

Operations such as subcritical experiments at the U1a are exercising some of the possible workforce, physical assets, and infrastructure required for an underground nuclear explosive test. These experiments involve critical skills and formality of operations, including design, preparation, and fielding of advanced diagnostics; modern safety analysis; experimental execution; and recovery and analysis of the data. Subcritical experiments also exercise critical skills and concept of operations with respect to weapon design.

DOE/NNSA continues to leverage subcritical experiments for test readiness, as such experiments are challenging, multi-disciplinary efforts that enhance the technical competency of the nuclear security enterprise workforce. DOE/NNSA also leverages experiments on HED physics platforms such as NIF, Z, and the Omega Laser Facility to preserve the capability for maintaining relevant measurement capabilities, such as prompt measurement of optical, X-ray, gamma-ray, and neutron flux from experiments with next-generation technologies similar to underground nuclear explosive test measurements. The Stockpile Responsiveness Program also contributes to ensuring the readiness of the workforce.


Tunnel at the U1a Complex

Some of the capabilities and technologies used during testing continue to be updated or replaced. Migrating to newer technologies entails maintaining legacy capabilities while assessing options that adhere to the foundational data of previous tests. The test readiness strategy is to reconstitute underground nuclear explosive testing elements if or when needed, rather than maintaining obsolete facilities and capabilities. DOE/NNSA assesses that the current nuclear test readiness complies with current Presidential directives and public law.

Chapter 5
Security

This chapter covers several aspects of security within the Department of Energy's National Nuclear Security Administration (DOE/NNSA): The Secure Transportation Asset (STA) program, the Defense Nuclear Security (DNS) program, and the Information Technology (IT) and Cybersecurity program. Together, these programs provide the safe and secure transportation of nuclear weapon assets; security of the Nation's nuclear materials, physical infrastructure, and workforce; and security of information assets at DOE/NNSA Headquarters and its field offices, national security laboratories, nuclear weapons production facilities, and the Nevada National Security Site (NNSS).

5.1 Secure Transportation Asset

The STA provides safe, secure transport of the Nation's nuclear weapons, weapon components, and special nuclear material (SNM) throughout the nuclear security enterprise to support DOE/NNSA missions. Nuclear weapon warhead modernization, limited life component (LLC) exchanges, surveillance, dismantlement, nonproliferation activities, and experimental programs rely on STA's safe and secure transport.

The fiscal year (FY) 2024 President's Budget Request supports modernizing and sustaining STA transportation assets, including life extension of the Safeguards Transporter (SGT) until it is replaced by the Mobile Guardian Transporter (MGT); vehicle sustainment; replacement armored tractors, escort vehicles, and support vehicles; upgrades of the Tractor Control Unit to accommodate for communications and security: and continued development and testing of the MGT. The MGT will replace the current SGT through a phased in approach. Program Direction resources in this account provide salaries and expenses for the secure transportation workforce.

Secure Transportation Asset Accomplishments

- *Completed approximately 150 safe and secure deliveries in fiscal year (FY) 2022.*
- *Completed Test Article 2 (TA2) Over-the-Road Testing, delivered the Pre-Production Unit Rolling Chassis, and completed the Qualification Door Assembly in support of the Mobile Guardian Transporter.*
- *Completed 3 Nuclear Material Courier Basic training courses graduating 36 new Federal Agents.*
- *Executed vehicle sustainment efforts to ensure mission vehicles are upgraded and maintained to provide reliable mission support.*

While STA's highest priority is Weapons Activities missions, it also provides secure transport for other DOE/NNSA programs and offices, such as NNSA's Nuclear Counterterrorism and Incident Response Program, NNSA's Office of Naval Reactors, and DOE's Office of Nuclear Energy, as well as the Department of Defense (DoD) and other U.S. Government agencies. STA is U.S. Government-owned and operated because of the control and coordination required and the potential security consequences of material loss or compromise.

5.1.1 Status

STA has continued its record of 100 percent safe and secure shipments without compromise, loss of components, or release of radioactive material. This record is enabled by the core components of the STA security concept of specialized vehicles, secure trailers, specially trained Federal Agents (FAs), and leading-edge communication systems. To maintain its exemplary record, STA must continue to modernize the transportation assets and communication systems for convoy safety and security, and recruit and retain the FA and program staff workforce to meet mission capacity and customer requirements. These efforts are described below. STA must maintain assets to sustain convoy safety and security to support missions based on changing customer needs, and current and future threats. These assets include vehicles (trailers, armored tractors, escort vehicles, and support vehicles), aircraft, and a highly trained FA workforce. The process of identifying, designing, procuring, and manufacturing vehicles takes several years. The SGT fleet vehicles reached the end of the projected design lifecycle in 2018. STA has implemented a standard 4-year maintenance, risk mitigation, and refurbishment program to extend the life of the SGT until replaced by the MGT. The MGT will assure weapon-related cargo and containers, safety, and security; protect the public; and meet nuclear explosive safety standards.

Nuclear Material Courier Basic Graduates

In FY 2021, STA procured its first Boeing 737-700 aircraft replacement which was delivered in FY 2023 to begin mission operations.

5.1.1.1 Vehicles

Modernizing and sustaining STA's vehicle assets requires an integrated strategic plan and a substantial investment for lifecycle replacement. The STA strategy includes steady-state initiatives such as eliminating outdated vehicles, refurbishing operational vehicles to extend their useful life, and procuring new vehicles.

The process of identifying, designing, procuring, and manufacturing these vehicles takes several years. The current armored tractor and escort vehicle are being replaced by the Next Generation Armored Tractor (T4) and Escort Vehicle (EV4). STA continues to assess and refurbish vehicles to extend lifecycles until replacements are available. Evaluating demands on vehicles is a continuous effort to keep pace with operational requirements.

Escort Vehicle

5.1.1.2 Trailers

The trailer fleet is a critical asset for transporting nuclear cargo on public highways. The design, engineering, testing, production, and use of these trailers can span several decades. The design and construction features address public safety, unique cargo configurations, and protection systems. The SGT fleet began reaching its end-of-design lifecycle in FY 2018, years before the first MGT will enter production. STA has implemented an aggressive SGT maintenance, risk reduction, and refurbishment program to ensure safe and secure transport. The maintenance

Mobile Guardian Transporter – Test Article program ensures the trailers remain operational, while the risk reduction will help prevent issues such as components becoming obsolete.

The MGT program has been delayed due to staffing challenges and supply chain disruptions that emerged during the Coronavirus Disease 2019 pandemic. The delay has impacted the first production unit delivery schedule; however, efficiencies and strategies are being implemented to help mitigate further adverse program impacts. In FY 2022, MGT completed Test Article 2 (TA2) Over-the-Road Testing and site visits, Pre-Production Unit delivery, and the Qualification Assembly. Planned milestones for FY 2023 include completion of TA2 Stage Assembly Build, TA2 Testbed Integration Testing, and Thermal Testing, and Initiation of Active Delay System Energetics Production. Major planned activities for FY 2024 include TA2 Head-On Crash Test, completion of the Pre-Production Unit Assembly, and Qualification Post Crash Testing. The photo below shows the completed MGT Pre-Production Unit Rolling Chassis prepped for the first road trip.

Mobile Guardian Transporter – side view

Mobile Guardian Transporter – rear view

5.1.1.3 Aviation

The fleet of U.S. Government-owned aircraft provides for the efficient and flexible airlift of LLCs, nuclear incident response elements, FAs, joint test assemblies, training assemblies, and personnel and equipment associated with national emergencies and disasters. STA is required to maintain an aircraft on continuous alert with a rapid response time to nuclear incidents. STA must also support evacuation and relocation of key personnel to maintain the continuity of U.S. Government operations.

STA aircraft support the NNSA Nuclear Emergency Support Team, which includes the Joint Technical Operations Team, the Accident Response Group, and the Radiological Assistance Program. STA procured a Boeing 737-700 aircraft in FY 2021 (shown) that replaced a 1969 DC-9 aircraft and was delivered in FY 2023. STA's current fleet of two Boeing 737-400 aircraft are over 30 years old and are planned for lifecycle replacement in FY 2027 and FY 2032, respectively.

Replacement Aircraft (Boeing 737-700)

5.1.1.4 Communications

Reliable, secure, real-time communication is crucial to STA mission success. Essential communications include information that is obtained, analyzed, and disseminated for mission planning; continuous monitoring and updating of that information during mission execution; and continuous communication during convoy operations. These various tiers of communication must be executed seamlessly in real time, while balancing the evolving need for cybersecurity to ensure system reliability and integrity. STA is continually evaluating risk, researching emergent technologies, and implementing new tools and practices, such as incorporating new vehicle communications, (Global Positioning System and Trailer Status Interfaces), including Radio Frequency Identification in fixed-site communications, and ensuring Exercise Command and Control support.

5.1.1.5 Workforce

STA is committed to strategies to recruit and retain people with the requisite skills to meet priorities and mission requirements, and considers the many years it takes to achieve growth in the FA workforce due to the extensive hiring process, security clearances, and attrition. STA is encountering many of the workforce challenges described in Chapter 7 and is implementing initiatives to attract, hire, and maintain the FA workforce.

Federal Agent Training

Once hired, FAs receive cutting edge training, accredited by the Federal Law Enforcement Training Center, in full-scale emergency and tactical operational scenarios, tactical driving techniques, and a variety of weapons and explosives. Each FA Command has facilities and staff to refresh primary skills and accomplish qualification training. The Training Command in Arkansas supports basic to advanced training, including special weapons, tactical scenarios, and other general training covering all aspects of convoy operations, as well as an initial Nuclear Material Courier Basic training program for FA candidates. The Federal Law Enforcement Training Center in Georgia provides a follow-on course for FAs, emphasizing legal authorities and law enforcement concepts. FA law enforcement authority and specialized training are continually evaluated to respond to the dynamic operational environment. STA continues to recruit and retain the FA workforce to meet mission capacity and customer requirements.

5.1.1.6 Safety and Security

Validation Force-on-Force exercises are assessments designed to test STA's Active Security Doctrine and determine system effectiveness for the STA's Site Security Plan. The vulnerability assessment team designs, performs, evaluates, and documents the conduct of these assessments; the training and logistical staff support the Validation Force-on-Force exercises and integrate them with the emergency command and control elements to provide the most realistic convoy scenarios possible. STA also executes safety studies and safety engineering for the safety basis, nuclear explosive safety, and over-the-road safety issues. The Site Security Plan and the Documented Safety Analysis outline compliance with security and safety orders and regulations as related to nuclear operations within DOE/NNSA.

5.1.1.7 Liaison

STA maintains a liaison program with agencies and organizations that may be in contact with a convoy or must respond to an STA emergency. This interface extends across the United States, with a focus on primary and secondary convoy routes. The scope of the liaison function includes Federal, state, Tribal, and local agencies and involves interactions with law enforcement officers, firefighters, emergency and hazardous materials responders, dispatchers, and military personnel.

5.1.2 Challenges and Strategies

Table 5–1 provides a high-level summary of Secure Transportation Asset challenges and the strategies to address them.

Table 5–1. Summary of Secure Transportation Asset challenges and strategies

	Strategies	
Challenges	***Current Strategy Being Implemented***	***Future Strategies Needed***
The SGT fleet is beyond its design life and sustaining it involves challenges such as unavailable or obsolete parts, difficulty finding new manufacturers, the high cost of limited-run production, and meeting Nuclear Explosive Safety Study requirements.	Support SGT risk-reduction program and continue design and production activities toward development of the MGT. Work with partners to identify mitigation strategies, address Nuclear Safety Study requirements, and sustain the required readiness posture of the STA fleet.	Evaluate, update, and replace STA assets as required to meet mission. Incorporate MGT into mission operations as fleet becomes available.
STA is facing FA staffing challenges. Feedback and analysis have shown that pay is not competitive with other organizations, it takes too long to be promoted, and there is a lack of financial assistance to move to duty locations.	Continue to implement initiatives to attract, hire, and maintain FA end strength. Initiatives include increasing starting pay for incoming FAs, offering recruitment incentives, and creating ladder positions for FAs.	Evaluate and monitor results from STA hiring initiatives (to support increases FA end strength and decreases in attrition).
Delayed schedule to MGT first production unit have resulted due to supply chain disruptions which are impacting deliverables (emanating from supply chain issues for materials/piece parts and a loss of critical skills within the vendor workforce bases). Custom electronic printed wiring board/printed wiring assembly fabrication needed to support MGT have been especially impacted.	Allowing for longer lead times and making parallel purchases from multiple vendors to reduce schedule risk has had some success. Alternate parts to address shortages have been identified to circumvent fabrication delays but often require design modifications.	Strengthen the U.S. industry base of suppliers in custom electronics design.

FA = Federal Agent
MGT = Mobile Guardian Transporter
SGT = Safeguards Transporter
STA = Secure Transportation Asset

5.2 Defense Nuclear Security

DNS leads, develops, and implements the security program to enable DOE/NNSA's nuclear security enterprise missions. DNS provides protection for DOE/NNSA personnel, facilities, and nuclear weapons and materials from a full spectrum of threats, ranging from minor security incidents to acts of terrorism, across all the sites of the nuclear security enterprise. In addition, DNS provides nuclear security expertise for a broad set of 21st century national security needs, such as those in defense nuclear nonproliferation, homeland security, and intelligence, in line with its core mission. Employing more than 1,700 Protective Force officers, DNS secures SNM, classified materials, and more than 6,000 buildings in addition to protecting more than 57,000 personnel at its national laboratories, production plants, processing facilities, and NNSS. DNS also provides personnel security clearance processing and adjudication for the nuclear security enterprise. The major elements of the DNS program are illustrated in **Figure 5–1**.

Dedicated and specially trained security professionals address general and site-specific threats and carry out the physical security mission at each field location. DNS comprises Safeguards and Security elements that provide the day-to-day secure environment necessary to execute DOE/NNSA's national security mission. DNS also provides facility clearances for contractor organizations that perform classified and unclassified work; processes personnel security clearance actions for DOE/NNSA; and administers the classification program to ensure information is properly identified for appropriate handling and protection. **Table 5–2** provides a brief description of each DNS program element.

Defense Nuclear Security Accomplishments

- *Completed operational capability of counter uncrewed aircraft systems (CUAS) for operations:*
  - *2018 – Los Alamos National Laboratory*
  - *2022 – Nevada National Security Site*
  - *Q2-2023 – Pantex Plant*
- *FY 2022: Successfully implemented Trusted Workforce 1.5. This included submitting over 30,000 fingerprint requests and enrolling over 90 percent of DOE clearance holders into the Record of Arrest and Prosecution Back system, which supports near real-time evaluation of clearance holders.*
- *FY 2022: Granted over 6,000 new security clearances in support of mission growth across the NNSA nuclear security enterprise.*
- *FY 2022: Initiated efforts to streamline security approvals for medically necessary personal electronic devices used in security areas.*
- *FY 2022: Started construction on first Security Infrastructure Revitalization Program (SIRP) project at the Y-12 National Security Complex (Y-12).*
- *FY 2023: Achieved full operating capability of the Portable Intrusion Detection System, a rapidly deployable detection system/compensatory measure developed in partnership with DoD.*
- *FY 2023: Collaborated with the DoD Office of Nuclear Matters to improve threat assessments, technology development, policy, and other areas of mutual benefit.*
- *FY 2023: Implemented Local Area Nuclear Material Accountability System software enhancements at all user sites. This enables accurate material accounting.*
- *FY 2023: Co-led the Enduring Organizational Improvement Initiative for the Risk Management sub-group of the Governance and Management effort to identify safety and security requirements that could be retired permanently or modified to improve efficiency without increasing risk.*

Figure 5–1. Defense Nuclear Security Program elements (excludes construction)

Table 5–2. Defense Nuclear Security Program elements

DNS Element	*Description*
Protective Force	*Protective Force* officers are an integral part of a site's security posture and are trained in tactics and techniques necessary to protect DOE/NNSA sites. These forces are each site's primary front-line protection and consist of armed and unarmed uniformed officers.
Physical Security Systems	*Physical Security Systems* oversees counter uncrewed aircraft systems, intrusion detection and assessment systems, performance testing and certification/recertification, access control systems, barrier and delay mechanisms, canine explosive detection programs, and tactical systems. This element includes the Security Infrastructure Revitalization Program.
Information Security	*Information Security* provides classification guidance, technical surveillance countermeasures, operations security, classified matter protection and control, and administration of special access programs.
Personnel Security	*Personnel Security* includes access authorizations, badging, portions of the Human Reliability Program, classified and unclassified visits, and foreign national assignments. It encompasses administrative support for the site clearance process, including security clearance determinations at each site.
Nuclear Material Control and Accountability	*Nuclear Material Control and Accountability* controls and accounts for special and alternate nuclear materials through measurements, quality assurance, accounting, containment, surveillance, and physical inventory. Management of the Local Area Nuclear Material Accountability System, or LANMAS application, as well as training and operational support, is provided to DOE/NNSA sites and facilities.
Security Program Operations and Planning	*Security Program Operations and Planning* manages development of budgets; responses to audits and information requests; reviews of Site Security Plans, security planning, and assessments (including vulnerability/risk assessments); and performance testing and assurance. It also includes security incident and reporting management, security surveys and self-assessments, activities related to deviation requests, and control of security technology transfer activities. Lastly, it supports facility clearance processing and foreign ownership, control, or influence determinations for security contracts.

5.2.1 Status

5.2.1.1 Counter Uncrewed Aircraft System

DNS is focused on addressing the threat posed by uncrewed aircraft systems (UAS) and the need for effective countermeasures, which is among DOE/NNSA's top security priorities. The first DOE/NNSA CUAS platform was deployed at Los Alamos National Laboratory in 2018. NNSS and the Pantex Plant achieved full operational capability in 2022 and mid-2023, respectively. DNS participates in the CUAS National Action Plan Interim Planning Committee and continues to work closely with departmental security counterparts and interagency partners, including DoD, the Department of Homeland Security, the Federal Aviation Administration, the Department of Justice, and appropriate congressional stakeholders to maintain an effective CUAS capability.

5.2.1.2 Security Infrastructure Revitalization Program

The Security Infrastructure Revitalization Program (SIRP) is a multi-year program designed to addresses critical security systems and related security infrastructure across DOE/NNSA, focusing on revitalizing aging security infrastructure by providing Physical Security Systems upgrades and lifecycle management across the nuclear security enterprise through General Plant Project. SIRP project requirements were derived from the data obtained during a detailed condition assessment completed at each DOE/NNSA facility. The condition assessment identified the oldest systems and systems with the highest risk for failure and assessed these systems' contributions to the overall security posture. DNS recently began work on the Quadrant 1 Perimeter Intrusion Detection and Assessment System refresh and completed the Post 8 Booth Replacement SIRP projects at Y-12.

5.2.1.3 Departmental Collaboration

DNS participates in the Capital Acquisition process, the Integrated Planning Group, the Management Council, the Chief Security Officer Committee, and the Insider Threat Steering Committee to maintain close collaboration with other NNSA and DOE entities. DNS recently revitalized collaboration with the United Kingdom's Ministry of Defence and its Atomic Weapons Establishment, as well as DoD, to identify opportunities for partnership on respective nuclear security programs. This effort focuses on opportunities to identify and implement improvements in how the two agencies harmonize their respective nuclear security programs, including threat assessments, technology development, policy, and other areas of mutual benefit.

5.2.1.4 Personnel Security

DNS successfully implemented Trusted Workforce 1.5, which included submitting over 30,000 fingerprint requests and enrolling over 90 percent of DOE clearance holders into the Rap Back system. In addition, the web-based Clearance Action Tracking System was recently upgraded to track and manage Trusted Workforce changes. This system was also adopted by DOE as the adjudication system of record for clearance activities and provides Trusted Workforce workload intake, case management, and adjudicative support.

5.2.2 Sustainment Investments

DNS has a process in place for funding operations and sustainment of Safeguards and Security infrastructure, equipment, and facilities. During the annual programming process, management and operating (M&O) partners submit requests for funding these requirements, which include upgrades to, and replacement of, security infrastructure, security systems, equipment, and facilities. This routine Planning, Programming, Budgeting, and Evaluation process, accomplished in close coordination with NNSA's Office of Management and Budget, is essential to the protection of DOE/NNSA's critical missions.

5.2.3 Challenges and Strategies

A continuing challenge for DOE/NNSA, and the U.S. Government overall, is identifying and addressing new and emerging security threats. Each threat is assessed and prioritized according to national security importance, taking into consideration the effectiveness of existing security measures. Through tactical and strategic planning and collaboration with counterparts, DOE/NNSA remains focused on addressing these security challenges. **Table 5–3** provides a high-level summary of various DNS challenges and the strategies developed to address them.

Table 5–3. Summary of Defense Nuclear Security Program challenges and strategies

Challenges	*Strategies*	
	Current Strategy Being Implemented	***Future Strategies Needed***
Increasing presence of CUAS	DOE/NNSA currently employs three fully operational CUAS platforms and will achieve full operational capability in FY 2023 at the remaining planned Category I sites. In addition, DOE/NNSA continues to engage with other government agencies on the CUAS threat and furthering CUAS technologies.	DNS plans to leverage future technologies and next-generation efforts to continue addressing emerging threats.
Modernizing aging security systems and infrastructure, while leveraging new technology	DOE/NNSA is in the final stages of development and initial stages of deployment for Caerus, a modern security system that will replace Argus, which has been in use for over 25 years. Caerus is a modernized and upgraded version of an integrated system that can incorporate commercial off-the-shelf technologies while possessing improved cybersecurity. In addition, NNSA continues to prioritize security infrastructure recapitalization efforts through the SIRP and WEPAR project.	Partner with various organizations/agencies to assess and deploy future technologies designed to enhance the overall effectiveness of in-place security measures, aid in the development of enhanced cybersecurity, and incorporate the use of artificial intelligence.
Addressing Insider Threat	DOE/NNSA has implemented a robust process that includes continuous vetting as part of Trusted Workforce, screening technologies to deter and detect insiders, and insider vulnerability interviews of employees and contractor partners designed and conducted by the site vulnerability assessment analysts and the Local Insider Threat Working Groups. In addition, steps taken to identify and mitigate insider threats include utilizing the DOE Employee Concerns Program website to report potential insider threats, continuous evaluation conducted by supervisors and cybersecurity personnel, security and law enforcement reporting, and administrative reporting on employees who are members of the Human Reliability Program.	Collaborate with DOE partners to strengthen the current insider threat mitigation techniques, establish a DOE/NNSA-managed Insider Threat Program, and identify opportunities to address the increased insider threat resulting from the advancement of technology and popularity of social media.

CUAS = Counter Uncrewed Aircraft System
DNS = Defense Nuclear Security
SIRP = Security Infrastructure Revitalization Program
WEPAR = West End Protected Area Reduction project

DOE/NNSA began analyzing new and emerging threats, including weaponized UAS, in the Design Basis Threat Change 1 Order. By late 2023, all DOE/NNSA Category I site CUAS platforms will have full operational capability. These systems currently provide DOE/NNSA with a capability to counter UAS; however, the increasing sophistication of UAS will require frequent updates and additional investments to continue to address the threat. DNS is exploring options to transition to a more adaptable approach necessary to detect, track, identify, and deny current and future technologies from threatening the security enterprise.

The continuation of increased weapons requirements has led to mission growth across the nuclear security enterprise, especially in the areas of weapon modernization and infrastructure investment and recapitalization. This mission growth drives increased security program resource requirements across every security discipline. For example, increases in site staffing necessitate additional personnel clearance action, and increases in square footage require additional personnel and physical security infrastructure; Protected Force support; classified matter protection and control; technical surveillance countermeasures; classification program support; and programmatic management. **Figure 5–2** illustrates these requirements.

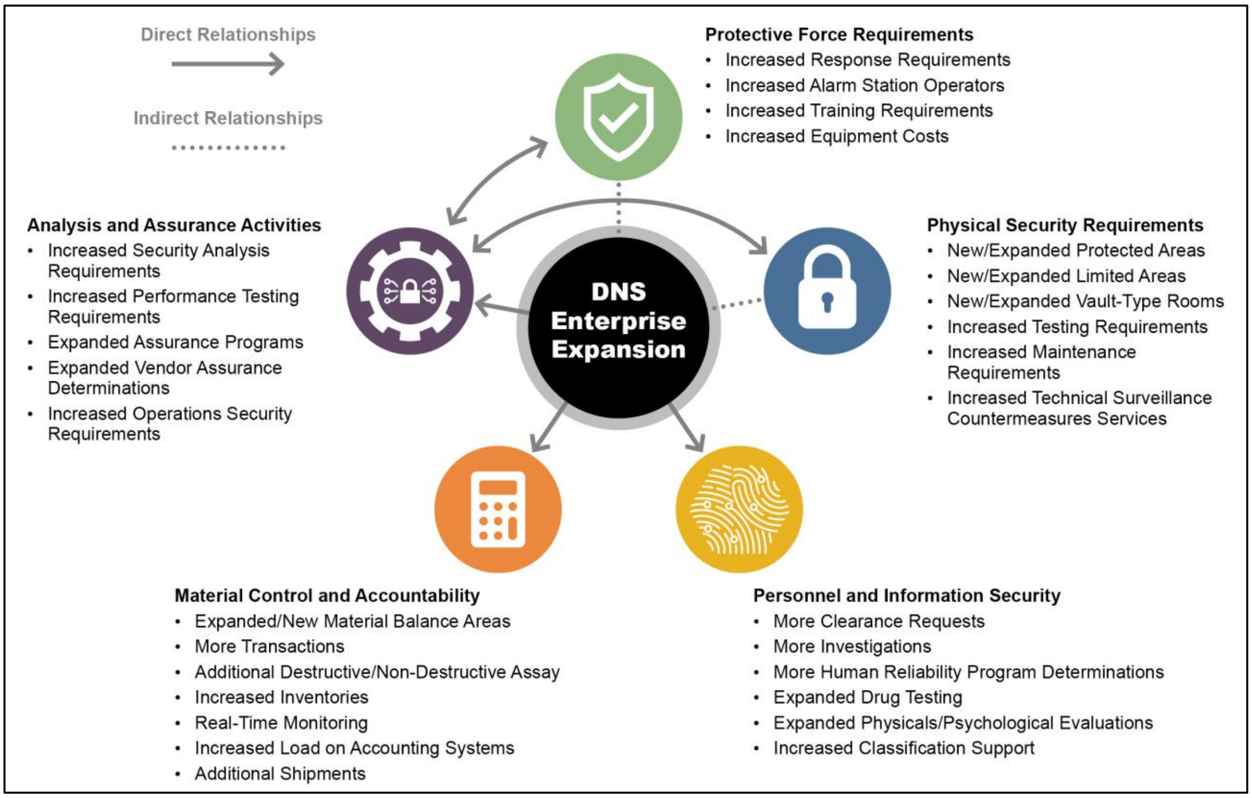


Figure 5–2. Infrastructure and Weapons Program expansion

5.3 Information Technology and Cybersecurity

DOE/NNSA's Office of the Associate Administrator for Information Management and Chief Information Officer (NNSA OCIO) is the organization responsible for Federal information management and IT and complex-wide cybersecurity for DOE/NNSA. The NNSA OCIO is a mission partner that enables DOE/NNSA to accomplish its strategic goals and objectives through the delivery of secure, agile, and risk-informed IT and cybersecurity solutions.

NNSA OCIO accomplishes its mission by improving network connectivity and resilience, maturing DOE/NNSA's cybersecurity posture, and providing and directing cybersecurity across DOE/NNSA enterprise and to its mission partners. This office manages the IT portfolio, Federal IT investments, services, and projects in alignment with DOE/NNSA and departmental strategies, as well as other national policy drivers. Services are provided through three offices: Cybersecurity, Mission Integration, and IT. These offices work in tandem to:

- Increase organizational efficiency and effectiveness
- Protect classified and unclassified information assets
- Enhance communication with internal and external partners
- Provide continuous monitoring and support effective incident response
- Ensure information is protected from unauthorized access and malicious acts
- Comply with statutory requirements governing classified data protections and information assurance

5.3.1 Transformations to Ensure Information Security and Cybersecurity Throughout the Nuclear Security Enterprise

Digital Transformation

In FY 2022, the NNSA OCIO embarked on a digital transformation effort that:

- Improved, upgraded, and enhanced the mission unclassified and classified logical infrastructure
- Enabled Artificial Intelligence and Machine Learning
- Performed IT and application modernization

The goal of the transformation was to implement sufficient management, operational, technical operation, and safeguards throughout the nuclear security enterprise to maintain adequate protection of information and information assets.

Enterprise Transformation

DOE/NNSA continues to implement an enterprise transformation initiative that will deliver a modern, reliable, comprehensive, secure computing environment that supports the enterprise and aligns with current and future IT service delivery models. With the managed services model, DOE/NNSA's networks will benefit from industry best practices and receive ongoing patching and monitoring. They will incorporate hardened configurations from a security perspective, fine-tuned settings for performance, and dynamic configurations to meet evolving business environments.

5.3.2 Information Technology and Cybersecurity Program Elements and Initiatives

The IT and Cybersecurity Program focuses on the development of integrated IT initiatives that provide an effective technology infrastructure and support to the DOE/NNSA nuclear security enterprise shared services. These initiatives will fundamentally redesign the IT and cybersecurity environments to provide a more secure and responsive set of capabilities, including unified communication, agile cloud infrastructure, and next-generation collaboration services across the nuclear security enterprise. The major elements and initiatives of the IT and Cybersecurity Program, supported by Mission Integration, are illustrated in **Figure 5–3**. **Table 5–4** provides a brief description of each of these program elements.

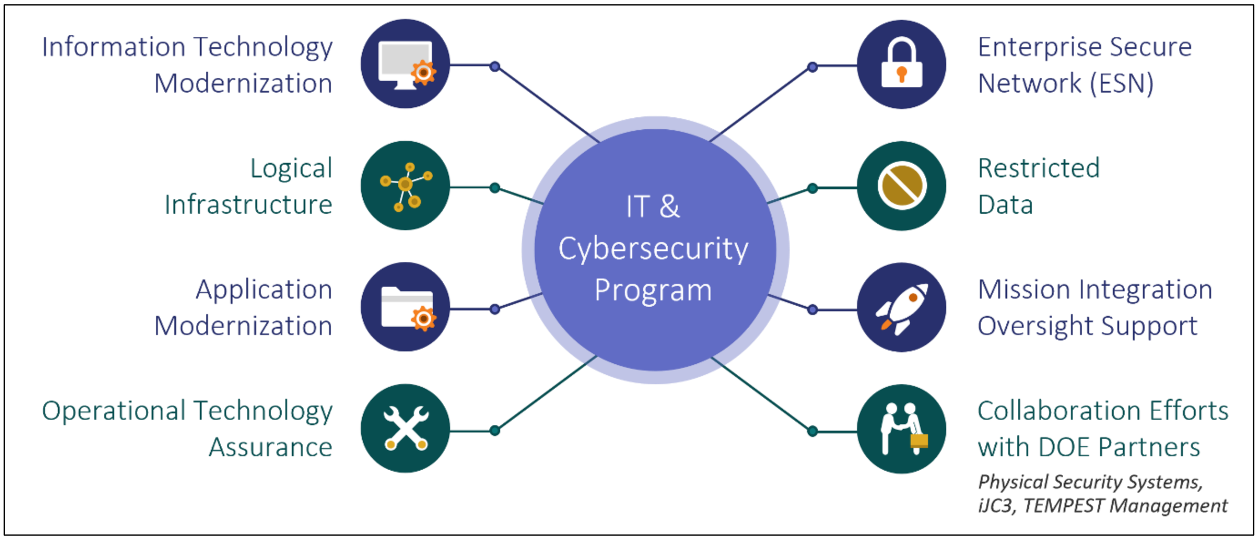


Figure 5–3. Information Technology and Cybersecurity major elements and initiatives

Table 5–4. Elements of the Information Technology and Cybersecurity Program

NA-IM Element	*Description*
IT Modernization	An enterprise transformation initiative that will grow cloud services over time and deliver a modern, well-managed, secure computing environment that will eliminate many of the inefficiencies and performance degradations currently experienced by the workforce.
Logical Infrastructure	To improve and enhance the classified infrastructure for its Enterprise Secure Network.
Application Modernization	To perform application rationalization for mission IT applications. This evaluation of applications will be used to determine the best method of migration for current applications onto the modernized classified network.
OT Assurance	A methodology to secure the operational technology used in nuclear weapons production, testing, and facility control capabilities across the enterprise.
Enterprise Secure Network	Increases the capability, capacity, and responsiveness of the DOE classified infrastructure in direct support of DOE/NNSA missions and the statutory requirements governing classified data protections and information assurance.
RD	Working collaboratively with other Government agencies (such as DoD and the FBI) to identify interagency needs and opportunities for accessing, sharing, and leveraging RD.
FITARA	OMB Memorandum M-15-14, Management and Oversight of Federal Information Technology. The NNSA FITARA Implementation Framework, approved in September 2019, provides details on how NNSA will implement the Act in accordance with the OMB memorandum.
Mission Integration Oversight Support	To provide oversight support to core IT and cybersecurity operations and achieve organizational, strategic, and mission goals.
Collaboration Efforts with DOE Partners	Physical Security Systems – The application of technology to improve physical security. Integrated Joint Cybersecurity Coordination Center – Provides 24/7 situational awareness of evolving cybersecurity threats, operational status, and associated risks to DOE mission essential functions. TEMPEST Management – To evaluate and mitigate technical risks to systems in support of its risk management oversight and control authorities.

FBI = Federal Bureau of Investigation
FITARA = Federal IT Acquisition Reform Act
IT = information technology
OMB = Office of Management and Budget
OT = operational technology
RD = Restricted Data

5.3.3 Ongoing NNSA OCIO Activities

NNSA OCIO continues to manage IT and cybersecurity projects designed to help reduce risks. While these efforts are projectized, they are not managed under the same acquisition policies as the line-item construction or minor construction projects.

5.3.4 Planned NNSA OCIO Activities

Figure 5–4 are the recent and ongoing accomplishments for NNSA OCIO and the office anticipates completing the following activities in FY 2023:

- Pilot classified mobility solutions
- Expand the Center of Excellence for threat intelligence beyond DOE/NNSA
- Execute the acquisition strategy to provide additional IT mission and cybersecurity support to critical classified and unclassified systems
- Complete the development of the next level of operational technology (OT) classes in collaboration with the Office of Defense Programs
- Complete deployment of multifactor authentication and encryption for national security systems data-at-rest and data-in-transit
- Support field office IT services provisioned by M&O and oversee the M&O unclassified IT programs
- Implement the application modernization project and enterprise Voice over Internet Protocol as a service
- Provide oversight of activities related to, and ensure agency compliance with, the provisions of the Federal IT Acquisition Reform Act (FITARA)
- Enable IT operations and maintenance of the critical infrastructures and networks
- Cybersecurity improvements identified in Executive Order 14018, *Improving the Nation's Cybersecurity Infrastructure*
- Address specific findings from the Institute for Defense Analyses (IDA) Cybersecurity Assessment:
  - DOE/NNSA contracted with the IDA, a Federally Funded Research and Development Center, to conduct the assessment.
  - The cybersecurity assessment was completed in the spring of 2022.

Figure 5–4. Ongoing and recently completed information technology and cybersecurity projects

5.3.5 Status

5.3.5.1 Significant Changes Since the Last Stockpile Stewardship and Management Plan

The NNSA OCIO continues to make enhancements to the Enterprise Secure Network infrastructure, and is implementing additional IT modernization, with an emphasis on addressing risks related to software assurance, operational OT assurance, and supply chain management. The IT and Cybersecurity Program continues to support working from home and extensive videoconferencing, including classified videoconferencing for a large portion of the workforce.

5.3.5.2 The Current and Future Anticipated Mission Requirements

Due to the increased demand for advanced technology to protect information, agility is critical to respond to cybersecurity threats and technology requirements.

5.3.5.3 Current State of the Infrastructure

The NNSA OCIO is currently securing unclassified and classified networks in place that adequately support nuclear security enterprise needs, but require constant evaluation and ongoing upgrades against changing threats.

5.3.5.4 Current State of the Workforce

There are continuing challenges recruiting and retaining top talent due to competition for IT and cybersecurity resources. NNSA OCIO will continue its efforts to meet current and future workforce needs by analyzing job requirements to meet the mission's evolving needs. By doing so, NNSA OCIO will continue to be a competitive employer that can recruit, develop, and retain top talent in the IT and cybersecurity workforce.

5.3.5.5 Technologies Deployed to Address Cybersecurity Threats

NNSA's IT and Cybersecurity program maintains management, operations, and technical security safeguards throughout the nuclear security enterprise for adequate protection of information assets. The workforce that develops, deploys, and uses the security tools listed in **Table 5–5** to provide the first lines of defense against known adversaries and emerging threats.

Table 5–5. Technologies deployed or to be deployed to address Information Technology and Cybersecurity threats

Cybersecurity Framework Core Function	*Technology*
Identify	Enterprise Governance, Risk, and Compliance
	Center of Excellence Sensor Platform for Cybersecurity Intelligence
	Vulnerabilities Asset Management
	Supply Chain Management Center Solution
Protect	Multifactor Authentication Identity and Access Control Management Solution
	Encryption
	Firewalls
	Intrusion Prevention System
Detect	Network Monitoring
	Configuration Management
Respond	Incident Response
	Enterprise Forensics
Recover	The nuclear security enterprise maintains overlapping cybersecurity technology capabilities that ensure defense-in-depth and continuity of operations at alternate locations.

5.3.6 Challenges and Strategies

The highly complex and global nature of DOE/NNSA and its nuclear security enterprise, coupled with limited resources, makes it critically important that information and information assets are secured, managed, and protected using a risk-management approach. As the cybersecurity threat landscape constantly evolves, it is critical for NNSA OCIO to keep up and adapt to the ever-changing IT, OT, and cybersecurity defenses and to respond rapidly to the evolving and sophisticated threats. **Table 5–6** provides a high-level summary of IT and cybersecurity challenges and the strategies developed to address them.

Table 5–6. Summary of Information Technology and Cybersecurity challenges and strategies

	Strategies	
Challenges	***Current Strategy Being Implemented***	***Future Strategies Needed***
Ensure purchased equipment is from the manufacturer, as designed, and without modification.	Move toward centralized purchasing and equipment review before issuing equipment to the field will address current supply chain and software assurance issues. This will align to OMB Memo 22-18: Enhancing the Security of the Software Supply Chain through Secure Software Development Practices.	Threat analysis will determine future strategies. However, ongoing threat analysis will determine whether further strategies are needed.
Insider Threat	Continue to work with counterintelligence on an insider threat program.	Threat analysis will determine future strategies. However, ongoing threat analysis will determine whether further strategies are needed
Network Aging Infrastructure/IT Support	• Improve network infrastructure by updating and enhancing networking equipment through public/private cloud services, managed services, software, and hardware enhancements. • Mature capabilities of aging infrastructures enterprise-wide to identify and alert concerning emerging threats. • Ensure faster capabilities development and implementation to counter such threats.	Threat analysis will determine future strategies.
Identify, inventory, and ensure proper cybersecurity hygiene is applied to OT	• Collaborate early with program managers, operations, and engineering teams to plan for IT and cybersecurity requirements during the planning stage. • For legacy OT and Industrial Control systems, perform analysis to identify and inventory systems, devices, and all assets. • Ensure applicable cybersecurity hygiene is applied to OT and industrial control systems.	Threat analysis will determine future strategies.
Current network monitoring services restrictions	• Upgrade sites across the enterprise through deploying new cybersecurity solutions. • Ensure all networks, IT, and OT systems are monitored	Threat analysis will determine future strategies. However, ongoing threat analysis will determine whether further strategies are needed.
Not all buildings support network speeds are fast enough for today's scientific computing, and with technology's reliance on computers, capacities are being exceeded across the nuclear security enterprise.	Continued investment is needed in network communications systems and in the central networking and telecommunications facilities.	Threat analysis will determine future strategies. However, ongoing threat analysis will determine whether further strategies are needed.
Program effects from 2022 *Nuclear Posture Review* Implementation	• Ensure IT and cybersecurity capabilities keep pace with increases in weapons program workloads. • Ensure a secure, protected, and innovative work environment.	Threat analysis will determine future strategies. However, ongoing threat analysis will determine whether further strategies are needed.
Fill critical cybersecurity and IT vacancies across the enterprise.	Bolster cybersecurity and IT workforce as recommended in the IDA cybersecurity assessment report.	Threat analysis will determine future strategies. However, ongoing threat analysis will determine whether further strategies are needed.

	Strategies	
Challenges	***Current Strategy Being Implemented***	***Future Strategies Needed***
Fulfill OMB guidance to consider and use cloud solutions in a secure manner.	Modernize current services by capitalizing on cloud technology to increase performance and strengthen security.	Threat analysis will determine future strategies. However, ongoing threat analysis will determine whether further strategies are needed.
Fully adopt cybersecurity improvements identified in Executive Order 14028 (*Improving the Nations Cybersecurity Infrastructure*).	• Conduct baseline inventory and state of existing threats, risks, and mitigations associated with current enterprise IT systems. • Work with IT and program offices to implement a strategy to migrate to zero trust across environments.	Threat analysis will determine future strategies.
Accommodate current and future teleworking needs across the NNSA complex.	• Continue to develop and implement services and solutions to increase teleworking security and ease of use, while transitioning focus to recruiting retention.	Apply future technology to ensure services and solutions are available to enhance operational connectivity and transition focus to recruiting retention.
Artificial Intelligence/Machine Learning (AI/ML)	• Develop an AI/ML strategy. • Improve supply chain security processes using business intelligence. • Unlock the power of data to make risk-based decisions. • Set policy for artificial intelligence and machine learning for the enterprise. • Seek technical applications to meet business/mission requirements.	The current strategy is sufficient. However, ongoing threat analysis will determine whether further strategies are needed.

IDA = Institute for Defense Analyses
IT = information technology
OMB = Office of Management and Budget
OT = operational technology

Chapter 6
Infrastructure and Operations

Infrastructure modernization is essential to the Department of Energy's National Nuclear Security Administration's (DOE/NNSA) mission to ensure a safe, secure, and effective stockpile, reduce mission risk, and improve employee, public, and environmental safety. Demand on the existing infrastructure is increasing due to multiple concurrent stockpile modernization programs and the need to advance science, technology, and engineering activities at DOE/NNSA's laboratories, plants, and sites. These factors present many complex challenges, particularly given DOE/NNSA's aging infrastructure. In light of these challenges, DOE/NNSA, with congressional support, has increased the resources allocated to and made significant progress in modernizing its infrastructure, eliminating excess facilities, and improving management practices.

Infrastructure and Operations Major Accomplishments

- *The Standardized Acquisition and Recapitalization Initiative (STAR), which uses a standard design to reduce costs and accelerate construction of small office and light laboratory facilities across the nuclear complex, has been the basis for 17 projects, with four completed in fiscal year (FY) 2023.*
- *Three Emergency Operations Centers at Lawrence Livermore National Laboratory (LLNL), Y-12 National Security Complex (Y-12), and Sandia National Laboratories (SNL), as well as a Fire Station at Y-12, were all executed within the pilot program for Enhanced Minor Construction and Commercial Practices (EMC^2) under budget and ahead of schedule.*
- *In April 2022, NNSA completed construction on the John A. Gordon Albuquerque Complex, a modern, energy efficient, 333,000 square foot building that provides workspace for over 1,200 NNSA employees and contractors along with great common areas.*
- *In March 2023, DOE/NNSA purchased Building 23 to support the Kansas City National Security Campus (KCNSC) mission. This facility will help KCNSC meet mission demands and be more strategic with manufacturing space to accommodate near-term facility needs while supporting long-term manufacturing requirements.*

Figure 6–1 illustrates the size, age, and scope of DOE/NNSA's nuclear security enterprise infrastructure that drives the challenges and strategies discussed in this chapter. Comprehensive enterprise asset management requires continuous, multi-level planning across the entire spectrum of asset types, resulting in balanced enterprise investment decision-making across the entire asset management lifecycle, as shown in **Figure 6–2**. Planning initiates an asset's lifecycle, followed by acquisition through new construction, lease, or purchase.

The majority of an asset's life is spent in continuous sustainment through maintenance, repairs, and replacements-in-kind, with periodic recapitalizations to upgrade and extend the asset's service life prior to disposition. These lifecycle asset management activities are presented in the rest of this chapter.

Chapter 6 begins with a set of high-level, enterprise-wide challenges to lay the foundation for subsequent discussions. More specific challenges are contained in the discussions for each subsection, as appropriate. The asset management lifecycle model shown in Figure 6–2 is used to frame the discussion for different types of investments across a variety of funding sources and sponsoring programs. Sections 6.2 through 6.6 each reflect the activities within each element of the model. Infrastructure planning and asset management, described in Section 6.2, estimates future repair of and modernization investments in facilities as they age, forecasting facility replacement schedules, planning for new and replacement acquisitions, and anticipating the disposition needs and costs of excess facilities for completion in a timely manner. Sections 6.3 through 6.5 describe the different acquisition strategies and funding approaches necessary to build long-term infrastructure modernization programs, and Section 6.6 addresses the disposition of excess facilities. Programmatic equipment, when acquired independently of other infrastructure projects, is discussed in Section 6.7, rounding out the discussion of the Weapons Activities capability element that consists of facilities, infrastructure, and equipment.[1] Section 6.8 discusses how the DOE/NNSA programs outside the direct nuclear weapons mission areas benefit from Weapons Activities investments for their own national security mission needs. Section 6.9 concludes the chapter with a discussion on management and performance.

Within Sections 6.2 through 6.6, the various funding strategies and acquisition approaches provide the organizing framework for discussion. The wide range of programs, processes and funding types discussed are testament to the complexity of aligning investment needs to funding sources. The funding strategy to support any given type of project can vary greatly due to the project's size, scope, and other factors. Facility acquisition occurs through line-item projects, minor construction, purchase, or leasing. Operating, maintaining, and revitalizing existing facilities are funded through Recapitalization, Maintenance, and other programs.

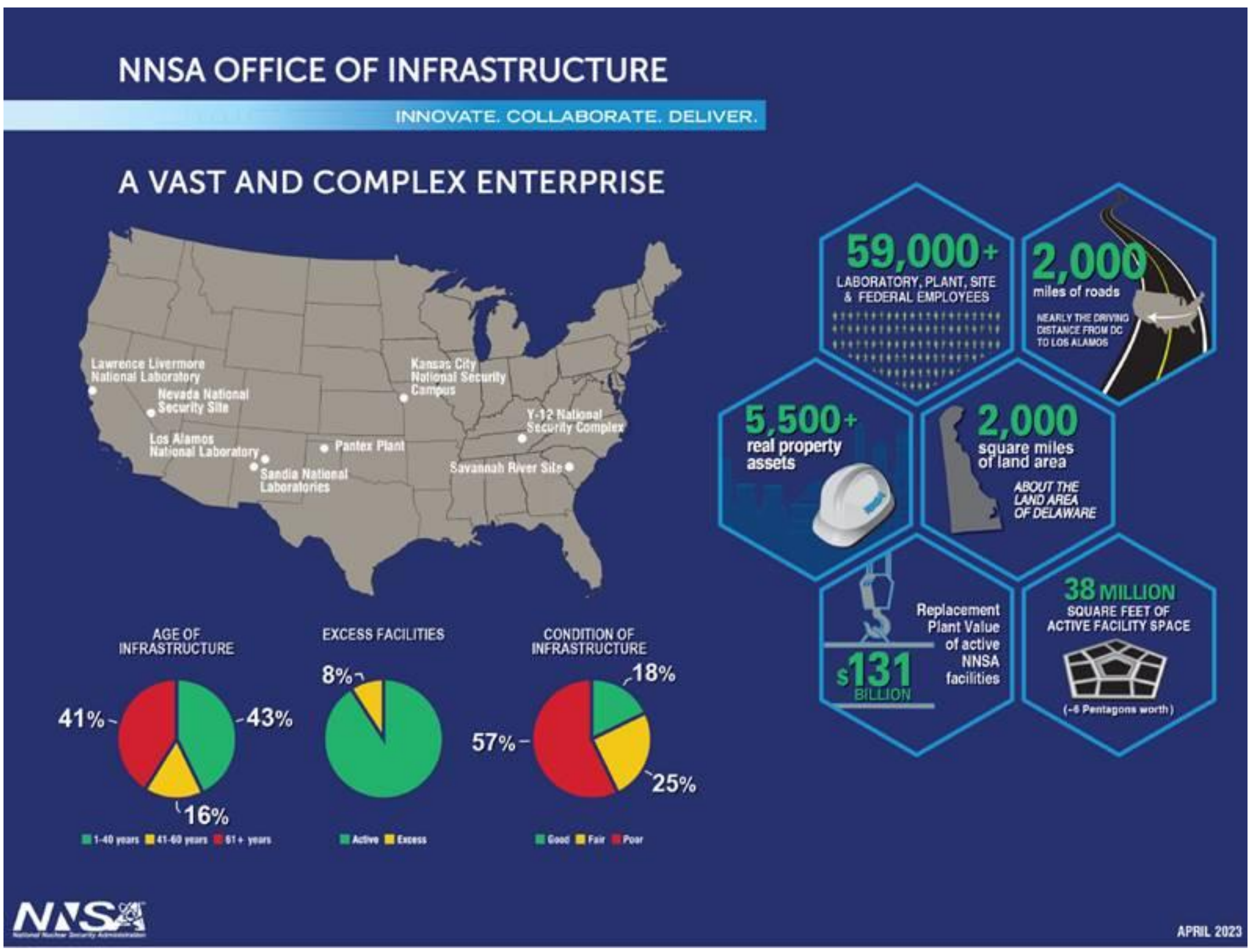


Figure 6–1. DOE/NNSA infrastructure size and scope

[1] The Weapons Activities capability elements were discussed in detail in Chapter 3 of the *Fiscal Year 2023 Stockpile Stewardship and Management Plan* (FY 2023 SSMP).

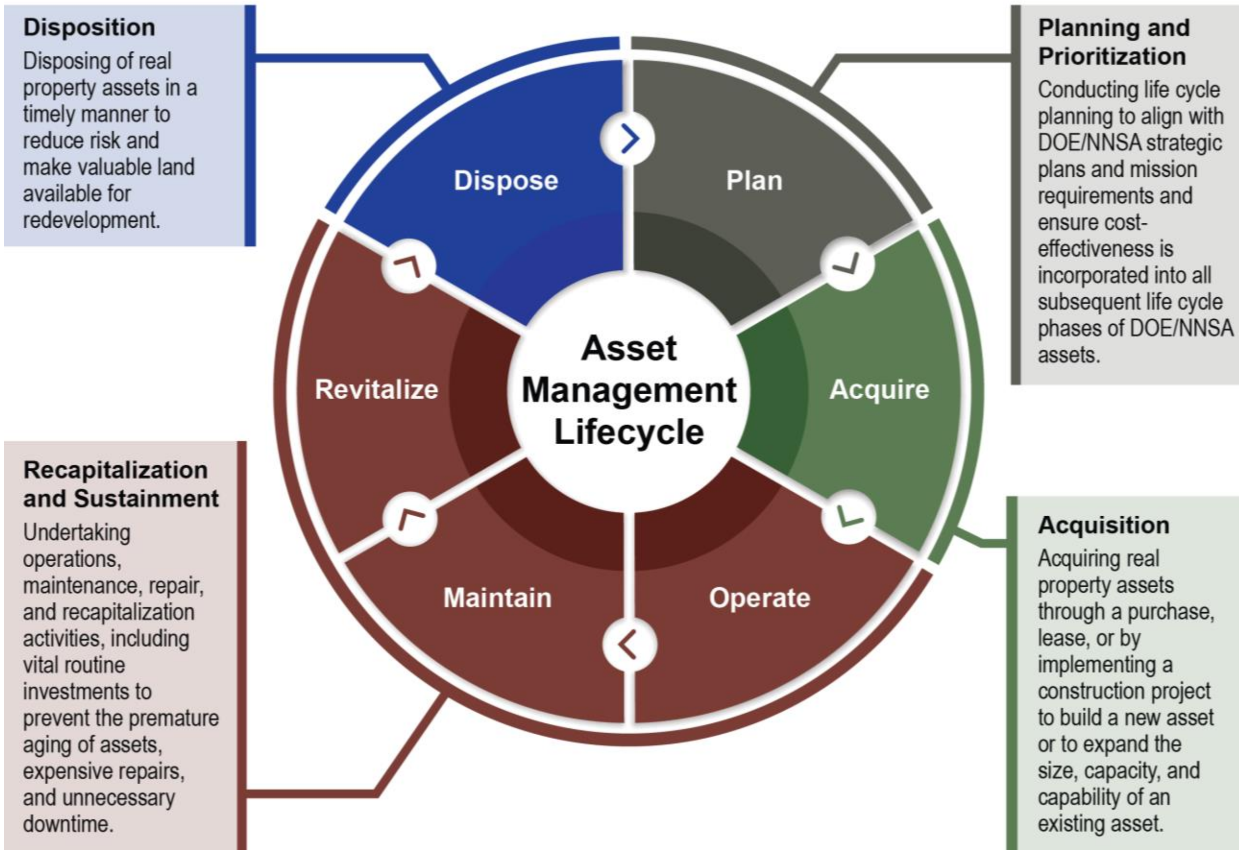


Figure 6–2. Asset management lifecycle

In addition to modernizing DOE/NNSA's physical infrastructure, continuous investments are required to sustain and modernize critical physical security and cybersecurity elements across the nuclear security enterprise. Specific construction and recapitalization activities related to security are included in Sections 6.3 and 6.4. Additional physical security and information technology/cybersecurity activities are described in Chapter 5, Security.

6.1 Challenges and Strategies

To enable the nuclear deterrent mission, DOE/NNSA develops and implements infrastructure modernization strategies to meet significant challenges:

- The need to address the poor, but improving, conditions of DOE/NNSA facilities
- Continued execution of comprehensive, enterprise-wide lifecycle asset management
- The need for a more responsive, resilient enterprise
- The need for more efficient, effective execution

More than half of DOE/NNSA facilities are not in sufficient condition to serve mission needs (e.g., poor or very poor condition). Nearly 25 percent are in fair condition and must be vigilantly maintained to avoid degradation (see **Figure 6–3**). Nearly 60 percent of facilities are more than 40 years old, nearly 30 percent of facilities were constructed during the early Cold War era, and 8 percent are deemed excess to mission needs. The success of DOE/NNSA's unique national security mission depends on creating a safe, reliable, and modern infrastructure. However, the current state of DOE/NNSA's infrastructure poses risk to the availability, capacity, and reliability of Weapons Activities capabilities.

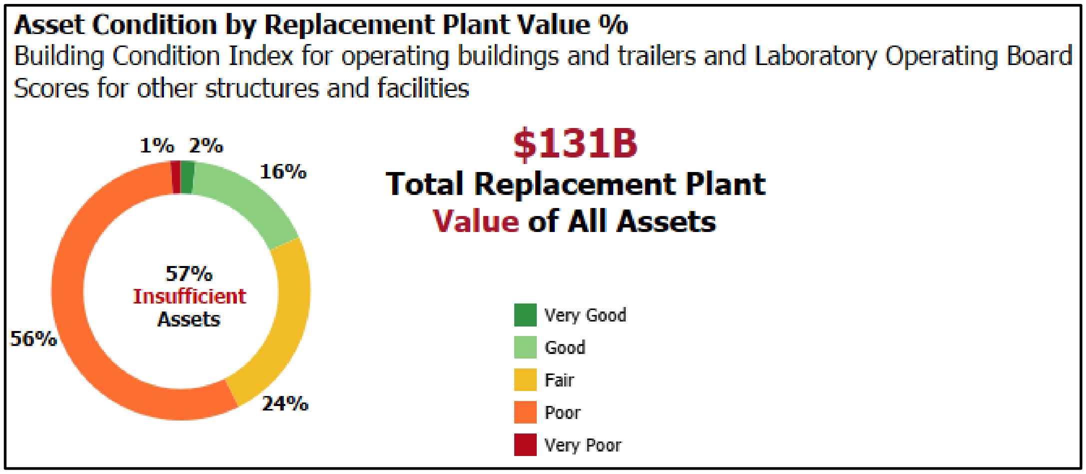


Figure 6–3. Asset condition by replacement plant value percentage

The Need for Enterprise-Wide Lifecycle Asset Management

Though major production capabilities have received strong support, DOE/NNSA must appropriately prioritize sustainment of all capabilities that enable Weapons Activities programs throughout the lifecycle of those capabilities. Going forward, DOE/NNSA must balance executing a handful of high-visibility megaprojects needed to produce strategic materials and recapitalizing the many smaller components or systems and facilities necessary for the design, production, and qualification of U.S. nuclear weapons components. Additionally, DOE/NNSA continues to invest in and sustain facilities and capabilities to support important nonproliferation and counter-terrorism missions at DOE/NNSA.

DOE/NNSA's assets include over 5,500 facilities, including major programmatic, office and laboratory buildings, electrical distribution systems, and security infrastructure. More than half of those assets are currently in insufficient condition and beyond their life expectancy. Upgrading or replacing aging infrastructure will require significant and sustained investment. By addressing infrastructure needs, DOE/NNSA can improve the overall condition of the physical infrastructure, increase efficiency of operations, and improve worker morale thereby increasing the ability to attract and retain the next-generation workforce.

A More Responsive, Resilient Enterprise

Supporting multiple concurrent warhead modernization programs requires a more responsive and resilient infrastructure. The modern nuclear security enterprise lacks resiliency, and aging facilities and equipment present a risk to mission execution. Further, the existing infrastructure lacks the capacity in some areas to meet emerging mission requirements, with the result being that the enterprise may not be sufficiently responsive for future anticipated mission.

To meet expected future demands, DOE/NNSA's challenge is to transform the infrastructure so it is responsive and resilient enough to enable development and deployment of new weapon designs and refurbishments more rapidly and at lower risk than is currently possible. This transformation also includes continued sustainment and advancement of the DOE/NNSA's research and development (R&D) capabilities to facilitate technological advancements to support the future stockpile.

More Efficient, Effective Execution

DOE/NNSA is taking steps to address the declining state of infrastructure through enhanced and optimized resources, including use of innovative management tools to facilitate a data-driven, risk-informed planning process to guide investment decisions. Sites are also making investments to recapitalize facilities and equipment in support of multiple capabilities. The nuclear security enterprise demands best-in-class safety and physical security practices, emergency preparedness and response, and enhanced cybersecurity to counter the unexpected. Additional investments in these areas ensure those demands are met.

The remainder of the chapter describes how DOE/NNSA is resolving these challenges through continuing improvements in data-driven long-term planning and project execution.

6.2 Infrastructure Planning and Asset Management

Infrastructure planning and asset management covers the planning phase for operational and capital investment needs. Operational planning involves the maintenance, repair, and operation of facilities, utilities, and equipment at the sites. Strategic investment planning includes major system upgrades and replacement. Capital investment planning involves identifying future and anticipated emerging needs in the weapons programs, as well as science and technology investments to support those missions into the foreseeable future. Operational and capital investment planning must work in tandem to achieve the desired balance and cost-effectiveness that reflects capable asset management.

DOE/NNSA has taken considerable action over the last 5 years to better understand the nuclear security enterprise's long-term strategic investment needs. DOE/NNSA is using data driven, risk informed tools to better pinpoint when and where infrastructure investments are needed. These tools are reducing mission risk by improving decision making, increasing buying power, and accelerating delivery. Direct mission needs are integrated and aligned with routine infrastructure sustainment and renewal processes to create a comprehensive plan for long-term investments. Bottom-up planning across the nuclear security enterprise is completed through area planning, described below, and deep dive reviews. Asset management software has provided accessible data for maintenance and sustainment-needs planning. Because of this expanded, more integrated planning, DOE/NNSA has a comprehensive understanding of the state of its physical assets and the actions needed to acquire, sustain, recapitalize, and dispose of its assets. These processes are also aligned with industry standards.

The asset management lifecycle, shown in Figure 6–2, is the basis for all investment planning within DOE/NNSA. It can be applied to a single facility or, if applied to numerous facilities, it can be used to organize the way the infrastructure program operates. The elements of the cycle must remain in balance to allocate resources appropriately to optimize the nuclear security enterprise's ability to accomplish the mission and keep the nuclear security enterprise assets healthy. While the model appears straightforward, the processes used to achieve that balance across multiple facilities for the purpose of meeting multiple competing priorities are not. The following sections include some definitions of terms and background to understand these intricacies and to aid in understanding the nuclear security enterprise's broad extent of investment planning and execution.

6.2.1 Area Planning

The newest element of DOE/NNSA's planning process is area planning, which connects DOE/NNSA's Strategic Vision for the future nuclear security enterprise with planned infrastructure investments. The area plans provide detailed information on the lifecycle management strategies of co-located or functionally similar facilities, buildings, and other structures at each site. Area plans are part of an integrated planning process that flows from high-level requirements to interdependent project plans. Frequent communication among stakeholders at all levels through infrastructure deep dives and other forums keeps the planning process in alignment with DOE/NNSA mission needs. Area plans consider multiple funding sources and are regularly updated to reflect the latest developments and priorities.

> ***Savannah River Site (SRS) Transition***
>
> *As the SRS mission requirements for DOE/NNSA increase and DOE's Office of Environmental Management progresses toward a defined end state of the site's clean-up mission, the primary authority, accountability, and site stewardship responsibility for SRS is planned to transition to DOE/NNSA by 2025. An implementation plan for the necessary infrastructure, contract, and budgetary transfers is underway.*

DOE/NNSA and its management and operating (M&O) partners have developed area plans which align mission capabilities with associated assets across the nuclear security enterprise. These area plans showcase important elements of each capability's long-term infrastructure plans and span direct mission and mission-enabling capabilities. They cover a myriad of topical areas, from flagship experimental facilities, weapon component production facilities, to utilities and emergency services. When viewed collectively, area plans provide a roadmap for modernizing DOE/NNSA infrastructure to deliver the mission.

6.2.2 Weapons Activities Line-Item Planning Integration

The Weapons Activities line-item planning integration process establishes procedures to consolidate the line-item data collection process and synchronize infrastructure planning across Weapons Activities programs. The integrated planning process is conducted in collaboration with the DOE/NNSA laboratories, plants, and sites to identify and prioritize major line-item construction projects for Weapons Activities programs. This prioritization informs near- and long-term planning efforts for programmatic and mission-enabling construction projects. It also informs the Future Years Nuclear Security Program programming and budgeting process as projects reach appropriate milestones.

> ***DOE/NNSA Construction Categories***
>
> *Line-item – a construction project with total estimated cost greater than the minor construction threshold, so called because the project requires its own line-specific authorization and appropriation by Congress.*
>
> *Minor Construction – any plant project not specifically authorized by law for which the approved total estimated cost does not exceed the minor construction threshold of $30 million.*
>
> *Institutional Minor Construction – a minor construction project that addresses an institutional, multi-program, general site need rather than a specific program need, using funding derived from indirect cost pools.*

Programmatic infrastructure investments are linked to mission-specific capabilities within Weapons Activities, such as plutonium modernization. They address investment needs for direct programmatic infrastructure including facilities, computers, diagnostic equipment, weapon-related production facilities and equipment, or anything else that enables the nuclear security enterprise to carry out research, testing, production, and sustainment activities to meet its national security missions. In contrast, mission enabling infrastructure provides support for programmatic activities, including general purpose office buildings, site-wide support facilities, utilities, and equipment. Both types of investments are required to sustain Weapons Activities capabilities in the near-term and for the foreseeable future.

> ***Cost Estimating and Analysis Group (CEAG)***
> *The CEAG, a DOE/NNSA organization led by headquarters and including cost estimating experts from each DOE/NNSA site, aims to improve programmatic cost estimating capabilities across the nuclear security enterprise. To improve cost estimating for line-item capital acquisition projects, CEAG developed a Capital Acquisition Estimating Framework reminiscent of that developed for weapons modernization to ensure consistent program cost estimating support and improved data stewardship among headquarters and the sites.*

Consolidating line-item investment proposals combine multiple data collection processes currently in use and ensures a consistent, repeatable planning process for all line-item construction projects. The program offices' comprehensive review of project proposals prior to Critical Decision (CD)-0, *Approve Mission Need,* ensures all current and proposed line-item construction projects (detailed in Sections 6.3.1–6.3.2) represent necessary investments to support the program of record. The cost estimation process for proposals within capital acquisition has been improved by the Cost Estimating and Analysis Group (CEAG) and is further described in Chapter 8, Section 8.9.3.

6.2.3 Critical Decision Acquisition Milestone Process

A basic understanding of DOE's CD acquisition milestone process is integral to understanding current and planned line-item construction projects and major item of equipment (MIE) projects. DOE Order 413.3B, Chg 6, outlines a series of staged approvals for line-item and MIE projects greater than $50 million, each of which is referred to as a CD. Each CD stage requires specific deliverables prior to and during the process to progress to the next stage. **Figure 6–4** shows the four phases of the CD process (Initiation, Definition, Execution, and Closeout), with their corresponding CD stages.

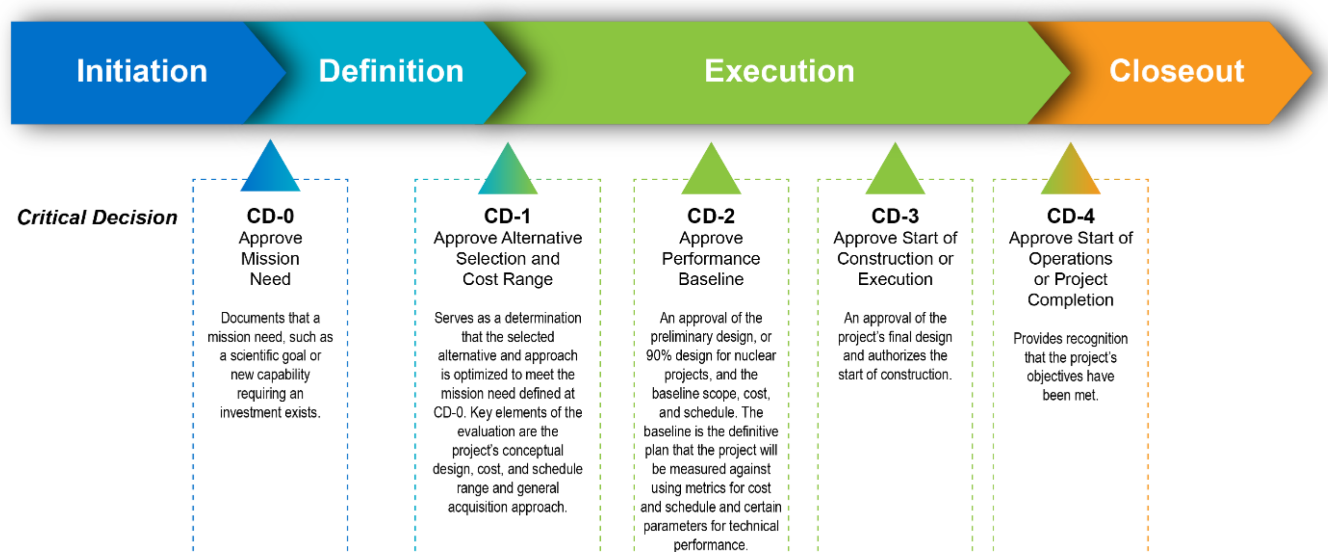
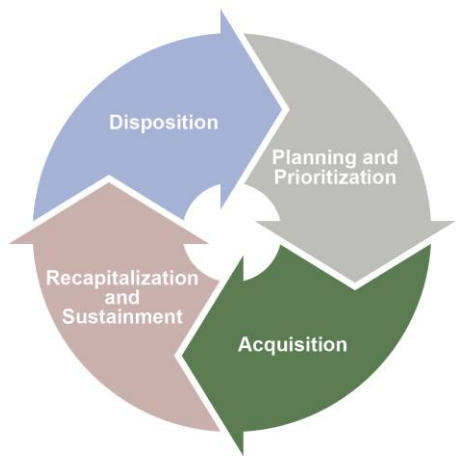


Figure 6–4. Critical Decision process

Activities prior to CD-0, *Approve Mission Need*, through approval of CD-1, *Approve Alternative Selection and Cost Range*, constitute the Definition Phase. These activities are prerequisites to commencing the Execution Phase, which includes approval of CD-2, *Approve Performance Baseline*, approval of CD-3, *Approve Start of Construction*, and activities up to CD-4.[2] Approval of CD-4, *Approve Start of Operations or Project Completion*, reflects project completion based on previously determined criteria and the approval to transition to operations. DOE/NNSA Supplemental Directive 413.3 provides further guidance on this process, including that DOE/NNSA typically combines CD-2 and CD-3. The beginning of CD-4 marks the transition into the Closeout Phase. The approval of CD-4 is predicated on the readiness to operate and maintain the system, facility, or capability. Transition and turnover do not necessarily terminate all project activities. In some cases, it marks a point at which the operations organizations assume responsibility for operating and maintaining the new facility.

6.3 Acquisition

DOE/NNSA has more than 5,500 facilities with an average age of 47 years. Many of the largest and most complex facilities will require line-item construction projects to accomplish modernization or replacement. Since aging facilities represent increasing risk to mission execution and line-item projects require significant coordination and funding over multiple years, DOE/NNSA continues to evaluate line-item construction project proposals as a part of the overall 25-year plan for Weapons Activities to identify for decision-makers the long-term funding levels required to replace infrastructure that has or will be aging out in that time period.



DOE/NNSA also actively works to improve its acquisition process to make efficient use of the funding that is provided. For example, DOE/NNSA recently launched two initiatives with the goal of streamlining design and acquisition, while decreasing cost and schedule impacts.

Enhanced Minor Construction and Commercial Practices (EMC^2)

In 2019, DOE/NNSA launched the EMC^2 pilot, which is successfully piloting a streamlined approach to executing $25–$50 million line-item projects that utilize a tailored DOE Order 413.3B processes. The pilot has established a new, streamlined process for a class of commercial-like, low-risk, low-cost construction using the International Building Code, Federal Safety Regulations (e.g., 10 Code of Federal Regulations [CFR] 851), and the Federal Acquisition Regulation as the framework. The EMC^2 pilot is challenging nuclear security enterprise historical processes to create a streamlined process for acquiring non-complex, non-nuclear capital construction projects. Key elements of the approach include:

- Clearly defining decision making authority, project supervision, direction, and oversight to the lowest levels to prevent redundancy and miscommunication
- Applying commercial construction standards and streamlining Environment, Safety, and Health requirements to match the project risks to project complexity
- Simplifying the project delivery model for some similar DOE/NNSA projects

[2] See DOE Order 413.3B for details regarding projects requiring long-lead procurement. If long-lead procurements are executed prior to CD-3 approval for the project, this is designated as CD-3A and requires an additional stand-alone CD by the Project Management Executive.

> ***Management and Performance***
>
> *DOE/NNSA is committed to encouraging competition and increasing the universe of qualified contractors by streamlining major acquisition processes. DOE/NNSA will continue to focus on delivering timely, best-value acquisition solutions for all programs and projects, by using a tailored approach to contract structures and incentives that are appropriate for the special missions and risks at each site. DOE/NNSA continues to:*
>
> - *Lead improvements in contract and project management practices*
> - *Provide clear lines of authority and accountability*
> - *Improve cost and schedule performance*

Cost savings up to 31 percent were realized on the four pilot projects. An additional six EMC^2 projects that support vital mission work are projected to result in estimated cost savings of 20–40 percent. In support of increasing buying-power and accelerating delivery, the EMC^2 pilot is testing and measuring the effectiveness of using existing successful minor construction project management instead of standard DOE Order 413.3B requirements and using commercial practices for oversight (e.g., Occupational Safety and Health Administration-like safety) for non-complex projects. This approach aligns with the fiscal year (FY) 2018 *National Defense Authorization Act* mandate to streamline the process for construction of non-nuclear facilities that have a total estimated cost of less than $100 million. A DOE/NNSA Supplemental Directive which incorporates EMC^2 processes for non-nuclear, non-complex construction projects with a Total Project Cost less than $100 million is in the process of being issued. Ongoing and proposed projects that are making use of the EMC^2 pilot are indicated in Section 6.3.2, Mission Enabling Construction.

Standardized Acquisition and Recapitalization (STAR)

The goal of the Standardized Acquisition and Recapitalization (STAR) initiative is to simplify the design and delivery of commercial-like buildings starting with small offices and light laboratories while meeting DOE standards, such as the Guiding Principles for Sustainable Federal Buildings. It has two elements:

- Design Library: STAR has created a library of concept-level designs that are submitted by sites, owned by DOE/NNSA, and can be reused or referenced by any site. By the end of 2022, there were 20 designs in the library, 10 STAR projects underway, and three more planned. Reusing successful designs is expected to save time and money.
- Design Criteria: LANL and Nevada National Security Site (NNSS) are leading the development of unified design standards and creating a standard design process for office buildings that can be used by all sites. By the end of 2021, they delivered conceptual designs for two buildings, each with construction estimates under $25 million, and completed their detailed designs in FY 2023. This initiative has expanded to include conceptual design for a $50 million building. Moving forward, the remaining six sites' criteria and processes will be reviewed and incorporated into the current model to create an Enterprise-wide standard.

In addition to the EMC^2 and STAR initiatives, DOE/NNSA continues to review line-items across the nuclear security enterprise to better ensure infrastructure is in place to meet mission requirements, while improving DOE/NNSA's facility condition and reducing the average facility age to a sustainable level. **Figure 6–5** shows the DOE/NNSA's facilities' historical average age growth and the planned reduction in average age after completing the projects described in the following sections. The average age calculation considers all DOE/NNSA facilities.

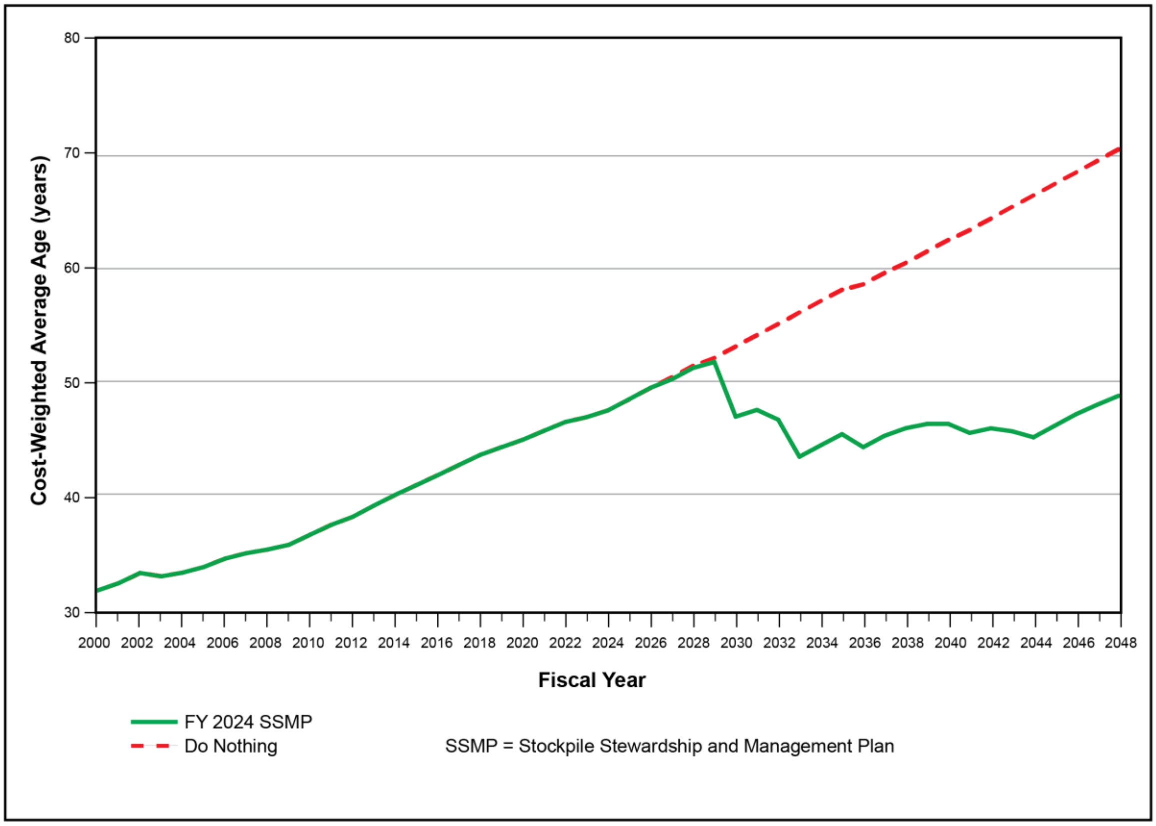


Figure 6–5. Historical and projected average age of all DOE/NNSA facilities

This section discusses the current and planned line-items for the nuclear security enterprise. Programmatic line-items are presented by Weapons Activities capability area, followed by mission-enabling line-items. The third section details other recent acquisition efforts undertaken by DOE/NNSA.

6.3.1 Programmatic Construction

Programmatic construction projects are categorized according to the Weapons Activities programs, which are detailed in Chapters 3, 4, and 5. The Stockpile Management Program does not fund programmatic construction projects. Sections 6.3.1.1–6.3.1.3 describe current and proposed line-item projects within each program, including their projected schedules and cost ranges. Project proposals (Pre-CD-0) capture potential mission gaps and emerging requirements across the nuclear security enterprise. However, they have not yet formally achieved approval of their mission need (per the CD process) nor accomplished the alternatives analysis to determine the best way to meet the need. The projected schedules and cost ranges shown represent one potential planning scenario and may change in future Stockpile Stewardship and Management Plans (SSMPs) as stockpile and enterprise requirements are refined and alternatives are formally assessed.

6.3.1.1 Production Modernization

Line-item projects in this section encompass the suite of subprograms within Production Modernization, including Primary Capability Modernization, Secondary Capability Modernization, Tritium and Domestic Uranium Enrichment, Non-Nuclear Capability Modernization, and Warhead Assembly. Additional information about these subprograms can be found in Chapter 3. Current planning estimates and schedule dates for projects in this program are listed in **Figure 6–6**.

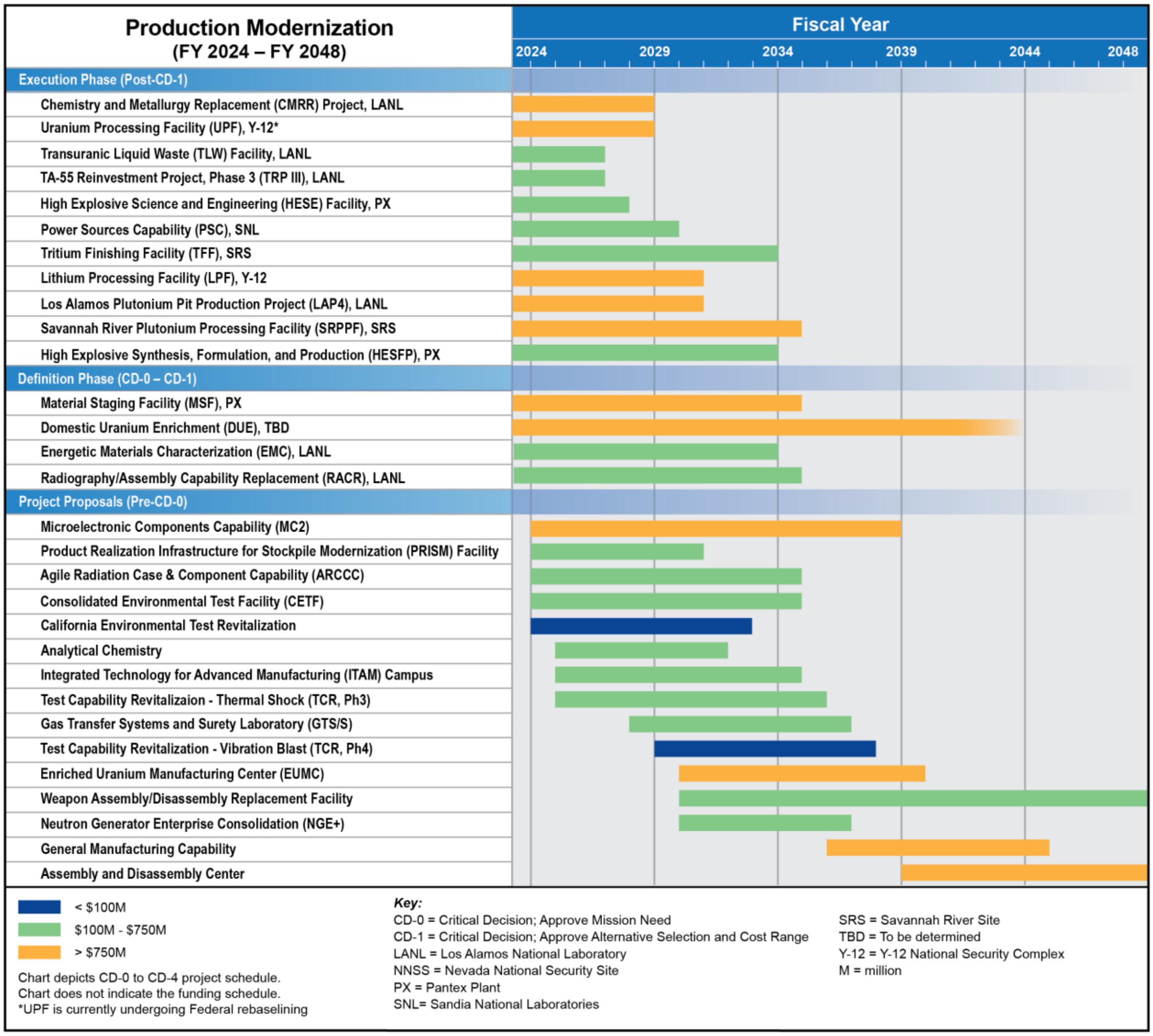


Figure 6–6. 25-year programmatic line-item schedule for ongoing and proposed projects under Production Modernization

The Production Modernization program is currently executing 10 programmatic line-item construction projects that are past CD-1. Cost and schedule estimates for these projects vary from conceptual design-based estimates to baselined project estimates:

- The **Chemistry and Metallurgy Research Replacement (CMRR)** project will maintain continuity in enduring analytical chemistry and materials characterization capabilities for DOE/NNSA actinide-based missions, such as pit production, and to maintain LANL as the Nation's Plutonium Center of Excellence missions. Active subprojects include reconfiguring space and installing additional analytical chemistry and materials characterization equipment in the Radiological Laboratory Utility Office Building and in the Plutonium Facility (PF-4).
- The **Transuranic Liquid Waste Facility** will support transuranic liquid waste treatment, which is a key support capability for DOE/NNSA operations at PF-4 at LANL. The current facility that treats liquid waste is past its useful life and does not meet current codes requirements. The Transuranic Liquid Waste Facility is designed to receive up to 29,000 liters of liquid waste annually from PF-4 operations, which produces pits for the Nation's enduring stockpile.

- The **Technical Area (TA)-55 Reinvestments Project, Phase 3** has begun and supports design and construction for new fire alarm systems in PF-4 at LANL and removal of the old system. Due to the current system's age, replacement parts are no longer readily available, adding risks to the program.
- The **High Explosive Science and Engineering (HESE) Facility** will construct three new buildings to qualify and surveille high explosives, provide a technology development laboratory and office space for technical staff. It will replace 15 current Manhattan Project-era facilities at the Pantex Plant (Pantex), support the high explosives (HE) Center of Excellence for Manufacturing mission for DOE/NNSA, and help sustain high-quality scientific staff. The average age of the facilities to be replaced is 68 years old. The HESE facility will be approximately 73,000 square feet. Project design is complete and received CD-2 and -3 approval in April 2022. Site preparation and long lead procurement activities began in FY 2021. The main works contract has been awarded and construction started in May 2022.

Construction on the High Explosive Science and Engineering Facility at Pantex

- The **Los Alamos Plutonium Pit Production Project (LAP4)** will support plutonium pit production at LANL. The LAP4 project replaces aging and outdated equipment with pit manufacturing equipment in the PF-4 at LANL to increase throughput. LAP4 achieved CD-2 and -3 for the Decontamination and Decommissioning subproject in the first quarter of FY 2022. Additionally, CD-3a was approved for long lead procurement of gloveboxes to support the 30 pits per year equipment subproject.
- The **Savannah River Plutonium Processing Facility (SRPPF)** will support plutonium pit production by repurposing the former Mixed Oxide Fuel Fabrication Facility into a safe, secure, compliant, and efficient pit production facility. The former Mixed Oxide Fuel Fabrication Facility is a Security Category I/Hazard Category II[3] structure that provides an opportunity to achieve pit production in a facility designed to meet stringent security and safety requirements for plutonium operations. The Savannah River Plutonium Processing Facility will provide a sustained production capacity of no fewer than 50 War Reserve pits per year as close to 2030 as possible at SRS. The project achieved CD-1 in FY 2021.
- The **Uranium Processing Facility (UPF)** project will complete the Uranium Mission Strategy's first phase and ensure the long-term viability, safety, and security of DOE/NNSA's enriched uranium capability. It will provide a modernized capability to manufacture weapon subassemblies containing enriched uranium components and convert excess enriched uranium into forms suitable for safe, long-term storage and reuse. The new facility will support Y-12 National Security Complex's (Y-12) enriched uranium processing capabilities currently located in Building 9212, which is an original Manhattan Project-era facility that is degraded, poorly configured to meet today's strategic needs, and poses multiple risks to meeting the mission.

[3] A Security Category I facility is one designed to contain certain quantities of strategic special nuclear materials that trigger the most rigorous level of security protections. Hazard Category II facilities are those for which a hazard analysis shows the potential for significant off-site consequences in the event of an accident.

Manhattan Project-era Building 9212 at Y-12 (left) and construction on its replacement, the Uranium Processing Facility, in September 2022 (right)

- The **High Explosives Synthesis, Formulation, and Production Facility (HESFP)** project at Pantex will establish HE production capability within the nuclear security enterprise to address the need to meet DOE/NNSA production requirements. This project will consolidate limited legacy facilities that are inadequate for the mission need and will ensure the required capability and capacity is available to meet the future HE workload and mission requirements. Areas to be addressed include explosive and mock formulation operations to support multiple weapon programs, technology development for future programs, and support for strategic partners. CD-1 was awarded in February 2021. However, as DOE/NNSA is facing issues like higher-than-expected inflation and supply chain and craft worker shortages while executing multiple large construction projects in parallel at individual sites, DOE/NNSA rebalanced line-item construction portfolio in recognition of the nuclear security enterprise's capacity to execute construction. *As this project can be deferred at this time without significant mission impact, it is planned to be paused between FY 2024–2026.*
- The **Lithium Processing Facility (LPF)** will construct a new facility to replace lithium processing capabilities in Building 9204-2 at Y-12. At 80 years old, the current lithium facility is one of the oldest operating facilities in the nuclear security enterprise. Until the new LPF is operational and qualified, much of the risk to lithium sustainment is associated with the existing facility's age and degradation. A site for LPF has been selected at Y-12 and the former Biology Building was demolished to make room for this project. Lithium process design is 60 percent complete. Facility design and site civil exploratory boring activities have commenced.
- The **Tritium Finishing Facility (TFF)** project at SRS will construct two new process buildings and relocate the reservoir-related and other capabilities from the current 65-year-old facility to the newer, centralized facilities. This alternative will significantly increase facility reliability specific to natural phenomena hazards, addressing Defense Nuclear Facilities Safety Board concerns. *While 30 percent design completion was authorized for the overall project, the need to prioritize staffing for SRPPF at SRS led DOE/NNSA to pause TFF from FY 2024–2026.* Funding carried over from FY 2023 will be used to complete site preparation work and 30 percent overall project design, as well as 60 percent of classified process design, to better position the project for resuming in FY 2027.
- The **Power Sources Capability (PSC)** project will support all current and planned nuclear weapon systems that require power source research, development, design, qualification, production, and surveillance activities. Requirements for these power sources are stringent and unique to nuclear

weapons, and very few commercial suppliers are viable for this work. The current facility cannot meet anticipated mission requirements due to increasing workload and poor facility condition, which poses increasing risks to meeting weapon program deliverables. DOE/NNSA also supplies advanced power sources for other national security mission needs that cannot be commercially sourced. This project will mitigate risk by establishing a new facility that is adaptable to changing needs, enables engagement with supply chain partners, supports technology development, and fosters innovation.

The following programmatic line-item projects under Production Modernization are in the Definition Phase of the CD process (CD-0 to CD-1):

- The **Domestic Uranium Enrichment (DUE)** project will analyze options for (and if necessary, establish) a reliable and economic supply of enriched uranium to support U.S. national security needs. The U.S. Government does not currently have the capability to enrich uranium for defense missions.
- The **Energetic Materials Characterization (EMC)** project will support R&D to advance predictive capabilities for safety and performance assessments, component qualification and surveillance, evaluate material responses to all aspects of the stockpile-to-target sequence, resolve significant finding investigations (SFIs) involving energetic materials, provide technical data on which to base annual weapon assessments, and develop new/replacement materials to support evolving HE technical requirements. The project will consolidate 18 structures at LANL into a single modern facility to increase operational efficiency and reduce operating costs. However, as DOE/NNSA is facing issues like higher-than-expected inflation and supply chain and craft worker shortages while executing multiple large construction projects in parallel at individual sites, DOE/NNSA rebalanced line-item construction portfolio in recognition of the nuclear security enterprise's capacity to execute construction. *As this project can be deferred at this time without significant mission impact, it is planned to be paused between FY 2024–2026.*
- The **Radiography/Assembly Capability Replacement (RACR)** project received CD-0 approval in October 2022. However, an integrated project team has since been tasked to investigate alternative strategies of meeting the program requirements in lieu of a single line-item investment. The pre-analysis of alternatives effort is underway to support acquisition, and further decisions have yet to be made regarding a path forward and preparation for initial design and baseline cost. Once constructed, RACR will consolidate existing assembly and radiography operations, currently conducted in a multitude of facilities dating to the 1950s. Safety, security, schedules, and quality assurance will all improve with RACR, while risk to the public, workers, and program will decrease. RACR will position the DOE/NNSA nuclear weapons program for nuclear explosive package assembly and radiography capability for the next 40 to 50 years for all site and surveillance mission assignments.
- The **Material Staging Facility (MSF)** at Pantex was placed on hold in April 2021. The project will provide a new safe, secure, and sustainable below-grade facility adjacent to Zone 12 South Material Access Area that meets weapon and special nuclear material (SNM) component staging capacities for the next 75 to 100 years. Prior to the project being placed on hold, SRS surplus plutonium material and Hanford Unirradiated Fuel Packages were also planned into the project. Significant cost reduction can be realized in the project with these items removed from consideration now that the State of South Carolina has settled its lawsuit with DOE. It will include shipping and receiving docks for SNM, and for transporting weapons in the Mobile Guardian Transporter and Safe Secure Transport.

In addition to projects in the Definition and Execution Phases, Production Modernization is considering several programmatic line-item proposals (Pre-CD-0). These project proposals are a part of the planning process, but should not be considered part of the program of record until they achieve appropriate approvals. Scope descriptions are illustrative, with DOE/NNSA evaluating options during the Analysis of Alternatives and making decisions at CD-1:

- The **Agile Radiation Case and Component Capability (ARCCC)**, formerly the Depleted Uranium (DU) Manufacturing Complex, would consolidate several processes required to meet the DU mission, and replaces capabilities currently located in other buildings. DU production facilities that support canned subassembly production at Y-12 were constructed in the 1940s and 1950s. These facilities perform production work for DU, and general manufacturing and are vital to canned subassembly production. They are oversized for today's mission, do not meet current codes and standards, are costly to operate, have many operating issues, and have exceeded their expected life. These facilities must be upgraded or replaced to ensure continued mission availability and to reduce annual operating costs.
- The **Product Realization Infrastructure for Stockpile Modernization (PRISM)** facility, formerly the Next Generation Life Extension Program (LEP) Research and Development Component Fabrication Facility, is a joint design agency-production agency-owned collaborative space and testbed that can assess, develop, tailor, and transition new manufacturing technologies and designs that would enable DOE/NNSA to accelerate the development and production of non-nuclear components for future modernization programs.
- The **Tritium Development Laboratory (TDL)** would reestablish the radiological research and development capability required for maturation and de-risking of new tritium and gas transfer system (GTS) processing technologies to meet mission requirements, address obsolescence, increase efficiency, and maintain core competencies. A DOE/NNSA study is underway to assess current capabilities across the DOE to establish whether TDL is needed. Due to this ongoing study, the proposal is not included in Figure 6-6 above.
- The **Microelectronic Components Capability (MC2)** project, formerly the Heterogenous Integration Facility, would provide modern and agile clean room space to support microelectronic design and production at the Microsystems Engineering, Science, and Applications (MESA) complex at SNL. Determination that a new facility is needed is based on analysis of MESA's age and space limitations, the rapid evolution of microelectronics fabrication technologies, and expectation of the potential need to continuously produce Trusted and Strategic Radiation-Hardened microelectronics while simultaneously installing new fabrication and production capabilities. The proposed facility would provide state-of-the-art cleanroom space, integrate a variety of microelectronic technologies, and would accommodate the evolving tool-size platforms that are not possible in the current MESA complex.
- The **Neutron Generator Enterprise Consolidation** project would optimize manufacturing by consolidating existing facilities for neutron generator operations that are currently conducted in several buildings across multiple sites. Additionally, modernizing aging infrastructure and providing flexible-use space is needed to accommodate agile responses to advancing requirements and technology, develop material and personnel flows, improve efficiency, consolidate processes, and reduce redundancies, waste, and risks to mission work.
- The **Consolidated Environmental Test Facility** aims to upgrade, modernize, and consolidate environmental testing capabilities in support of stockpile modernization programs and limited life components associated with enduring the stockpile.

- The **California Environmental Test Revitalization** project is intended to improve the efficiency, effectiveness, agility, and responsiveness of the California environmental test capabilities through structural upgrades to aging facilities to meet modern security standards and current energy codes.
- The **Analytical Chemistry** project would construct a stand-alone laboratory to replace the current analytical chemistry capabilities at Y-12 and remove the analytical chemistry laboratory capability from the future Enriched Uranium Manufacturing Center. This would enable replacement in an earlier year, and ensure the capability is viable to support all future mission requirements.
- The **Test Capability Revitalization - Thermal Shock (Phase 3)** and **Test Capability Revitalization - Vibration Blast (Phase 4)** projects focus on large subsystem- and system-level test facilities in thermal, fire, acceleration, impact, shock, and other environments. Phases 3 and 4 would renovate or replace existing capabilities and/or develop new capabilities at current facilities.
- The **Integrated Technology for Advanced Manufacturing (ITAM) Campus** project would create modern infrastructure with capabilities for development of advanced assembly system technologies (robotics and automation, welding, inspection, etc.) to accelerate deployment. ITAM would collocate several capabilities, including manufacturing, assembly, computing, characterization, and inspection expertise, in an open, collaborative space with the ability to elevate to secure, when needed.
- The **Gas Transfer Systems and Surety (GTS/S) Laboratory** would provide what is needed to meet GTSs and Surety enduring mission needs for future systems, such as the W93. The current facility is over 60 years old and has had several modifications made to temporarily shore up capabilities to meet past and current mission work. The future laboratory would provide a modern, lower maintenance structure capable of meeting the expanded, future demands of the weapons program. Work areas and equipment require an efficient layout and current state-of-the-art technology to meet future testing needs.
- The **General Manufacturing Capability** project would consolidate all the general manufacturing capabilities into a single, separate new build at Y-12. The non-nuclear general manufacturing operations provide components to support all secondary component fabrication, assembly, and inspection. Portions of the capability in the current facility have been identified for relocation to the future DU Manufacturing Center; however, this project would account for those processes not currently identified for replacement.
- The **Enriched Uranium Manufacturing Center (EUMC)** would complete the second phase of the Enriched Uranium Strategy. The new facility would support Y-12's enriched uranium processing capabilities. Functional Areas include machining, chip cleaning and conversion, dimensional inspection, and enriched uranium recycle and recovery operations.
- The **Assembly and Disassembly Center** project completes the third and final phase for the Enriched Uranium Strategy. The new facility would support Y-12's enriched uranium processing capabilities. Capabilities include product certification, quality evaluation and surveillance, assembly of components, dismantlement and disassembly of components, radiography, and dimensional inspection.
- The **Weapon Assembly/Disassembly Replacement Facility** would focus on increasing throughput and efficiencies, lowering operating costs, and reducing the number Technical Safety Requirements controls during weapons assembly/disassembly operations at Pantex. Weapons assembly/disassembly includes assembly, disassembly, refurbishment, maintenance, and

surveillance of stockpile nuclear weapons and weapon components, as well as dismantlement of retired stockpile nuclear weapons. These weapon assembly and disassembly operations are conducted in 60 bay and cell facilities, as well as special purpose satellite facilities. The facilities are, on average, 47 years old with many facility systems using outdated technology and nearing the end of their useful life.

6.3.1.2 Stockpile Research, Technology, and Engineering (SRT&E)

Projects in this section, including both line-items and MIEs, encompass the suite of subprograms within Stockpile Research, Technology, and Engineering (SRT&E), including Assessment Science, Engineering and Integrated Assessments, Inertial Confinement Fusion, Advanced Simulation and Computing, and Weapon Technology and Manufacturing Maturation. Additional information about these subprograms can be found in Chapter 4. Current planning estimates and schedule dates for projects in this program are listed in **Figure 6–7**.

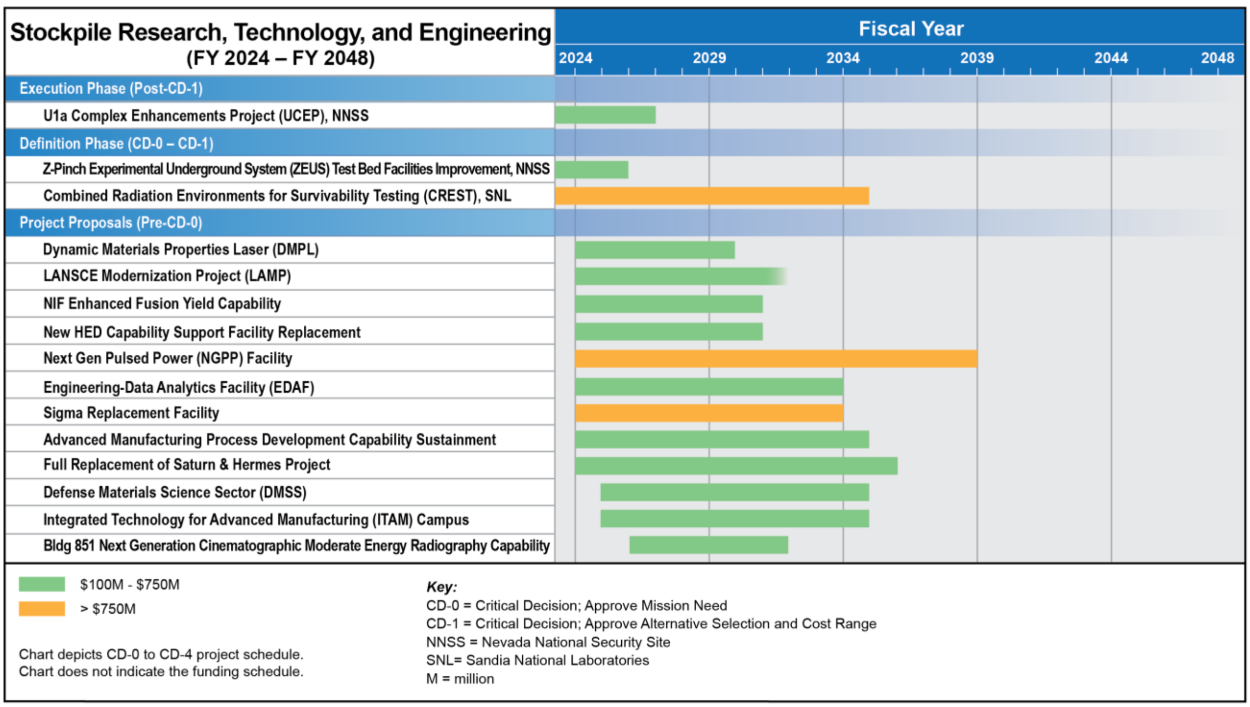


Figure 6–7. 25-year programmatic line-item schedule for ongoing and proposed projects under Stockpile Research, Technology, and Engineering

SRT&E is currently executing two programmatic construction projects that are past CD-1. Cost and schedule estimates for these projects vary from conceptual design-based estimates to baselined project estimates:

- The **Advanced Sources and Detectors (ASD)** project is an MIE that will fill the pulsed X-ray radiography capability gap through developing a multi-pulse linear induction electron accelerator. The scope includes design, technical maturation, fabrication, testing, installation, commissioning, and readiness execution at the U1a Complex (U1a). The ASD project achieved CD-3 in November 2022.
- The **U1a Complex Enhancements Project (UCEP)** comprised of two subprojects, UCEP10 and UCEP20, and will provide infrastructure modifications to the U1a at NNSS to house and field

multi-pulse radiography. This project includes structures, systems, and components necessary for deploying Enhanced Capabilities for Subcritical Experiment Advanced Sources and Detectors Project's pulsed X-ray radiography equipment. UCEP10 achieved CD-4 in June of 2022. UCEP20 achieved CD-2/3 in June of 2022.

The following programmatic line-item project under SRT&E is in the Definition Phase of the CD process (CD-0 to CD-1):

- The **Z-Pinch Experimental Underground System (ZEUS) Test Bed Facilities Improvement** project at NNSS includes the design, construction, and commissioning of the ZEUS Test Bed and systems to support dense plasma focus diagnostics. The area will be used for neutron diagnosed subcritical experiments. Due to changes in scope that have impacted the cost estimate, DOE/NNSA is requesting the conversion of the project from a minor construction project to a line-item construction project.
- The **Combined Radiation Environments for Survivability Testing (CREST)** project will provide an advanced radiation environmental test capability to fill a mission gap for R&D, qualification, and certification data in combined survivability/threat environments. The Annular Core Research Reactor's (ACRR) current capability provides high-fidelity neutron and gamma-ray environments that emulate nuclear weapon environments to support weapons development and certification. Every weapon system in the stockpile undergoes testing at the ACRR and demand is increasing. The facility's age and condition mean ACRR is unable to keep pace with demand. The proposed CREST project will provide a facility that will replace and enhance the legacy capability. This new facility will combine the current ACRR capabilities with an independent gamma-ray irradiation capability in a purpose-built facility specifically designed to meet current and future stockpile modernization needs.

In addition to projects in the Definition and Execution Phases, SRT&E is considering several programmatic line-item proposals (Pre-CD-0). These project proposals are a part of the planning process but should not be considered part of the program of record until they achieve appropriate approvals. Scope descriptions are illustrative, with DOE/NNSA evaluating options during the Analysis of Alternatives and making decisions at CD-1:

- **Mesoscale Science Gap:** The future of DOE/NNSA's predictive models used in assessment of the U.S. nuclear stockpile, and qualification of materials for future weapons systems would be increasingly reliant on experimental data interrogating physics and chemistry at the mesoscale. The mesoscale (1–100 μm) is the length scale in which many important materials, chemistry, and physics behaviors relevant to DOE/NNSA missions exist. Assessment of the future stockpile, maintenance of the current, aging stockpile, and qualification of new materials and manufacturing process changes will rely heavily on an understanding of materials behaviors at the mesoscale in weapons-relevant environments, particularly under the thermal, thermodynamic (including shock), and radiation environments encountered in the nuclear weapons. DOE/NNSA is pursuing a two-site strategy which would leverage the multi-billion dollar investments from the DOE's Office of Science to address this mesoscale science gap: (1) The **Dynamic Materials Properties Laser (DMPL)** is an MIE that would be a high energy (5 kilojoule) long pulse laser capability in partnership with the DOE's Office of Science/Fusion Energy Sciences to complement the Matter in Extreme Conditions-Upgrade line-item project at the Linac Coherent Light Source, and (2) The **Defense Materials Science Sector (DMSS)** would feature a dynamic experiments hutch in addition to a materials science and qualification hutch using enhanced X-ray properties from the Advanced Photon Source – Upgrade project.

- The **Los Alamos Neutron Science Center (LANSCE) Modernization Project (LAMP)** would replace technologically obsolete and high-risk accelerator systems with modern, sustainable technologies to ensure that LANSCE continues to provide a robust capability for dynamic multi-frame proton radiography, neutron scattering on defense-relevant materials, neutron radiography of components and subsystems, and nuclear physics on defense-relevant isotopes. The LAMP scope would address LANSCE accelerator end-of-life system failures and technology obsolescence by modernizing major accelerator systems to optimize beam quality and performance. This modernization would improve reliability, maintainability, efficiency, sustainability, and performance, while ensuring the ability to increase scheduled beam time to LANSCE science stations to meet increased demand. The LANSCE facility's unique capabilities will enable resolution of SFIs, assess the stockpile, evaluate and qualify components for the future stockpile, assess foreign systems, analyze historic and current experiments, and improve computational models. The facility continues to function as a user facility for scientific studies.
- The **Increased Laser Power and Energy on National Ignition Facility (NIF)** project would upgrade the NIF laser, which is currently operating at its highest sustained levels of energy and power to date, made possible only by continued investments in optics and laser technology. Recent ignition experiments show that small increases in laser energy could substantially increase fusion output. Four energy and power upgrade paths are being assessed within the limitations of the current facility.
- The **New High Energy Density (HED) Capability Support Facility Replacement** project would support experimental throughput for the national user facility at NIF with a building that would house key functions such as production and fabrication for targets, diagnostics, and optics in support of HED physics experiments. The new building would provide advanced clean room and laboratory facilities for the next generations of targets and diagnostics for HED physics.
- For the **Next Generation Pulse Power (NGPP) facility,** major gaps exist in high-energy X-ray and neutron sources to test the performance of circuit boards and other large components in the hostile threat environments that a nuclear weapon could experience. There are also gaps in the energy and power required to access the full range of high-energy density conditions relevant to the nuclear explosive package. The proposed NGPP facility would help close the aforementioned mission gaps, while ensuring the safety and effectiveness of the nuclear stockpile by addressing the shortcomings and limitations of the aging Z pulsed power facility (Z).
- The **Engineering-Data Analytics Facility (EDAF)** would enable data collection, storage, and analysis capability by bringing together high-performance computing (HPC), high-performance data-analytics, a scalable data enclave, and an extreme-speed network backbone. These capabilities would enable full-system engineering models (sometimes called digital twins) that would be automatically evaluated to explore combined environments, manufacturing issues, aging materials, and as-fielded conditions, with the results informing additional physical and computational evaluations, design options, and stockpile actions.
- The **Sigma Replacement Facility** project would construct new facilities to maintain and enhance capabilities for the many Stockpile Stewardship support roles that Sigma currently fulfills. These facilities would include the Integrated Technology Testbed for Advanced Manufacturing for developing transformative production technologies and three additional facilities that would support uranium foundry operations, replace LANL main shop capabilities for non-nuclear components, and enable beryllium fabrication capability in a building with appropriate ventilation scaled to support the projected size of future mission need.

- The **Advanced Manufacturing Process Development Capability Sustainment** project would provide for high bay laboratory space to accommodate advanced additive manufacturing research and production-capable manufacturing tools, while also addressing electrical and fabrication laboratories in a reconfigurable space that facilitates agile and rapid product realization. The current facility is in a substandard state and continues to deteriorate. A recent evaluation of the facility indicates the need to replace flooring, air handlers, and water and sanitary systems, as many of these systems have exceeded their initial design life. By FY 2031, the facility will be over 40 years old and will require a substantial investment to sustain this capability, consistent with industry standards.
- The **Full Replacement of Saturn and High-Energy Radiation Megavolt Electron Sources** project would involve the construction of a facility to replace the current capabilities of both. The project would include modified, upgraded, and enhanced accelerators; new buildings for high bay laboratory space, data collection and analysis laboratory space, and light electrical laboratory space; and support, storage, office, administrative, and conferencing space.
- The **Next Generation Cinematographic Moderate Energy Radiography Capability** project would upgrade the Building 851 open firing site to include a 10 mega-electron volt 20-pulse linear induction acceleration and a dense plasma focus for flash neutron radiography. This project would provide capability for cinematographic X-radiography that would enable X-ray movies for important weapons physics experiments, expand options for in-demand hydro tests, and deliver high-fidelity data for validating simulations.

6.3.1.3 Defense Nuclear Security

Line-item projects in this section fall under the Defense Nuclear Security (DNS) program. Additional information about DNS can be found in Chapter 5, Section 5.2. Current planning estimates and schedule dates for projects in this program are listed in **Figure 6–8**.

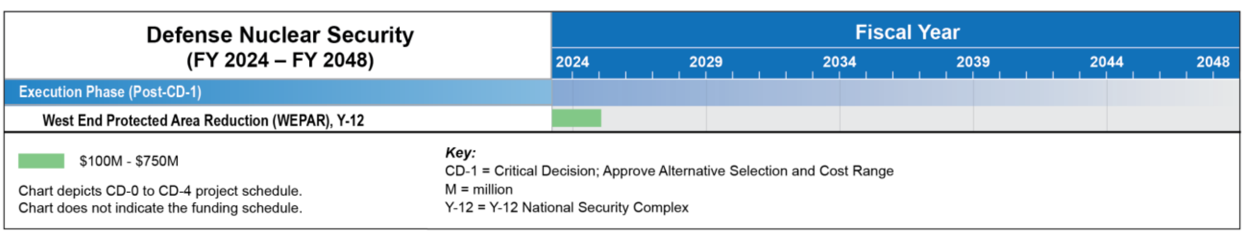


Figure 6–8. 25-year programmatic line-item schedule for ongoing and proposed projects under Defense Nuclear Security[4]

DNS is currently executing one programmatic line-item construction project that is past CD-1. Cost and schedule estimates for this project is the baselined project estimate:

- The **West End Protected Area Reduction (WEPAR)** project will reduce the size of the protected area at Y-12 from 150 acres to approximately 90 acres. This project will have two beneficial outcomes. First, a new Perimeter Intrusion Detection and Assessment System will protect the sensitive facilities remaining within the now reduced perimeter, which will reduce security and operating costs. Second, DOE Office of Environmental Management cleanup activities for facilities previously encompassed by the larger protected area may proceed more efficiently and

[4] The CD-4 date of FY 2025 for WEPAR is subject to revision with the forthcoming project re-plan.

cost effectively because those facilities will no longer be in a protected area. The project received CD-2/3 approval in January 2021.

6.3.2 Mission Enabling Construction

DOE/NNSA also funds mission-enabling infrastructure line-items that provide site-wide utilities, office and laboratory space, and other services that support the nuclear security enterprise missions (see **Figure 6–9**). These projects are required to meet daily operational needs across the nuclear security enterprise.

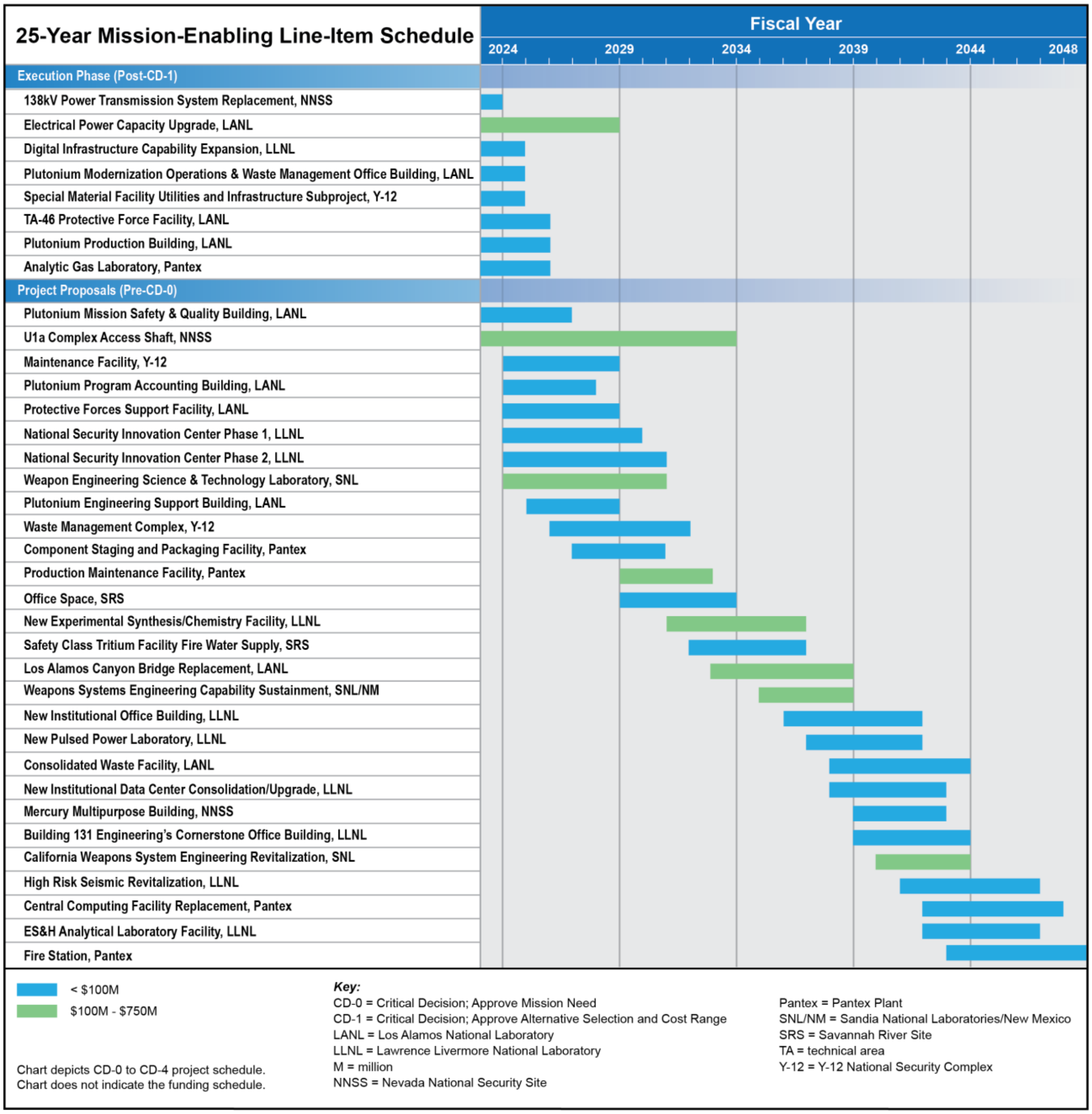


Figure 6–9. 25-year mission-enabling line-item schedule

Recently completed mission-enabling line-item projects include:

- The **Emergency Operations Center** at Lawrence Livermore National Laboratory (LLNL) provides a new permanent Emergency Operations Center with comprehensive emergency management capabilities for the development, coordination, control, and direction of emergency planning, preparedness, readiness, assurance, response, and recovery actions. The 20,000 square foot building will allow an occupancy capacity needed during an emergency event that the current Emergency Operations Center cannot accommodate, provide additional parking, and contain or interface multiple emergency and safety-related systems. This EMC^2 pilot executed construction and achieved full operations in 24 months and was delivered ahead of schedule and under budget.
- The **Fire Station** project at Y-12 provides an approximately 30,000 square foot commercial standard building to meet all emergency response requirements including firefighting, emergency medical treatment and transport, hazardous materials spill mitigation, and technical rescue responses for all events within the site emergency response boundary at Y-12. The new facility will be built to meet all safety standards and building codes to support 24/7 operations under all environmental conditions. The facility will accommodate a workforce and a fleet including large fire apparatus vehicles, ambulances, emergency response vehicles, and other support vehicles. This project was executed as part of the EMC^2 pilot. Construction began in FY 2021 and beneficial occupancy was completed in FY 2023.

Fire Station at Y-12

- The **TA-3 Substation Replacement** at LANL provides increased distribution capacity, improved reliability, reduced maintenance, support for greater operational flexibility, and increased worker safety.
- The **Emergency Operations Center** at Y-12 provides a centralized, comprehensive emergency management capability for the development, coordination, control, and direction of emergency planning, preparedness, readiness assurance, response, and recovery actions. The current facility is not compliant with DOE Order 151.1C, *Comprehensive Emergency Management System*. This project was executed as part of the EMC^2 pilot utilizing streamlined processes for non-nuclear, non-complex projects.

The mission-enabling projects listed below are currently in the Execution Phase of the CD process.

Construction at the Emergency Operations Center at Y-12

- The **Emergency Operations Center** at SNL will provide a facility that supports DOE/NNSA and SNL emergency operations, the 24/7 Emergency Management Communication Center, dedicated incident management and coordination space, multipurpose training rooms, and fuel and water storage sufficient to mitigate all potential emergency operations and management response capabilities. This project is being executed as part of the EMC^2 pilot and the center is expected to be operational in Fall 2023.

Construction on SNL's Emergency Operations Center

- The **138 kilovolt (kV) Power Transmission System Replacement** project will replace a 55-year-old 138 kV power transmission system in the NNSS Mission Corridor in Mercury, Nevada. The project will provide the site with reliable power and communications to mission critical facilities by designing and constructing a new 138 kV power transmission system to replace and upgrade 26 miles of the degraded existing power transmission system. It will also upgrade the collocated fiber optic lines to meet vital national security mission requirements.

- The **Electrical Power Capacity Upgrade** at LANL will address projected increases in the electrical demand to reliably support multiple program activities being performed at the site. Power demand for all programs is expected to exceed LANL's existing transmission and distribution system's capacity and performance requirements. This electrical upgrade will support critical Weapons Activities requirements for stockpile modernization programs, SFIs, ongoing stockpile stewardship programs, and other work.
- The **Digital Infrastructure Capability Expansion** project at LLNL will provide safe, secure, resilient, reliable, flexible, and sustainable infrastructure for LLNL's networking and telecommunications digital infrastructure needs. The project will expand capabilities to meet growth projections for the next 40 years.
- The **Plutonium Modernization Operations Complex** at LANL will provide additional office workstations and associated common space for increased operations within TA-55 and other supporting plutonium modernization capabilities in TA-46, -48, -50, and -63. This complex encompasses the Plutonium Modernization Operations & Waste Management Office Building, the TA-46 Protective Forces Facility, and the Plutonium Production Building listed in Figure 6–9.
- The **Special Materials Facility Utilities and Infrastructure** subproject will provide infrastructure and utility upgrades at Y-12. This repurposed facility is necessary to support special materials processing and production for future mission requirements. The facility has received funding and approval for execution under an EMC^2 like acquisition approach. Project design commenced in FY 2022.
- The **Analytic Gas Laboratory** at Pantex would provide the safe, secure, and reliable infrastructure necessary to perform gas analysis at Pantex. Gas analysis is required to perform the dismantlement, surveillance, stockpile refurbishment, and nuclear non-proliferation missions at Pantex.

There are multiple proposals for new mission enabling projects that are planned over the next 10 to 25 years, some of which include the following. For projects subject to DOE Order 413.3C project management requirements, scope descriptions are illustrative, with DOE/NNSA evaluating options during the Analysis of Alternatives and making decisions at CD-1:

- The **U1a Complex Access Shaft** at NNSS would provide expanded access to the U1a underground needed to support a greater number of people, equipment, and experiments necessary to support the ongoing expansion of the science-based Stockpile Stewardship Program.
- The **Maintenance Facility** at Y-12 would replace the antiquated maintenance facilities that support all Y-12 production missions and would enable preventive, predictive, and corrective maintenance across the site. The new facility would consolidate maintenance processes and eliminate square footage of aging facilities in a more optimized, efficient location.
- The **National Security Innovation Center** at LLNL would move staff out of dispersed, end-of-life Weapons Program office buildings into a more centralized location and would enable optimized use of space. Stockpile modernization efforts and future stockpile stewardship missions require multidisciplinary teams of scientists and engineers to develop, innovate, and apply sophisticated modeling and simulation tools to conduct high-fidelity experiments. The multidisciplinary team approach requires collocated weapons program staff equipped with quality classified workstations with modern information technology infrastructure.

- The **Weapon Engineering Science and Technology Laboratory** at SNL-California would integrate the Materials Science and Engineering capabilities across materials development and engineering design. The primary existing facility is in poor condition, is functionally unfit for advanced materials science R&D, and lacks sufficient capacity to meet the current and projected demand.
- The **Production Maintenance Facility** at Pantex would replace multiple facilities approaching the end of operational life expectancy and not located near critical Production and Production Support facilities. The new facility would consolidate maintenance processes and provide a more efficient location to support Production operations and facilities.

6.3.3 Other Acquisition Efforts

DOE/NNSA is also acquiring space through purchase and leasing. DOE/NNSA is executing multiple purchase acquisitions through various tools and expanding the use of NNSA acquisition authorities.

6.3.3.1 Real Estate and Leased Facilities

Leases are an important real estate strategy to address short-term needs. DOE/NNSA is streamlining its process and refining its strategy to make better use of leasing as a tool for addressing temporary mission needs, while ensuring long-term needs are addressed in the most cost-effective manner. Leases provide the flexibility needed to deal with surges in mission work but can be more costly than construction and ownership if not well structured or if used as permanent solutions. DOE/NNSA is implementing a range of innovative tools and processes related to leasing strategies. The lease scoring system rolled out in early 2019 is driving better decision-making by offering an objective metric for evaluating a lease's risk and comparing it within DOE/NNSA's broader leasing portfolio. This system helped improve the terms and conditions in leases, minimize tenant improvements, and ensure exit strategies are in place for new leases. Lease scoring is also normalizing the solicitation for space to encourage better rates, as well as site visits to improve usage and ensure lessor is delivering per the lease.

Kansas City Short-Term Expansion Project

Since the consolidation of operations in 2014 from the original Bannister Road facilities to the leased facility on Botts Road, Kansas City National Security Campus (KCNSC) has seen a significant increase in workload in support of the nuclear stockpile modernization. The activities supporting the growth in workload have consumed all KCNSC's factory space at the Botts Road facility and have driven KCNSC to address this shortfall by purchasing a nearby facility, KCNSC East (previously known as Building 23) after previously bridge leasing the facility. The Kansas City Short-Term Expansion Project (KC STEP) is a series of multi-year projects that will provide for KCNSC East infrastructure upgrades, relocation of specific manufacturing capabilities to KCNSC East, establish new capabilities at KCNSC East, and expansion and rearrangement of other manufacturing capabilities remaining at the Botts Road main campus. While efforts continue to assess a long-term facility expansion strategy, KC STEP will provide increased factory capacity to support the B61-12 LEP and W88 Alteration 370, as well as partially filling needs for the W80-4 and W87-1 programs.

KCNSC East Building

DOE/NNSA is currently investigating solutions to address the following projects through similar innovative strategies:

- The **Northwest Las Vegas New Campus** will provide sustainable infrastructure that supports the health, safety, and welfare of NNSS employees, the public, and the environment.

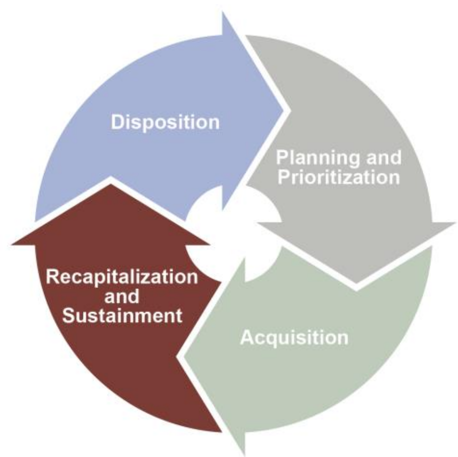
- The **Kansas City Non-Nuclear Expansion Transformation (KCNExT)** will include a multi-year phased campus plan to achieve an expanded campus to provide additional manufacturing space to meet the needs for non-nuclear production for multiple modernization programs and consolidate existing Kansas City National Security Campus (KCNSC) office space and exit office space leases.

6.3.3.2 Direct Purchases

One recently developed tool is an Option agreement, a contract with the land/facility owner that gives a prospective buyer the exclusive right to purchase the property at a fixed price within a stated time period. The option agreement allows necessary time for DOE/NNSA to perform the due diligence required for any Federally funded purchase.

DOE/NNSA executed its first "option purchase" acquisition in June 2020 and is preparing to pursue the purchase of other facilities across the enterprise. The purchase of 103 Palladium, a 73,000 square foot facility on a 21-acre campus in Tennessee will be repurposed as the John M. Googin Technology Development Facility to provide much needed footprint for the Y-12 Development program. In March 2023, NNSA purchased Building 23 to support the KCNSC mission. This facility will help KCNSC meet mission demands and be more strategic with manufacturing space to accommodate near-term facility needs while supporting long-term manufacturing requirements. All will use existing *Atomic Energy Act of 1954* authorities to acquire facilities.

6.4 Modernization Through Minor Construction and Recapitalization



This section describes how DOE/NNSA, in partnership with its M&O partners, modernizes assets to enable mission success and readiness; ensures operational safety and security; safeguards the workforce, public, and environment; and meets mission needs to support the nuclear security mission.

In addition to major acquisition and line-item construction, DOE/NNSA also uses minor construction and recapitalization to update infrastructure. This provides an important vehicle for DOE/NNSA to sustain major facilities and replace smaller capital assets below the $30 million line-item cost threshold. These projects are an effective method for making improvements to increase DOE/NNSA's mission performance and lower operating costs. They can be completed much faster than line-item construction projects, and they enable DOE/NNSA to be responsive to emerging infrastructure issues and changing stockpile requirements.

Modernizing the nuclear security enterprise is accomplished through formal recapitalization programs planned and funded at the DOE/NNSA level, through site-directed investments as well as other funding mechanisms. These investments improve the condition, reliability, efficiency, and capability of infrastructure to meet mission requirements. The programs plan and execute replacement, installation, upgrades, and minor construction projects to revitalize existing facilities or construct new facilities and additions.

6.4.1 Infrastructure Recapitalization Program

The Recapitalization program executes prioritized minor construction and recapitalization investments to improve the condition, reliability, efficiency, and capability of infrastructure to meet mission requirements. The program plans and executes replacement, installation, upgrades, and minor construction projects to revitalize existing facilities or construct new facilities and additions below the $30 million minor construction threshold. This investment method is used in conjunction with line-item construction to provide timely, appropriately sized, and integrated infrastructure solutions.

In addition to supporting the enterprise through strategic minor construction investments, the Recapitalization Program sustains and modernizes DOE/NNSA infrastructure by improving the state of obsolete support and safety systems. The program provides funding to revitalize assets that are beyond the end of their design life and improve the safety, reliability, and capability of infrastructure to meet mission requirements. Recapitalization investments also increase operational efficiencies; reduce risks to safety, security, environment, and programs; and improve the quality of the workplace.

Recapitalization Program investments are evaluated and prioritized using an enterprise-wide, risk-based assessment of program and safety effects, sustainability, return on investment, and deferred maintenance reduction to obtain optimal benefits within the available budget. DOE/NNSA has also incorporated enhanced project management practices that have increased transparency, reporting accuracy, project definition and readiness, and overall program performance.

In FY 2022, DOE/NNSA completed 41 recapitalization projects. This performance reflects the effect of advanced planning based on detailed data and the use of the improved reporting tools and processes.

Several completed projects show DOE/NNSA has directed many infrastructure investments to address risks identified through facility and mission assessments:

- KCNSC – Revitalization of Precision Cleanroom Upgrade, Low Humidity Production Revitalization, Assembly and Electrical Fabrication and Machining Revitalization
- Y-12 – Elevator Cylinder Replacement
- Y-12 – 13.8kV Power Distribution System Conversion Portfolio
- NNSS – Frenchman Flat Substation Transformer Replacement
- LANL – TA Electrical, Mechanical Revitalization
- Pantex – Secondary Electrical Feed Installation
- SNL – District Chilled Water System Upgrades
- Pantex – Equipment Room Expansion
- SNL – Process Oil Storage Tanks Replacement
- LANL – Environmental and Vibration Test Facility Fire Suppression Upgrade
- SNL – SiFAB UPS System Upgrade, TA-IV District Chilled Water System Upgrades
- SNL – Thermal Spray Research Laboratory Facilities' Systems Revitalization
- LANL – LANSCE Industrial Controls Replacement
- SNL – California Potable Water Distribution System Revitalization TA-IV District Chilled Water System Upgrades
- LANL – Safety Systems Two Over One Upgrade
- LLNL – Block East Utility Distribution Upgrade

- Pantex – Southwest Circuit Sectional Switches Installation
- NNSS – New U1a Powerline Connection to 34.5KVA Distribution Line
- LLNL – LEP Building Complex Power Upgrade
- NNSS – DAF Operations Complex Power Installation
- LANL – PF-4 Public Address System Replacement
- LANL – PF-4 Zone 1 Damper Controls and Actuators Safety Upgrades
- LLNL – Mechanical Test Capability Consolidation Revitalization
- LLNL – Domestic Water and Miscellaneous Valves Replacement
- NNSS – Mercury Campus Transportation Upgrades

6.4.1.1 Current Recapitalization Projects

DOE/NNSA currently has over 190 active recapitalization projects. The majority of these projects are below $10 million. There are more than a dozen projects ranging between $10–30 million. Projects are placed into portfolios, which are used to highlight significant multi-year investment in a common attribute or area at a particular site. Below are some examples of DOE/NNSA's ongoing Recapitalization portfolios and projects.

$10–30 Million Project Examples

- LANL – PF-4 Power and Communications Systems Upgrade
- LLNL – New Nondestructive Evaluation Building
- NNSS – New Mercury Building
- Pantex – New Advanced Fabrication Facility
- SNL – New Explosives Manufacturing Science and Technology Facility
- SNL-California – Limited Area Multi-Program Secure High Bay Laboratory
- SNL – New Geosciences Laboratory
- NNSS – New Nevada Site Operations Center
- NNSS – New U1a Mission Technical Support Facility (STAR)
- LANL – Flight Instrumentation Test Laboratory (Environmental Test Complex)
- LANL – Dual-Axis Radiographic Hydrodynamic Test Vessel Repair Facility & Electrical Circuit Upgrades
- LANL – New Fire Station 5
- LLNL – New Joining Capabilities and Vapor Disposition Facility
- LLNL – New Stockpile LEP Office (STAR)
- SNL – New TA-II Master Substation

Project Portfolio Examples

- KCNSC – Mechanical Component Manufacturing Revitalization
- LANL – CMR Initial Projects to Prepare for Closure Portfolio
- LLNL – Applied Materials and Engineering Complex
- NNSS – Mercury Modernization at NNSS
- Pantex – Bay and Cell Safety System Upgrades Portfolio

- Pantex – Site-Wide Facility Lightning Protection Upgrade
- SRS – Obsolete Glovebox Oxygen Monitors Replacement Portfolio
- SRS – 234-7H Exhaust Ventilation System Installation
- Y-12 – Fire Water Lateral Replacement Portfolio
- Y-12 – Nuclear Facility Criticality Accident Alarm System Replacement

6.4.1.2 Recapitalization Program Planning Improvements

DOE/NNSA is improving understanding of long-term programmatic capability and associated capacity throughput requirements to better evaluate infrastructure options. Additionally, more front-end planning studies are being initiated to ensure that DOE/NNSA can integrate recapitalization planning across multiple Federal and M&O site organizations, while designing multi-project plans to address complex infrastructure challenges. These efforts strengthen DOE/NNSA's modernization plans by ensuring that projects are fully scoped, well -integrated, and executed on time and within budget.

6.4.2 Defense Nuclear Security Minor Construction Investment

The Security Infrastructure Revitalization Program was created by DOE/NNSA's Office of Defense Nuclear Security (DNS) to assure the adequacy of the physical security infrastructure supporting the DOE/NNSA mission at the eight sites now and into the future. DNS developed and submitted to Congress the *10-Year Physical Security Systems Refresh Plan* to outline and guide the scope of the program's effort. This plan contains a comprehensive condition assessment of the security infrastructure at each site and a nuclear security enterprise-wide prioritized listing of the required upgrades.

The *10-Year Physical Security Systems Refresh Plan* identifies and prioritizes security infrastructure investments critical to revitalization efforts throughout the nuclear security enterprise.

DNS minor construction project status for FY 2023:

- Device Assembly Facility Vehicle Barrier, NNSS (design FY 2022, estimated completion FY 2028)
- Zone 12 Perimeter Intrusion Detection and Assessment System Vehicle Barriers, Pantex (start construction FY 2023)
- Vehicle Barrier, Y-12 (groundbreaking FY 2022, estimated completion FY 2025)

6.4.3 Site-Directed[5] Minor Construction Investments

DOE/NNSA's contracts with various groups for management and operation of its sites contain requirements for M&O partners to plan for and manage DOE/NNSA assets for current and future missions. Sites fulfill these responsibilities in part by making minor investments in facilities and infrastructure from funds controlled at each site. The sources for these investments can be direct programs (as discussed in the previous sections) or indirect funding pools, depending on the nature of the asset and whether the site has a multi-mission program portfolio.

Many DOE/NNSA M&O partners use indirect funding to address high priority needs at each site. On multi-mission program sites, indirect funding pools may be created through institutional assessments or other similar mechanisms. These pools are used to fund maintenance, utilities, and operations; some funding is set aside for site-wide investments. In all cases, spending these funds aligns with accounting standards for demonstrating a causal-beneficial relationship, i.e., indirect funds are used for multi-mission

[5] Another term for "site-directed" investments is "indirect-funded" investments.

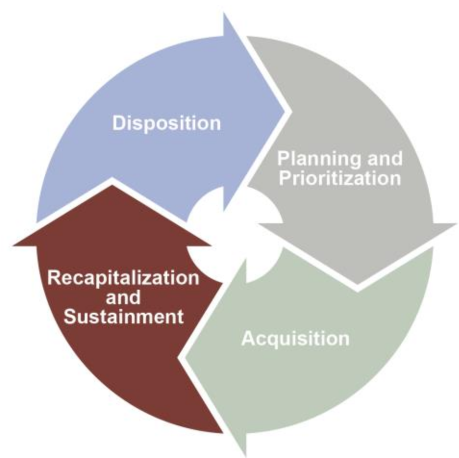
program functions and purchases that deliver benefits across programs. M&O partners are also responsible for maintaining Weapons Activities capabilities to meet mission needs and often use portions of their budgets to fund minor investments in facilities, infrastructure, and equipment to meet those responsibilities.

Examples of indirect expenditures include Institutional General Plant Projects at multi-mission program sites, especially the laboratories. These projects are often limited refurbishments of legacy facilities or new, moderately sized buildings to accommodate growth at the site and enable prudent space management for the institution to maintain facilities in good condition and replace worn-out assets. These projects can also provide upgrades/replacements for institutional services such as parking structures, cafeterias, or medical facilities.

Site-directed investments over $1 million are reported through the DOE/NNSA Program Management Information System, Generation 2 (G2). Providing this information to one centralized system increases transparency and coordination for all infrastructure investments (direct and indirect). Capturing the details of these projects in G2 ensures that indirect infrastructure investments align with DOE/NNSA's strategic priorities; enhances integration between direct- and indirect-funded infrastructure investments; improves reporting to understand total infrastructure recapitalization costs across the enterprise; and ensures the capability to prioritize and plan for DOE/NNSA's long-term stewardship responsibilities.

6.5 Sustainment

This section describes how DOE/NNSA maintains and operates existing infrastructure in support of the nuclear security mission. DOE/NNSA, in partnership with the M&O partners, sustains its assets to enable mission success and readiness; ensure operational safety and security; safeguard the workforce, public and environment; and meet mission needs more efficiently and cost- effectively.



6.5.1 Infrastructure Operations and Sustainment

The Operations of Facilities Program under the Infrastructure and Operations Program is responsible for operating DOE/NNSA facilities in a safe and secure manner and includes essential support such as water and electrical utilities, safety systems, lease agreements, and activities associated with Federal, state, and local regulations associated with the environment and worker safety and health.

The Maintenance and Repair of Facilities Program provides direct-funded maintenance activities across the nuclear security enterprise for the recurring day-to-day work required to sustain and preserve DOE/NNSA facilities and equipment in a condition suitable for their designated purpose. These sustainment activities are executed through a combination of innovative tools that provide data for risk analyses that inform infrastructure management decisions. These decisions dedicate critical resources to maintaining facilities already in good condition and repairing the highest risks in DOE/NNSA assets. One of these tools is the BUILDER Sustainment Management System, which is a best-in-class, web-based tool developed by the U.S. Army Corps of Engineers that provides a consistent, repeatable, quantitative method to track and predict the condition of facilities and their systems, components, and subcomponents. The DOE/NNSA procured BUILDER in October 2014 and continues to actively implement it across its real property infrastructure portfolio with the goal of reaching full program sustainment by the end of FY 2024. To lower the overall cost and ease of using the BUILDER system, DOE/NNSA integrated BUILDER with each site's local Computerized Maintenance Management Systems, which track daily maintenance activities, document replacement of components, and offer a variety of features such as preventive maintenance scheduling, warranty management, and space planning. These features help sites maintain effective and streamlined operations. Moving forward, DOE/NNSA will continue leveraging BUILDER's data-driven, risk-informed metrics to inform infrastructure renewal decisions and ensure the greatest return on investment.

Maintenance and repair activities sustain an acceptable condition of real property assets to perform their designated purpose or to mitigate risks posed by excess assets until their disposition. These efforts support the recurring daily work needed to sustain plant, property, assets, systems, roads, and infrastructure equipment in a condition suitable for its designated purpose. Efforts include required maintenance through surveillance and predictive, preventive, and corrective maintenance activities to maintain facilities, property, assets, systems, roads, equipment, and vital safety systems. Maintenance funding can be used for sustainment efforts or to respond to unexpected/urgent issues that require immediate correction to ensure safe, compliant, and reliable operations.

Deferred maintenance is defined as any maintenance activities that were not performed when they should have been or were scheduled. As a result, they are rolled over as a continued expected expense to subsequent fiscal years until the maintenance can be completed. Repair needs are the repairs required to ensure that a constructed asset is restored to a condition that is substantially equivalent to the most recently configured designed capacity, efficiency, or capability.

In FY 2019, DOE/NNSA began its transition to BUILDER data to determine total deferred maintenance and repair needs. Importantly, this transition to a standardized, structure-based approach provides DOE/NNSA with increased transparency and deferred maintenance data accuracy across the enterprise. In FY 2020, DOE/NNSA conducted an in-depth analysis of FY 2019 calculations and implemented a few minor enhancements to ensure a more accurate reflection of the true condition of DOE/NNSA's infrastructure. This along with regular degradation and increased supply chain issues resulted in DOE/NNSA's deferred maintenance backlog increasing from $6.07 billion in FY 2021 to $6.48 billion in FY 2022.

Revitalizing DOE/NNSA infrastructure requires grappling with a $131 billion enterprise in which more than half of DOE/NNSA facilities are in insufficient condition to serve mission needs (e.g., poor or very poor condition). Addressing this legacy while building for the future requires significant, sustained, and timely funding; robust planning and execution; and close collaboration across all stakeholders. DOE/NNSA remains committed to continuous improvement of management practices and transparency in stewarding taxpayer resources while working to modernize the nation's nuclear infrastructure.

DOE/NNSA's asset management programs use supply chain management strategies to increase quality, enhance buying power, and accelerate the delivery for repairing and replacing major common building systems. These efforts are particularly important during a period of increasing costs for building materials and long-lead equipment procurement delays. Since FY 2015 the Roof Asset Management Program has reduced the number of DOE/NNSA roofs rated as failed from 18 to 9 percent. Building on the program's successes, the Cooling & Heating Asset Management Program was established in FY 2017, completing 24 projects since inception. During FY 2021, there were active Cooling & Heating Asset Management Program projects at every site.

6.5.2 Programmatic Facility Sustainment

In some instances, the nature of core mission areas leads to direct programmatic sustainment funding for certain operations. For example, the SRT&E Program is responsible for the HPC capabilities needed for stockpile stewardship in modeling, simulation, and experiments conducted at various facilities and experimental capabilities such as inertial confinement fusion. Within SRT&E, operational costs at facilities are directly supported and budgeted within the Inertial Confinement Fusion (ICF) and Advanced Simulation and Computing (ASC) Programs. The ICF Facility Operations and Target Production subprogram supports efficient operations at NIF, Omega Laser Facility (Omega), Z, and the Trident and NIKE facilities (see Chapter 4, Section 4.3.3, for more information on NIF, Z, and Omega). Similarly, the ASC Facility Operations and User Support subprogram provides the facilities and services required to execute nuclear weapon simulations. Facility Operations include physical space, power, and other utility infrastructure; local area/wide area networking for local and remote access; and system administration, cybersecurity, and operations services for ongoing support.

Programmatic operations must provide for the safety and health of workers and the protection of the environment, regardless of the funding source. As part of DOE/NNSA's efforts for a more sustainable enterprise, Z was awarded an environmental management award of excellence for significantly reducing emissions of the powerful greenhouse gas, sulfur hexafluoride.

Sulfur hexafluoride reclaiming system being used on SNL's Z

ASC is the primary user and chief programmatic advocate for the facilities and services required to run nuclear weapons simulations and operate Commodity Technology and Advanced Technology systems. Each laboratory's computing capability comprises not only HPC systems, but also ancillary physical components such as space, power, storage, file systems, local area/wide area networking for local and remote access, and a host of system administration, cybersecurity, and operations services for ongoing support of HPC system and support equipment. There are also specific user services associated with items such as a computer center hotline and help-desk services, account management, web-based system documentation, system status information tools, user training, trouble-ticketing systems, common computing environment, and application analyst support that are included in the fiduciary responsibilities of the program. Therefore, each center's footprint can physically span multiple buildings.

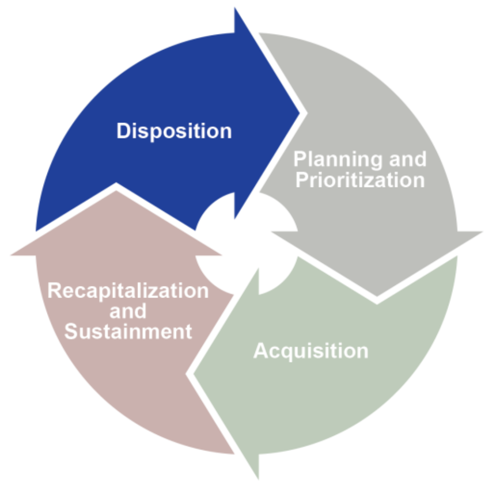
ASC manages the costs associated with each laboratory's current computing centers and considers multi-year budget planning to deliver future systems based on programmatic need. The funding necessary to operate and modify the computing centers comes from a combination of direct programmatic funding from the ASC and other DOE/NNSA programs, which may use the same buildings, or indirect overhead charges brought in by the laboratories directly. Within Weapons Activities, the Infrastructure and Operations Program provides capabilities and infrastructure for the nuclear security enterprise but is not responsible for maintenance and operations of the ASC computing centers themselves.

6.5.3 Site-Directed Sustainment Investments

At multi-program sites, indirect pools may be created to pay for maintenance and operations. These funds are then used to pay utility bills; provide preventive, predictive, and corrective maintenance to facilities and equipment; and replace equipment associated with facilities and infrastructure. These funds may also cover various site-wide services. Site-directed investments are reported through G2. Providing this information to one centralized system increases transparency and coordination for all infrastructure investments (direct and indirect). Capturing the details of these investments in G2 ensures that indirect infrastructure investments align with DOE/NNSA's strategic priorities; enhances integration between direct- and indirect-funded infrastructure investments; improves reporting to understand total infrastructure recapitalization costs across the enterprise; and ensures the capability to prioritize and plan for DOE/NNSA's long-term stewardship responsibilities.

6.6 Disposition of Excess Facilities

DOE/NNSA infrastructure that is no longer needed must be dispositioned to minimize risks to workers, the public, the environment, and the mission. Approximately 8 percent of assets located on DOE/NNSA's sites are designated as excess. This number has decreased 1 percent in the past year, and a 4 percent reduction since 2018, resulting in reduced risk to DOE/NNSA overall. DOE/NNSA's highest disposition priorities are to stabilize degraded facilities, characterize hazards and conditions, remove hazardous and flammable materials, and place facilities in the lowest acceptable risk condition possible until they can be dispositioned. DOE/NNSA's area plans outline the details of how DOE/NNSA plans to address these excess facilities.



Several recently completed projects demonstrate that DOE/NNSA has directed infrastructure investments to address risks identified through facility and mission assessments:

- Demolition of 17 process contaminated facilities at LANL including HE Buildings 16-0460 and 16-0306 and 15 magazines
- Removal of Building 9404-18 and demineralized water tanks at Y-12
- Advanced planning and field work performed in support of the utility reroute scope associated with DOE Office of Environmental Management disposition activities in preparation for the demolition of the large process contaminated excess facilities at Y-12.

The longer an unused facility is left standing before demolition, the more it deteriorates, and the more difficult it is to maintain in a safe shutdown condition. Aging facilities can pose risks to human health, the environment, and the mission. DOE/NNSA is committed to mitigating these risks by dispositioning excess facilities as quickly as possible and working with the DOE Office of Environmental Management when its expertise is required.

During the next 10 years, over 800 additional assets with $4.3 million gross square feet are planned to become excess on DOE/NNSA sites. Of these assets, approximately 40 percent are process contaminated and may require DOE Office of Environmental Management expertise to demolish.

6.7 Modernization of Programmatic Equipment

Facilities and infrastructure are just one of the three aspects of sustainment that must be managed in support of the mission; equipment and people are also critical to mission performance. The workforce aspects are discussed in Chapter 7. This section focuses on the equipment aspects of sustainment.

DOE/NNSA manages and funds equipment procurement across the nuclear security enterprise through multiple programs such as stockpile modernization programs or the Engineering Program. These programs selectively fund mission-related equipment procurement to meet their schedule or new requirements. In addition to these, several other programs maintain nuclear security enterprise capabilities through equipment refurbishment and replacement. Those programs include Capabilities-Based Investments (CBI), Production Operations, and Non-Nuclear Component Modernization. Furthermore, the organization that initially funds procurement of a piece of equipment will most likely not be the only organization benefiting from the acquisition in the future, which adds complexity to the task maintaining and replacing equipment.

While each program focuses on its own respective responsibilities and requirements, the integrated nature of nuclear weapons work creates natural mission overlap across programs. In these cases, the Programmatic Recapitalization Working Group works with the M&O sites to capture the current inventory of capital equipment items as well as future needs across the Future Years Nuclear Security Program to allow DOE/NNSA to better plan and program capital equipment needs amongst the appropriate funding program offices. This allows better alignment of planning and programming activities across relevant DOE/NNSA programs.

Equipment modernization, replacement, and refurbishment planning will enable DOE/NNSA to recapitalize the nuclear security enterprise’s infrastructure and provide an effective, responsive, and resilient nuclear weapons infrastructure. It is also crucial to the maintenance of the nuclear security enterprise’s current capability. The investment strategies described in the following sections presents a variety of programs focused on investing in programmatic equipment, as well as certain equipment-related sustainment activities funded by Infrastructure and Operations. Together, they provide the baseline activities essential to maintaining a functional and efficient nuclear security enterprise.

6.7.1 Programmatic Equipment Investments

Equipment investments by mission-specific programs are dictated by programmatic need.

For the weapons programs (e.g., Stockpile Major Modernization and Stockpile Sustainment), equipment purchased might include radiography machines, mass spectrometers, shaker tables, blast tubes, centrifuges for qualification, certification, and surveillance activities that are specific to a weapon system. A weapon program might also require specific capabilities in production equipment, such as specialized mills and lathes, to produce component designs and would cover these costs, as the requirements for that equipment would be tied directly to their program. For example, the W80-4 LEP has funded programmatic equipment such, as the digitizers needed for hydro shot diagnostics, a computer numerical controlled mill and lathe for HE and radiological materials to meet integrated weapon experiment deliverables, and inspection equipment to validate that machines’ experimental components meet weapon engineer-specified requirements.

Weapon programs also invest in equipment and infrastructure necessary to maintain their schedule. Often these investments are split among weapon programs that could benefit from such procurements in the future. For instance, the W88 Alteration 370 benefited from investments made by the W76 and

B61-12 LEPs. Where multiple stockpile modernization programs can benefit, CBI (described in Chapter 3) is also a major source of funding.

SRT&E investments cover a range of highly specialized and common equipment that is essential to the high-tech work of stockpile stewardship. SRT&E equipment might provide or facilitate environments for testing and experimentation, produce data from those experiments, or help synthesize the data from the experiments to inform research, design, production, qualification, and surveillance activities across multiple different weapon systems and programs. Examples include next generation computing platforms, diagnostic equipment tied to subcritical and hydrodynamic experiments, and accelerators associated with advanced radiography. Given the specialized nature of these types of equipment, investments can be quite costly. New equipment is procured by SRT&E programs as mission needs arise, equipment becomes technologically obsolete, emerging technologies demand investment in new capabilities, or new facilities or capabilities come online. In addition, as urgent needs arise, CBI and Non-Nuclear Component Modernization makes investments in equipment for SRT&E missions that are tied to LEP schedules.

The Additive Manufacturing and Component Manufacturing Development programs make equipment investments aimed at validating production and qualification processes that are vital to the future stockpile, with a long-term goal of reducing required production floor space and attendant infrastructure. While these programs may purchase one to two pieces of equipment with advanced capabilities, the weapon programs, CBI, or appropriate modernization offices would be expected to purchase the remaining equipment needed to realize the Additive Manufacturing and Component Manufacturing Development-provided capability at full production scale. In some cases, the initial investment by these programs could fulfill production requirements, and the responsibility for the operations and maintenance of that equipment would transfer to the appropriate program, such as Production Operations. Examples of equipment procured through these programs include a variety of additive manufacturing machines, advanced testers, and other supporting equipment.

6.7.2 Site-Directed Equipment Investments

As with facilities and infrastructure, sites may make investments in equipment for activities that support weapons and other site missions (multi-program), and these investments may either be made using direct funds or include indirect cost pools. The cost of programmatic equipment that supports multiple programs should be allocated to those programs in accordance with the benefits received.

6.8 Leveraging Weapons Activities Investments Across DOE/NNSA

Several other DOE/NNSA programs (e.g., NNSA's Offices of Defense Nuclear Nonproliferation, Counterterrorism and Counterproliferation, and Emergency Management) rely on infrastructure funded by Weapons Activities and other DOE program offices.

6.8.1 Support of Nonproliferation Efforts

The Office of Defense Nuclear Nonproliferation's Office of Global Material Security relies on infrastructure maintained by other DOE/NNSA offices, as summarized below.

- SNL and LANL conduct nuclear security training and non-destructive assay technique training for the International Atomic Energy Agency and bilateral partners.

- The DOE/NNSA National Training Center in Albuquerque, New Mexico, will provide bilateral partners with Protective Force training on a limited basis.
- The Alarm Response Training facility will transition to the Oak Ridge Enhanced Technology and Training Campus in FY 2023. The program conducts radiological security training for domestic and international security forces, health and safety personnel, and local law enforcement to effectively respond to the theft of radioactive sources.
- SNL and LANL provide technical expertise, testing equipment, and SNM sources that are critical in the evaluation and characterization of commercial detection equipment.

The Office of Defense Nuclear Nonproliferation R&D relies on supportive capabilities at several laboratories, plants, and sites that enable mission-relevant R&D activities, as summarized below.

- NNSS hosts several experimental and applied test beds to demonstrate next-generation nonproliferation technologies for detecting foreign nuclear weapons development activities, which will result in new capabilities at the national security laboratories.
- The Device Assembly Facility at NNSS hosts and facilitates detection experiments for university and laboratory projects.
- SNL, LANL, LLNL, and NNSS provide critical expertise and infrastructure to support multiple weapons-related experimental campaigns, including U1a and Big Explosives Experimental Facility.
- The Microsystems Engineering, Sciences, and Applications Complex at SNL provides resources to develop beyond leading-edge trusted microsystems technologies that enable space-based detonation detection capabilities.
- SNM irradiation experiments are conducted at the National Criticality Experiments Research Center at NNSS, where criticality assembly machines provide the capability for research to improve precision measurements of nuclear fission product yields and other nuclear data parameters.
- HPC capabilities are used for a broad range of modeling and simulation research across multiple research areas at SNL, LANL, and LLNL.

The Office of Defense Nuclear Nonproliferation's Office of Material Management and Minimization (M3) relies heavily on the infrastructure maintained by other DOE/NNSA offices. Effects of the aging infrastructure on the implementation of key nonproliferation programs are summarized below.

- **Conversion Program**
  - Y-12's uranium facilities perform downblending and casting activities that produce low-enriched uranium (LEU) material that is supplied to research reactors and medical isotope producers domestically and internationally and is used to produce LEU-molybdenum material that will allow conversion of the U.S. high-performance research reactors from highly enriched uranium (HEU) to LEU. Aging casting furnaces at Y-12 are a programmatic risk to production of future LEU material. In the future, M3 plans to shift to using BWX Technologies, Inc. (BWXT) for its alloy casting capability instead of Y-12. This shift is planned to begin in FY 2025 and fully transition by FY 2028. In the meantime, Y-12 alloy production will be required until BWXT proves fully capable. M3 will still rely on Y-12 for production of LEU for research reactors and medical isotope producers.
  - Plant and personnel challenges at the Analytical Chemistry Organization pose major programmatic risks to LEU production, USHPRR conversion efforts, and M3's LEU scrap

recovery project. The Analytical Chemistry Organization analyzes samples to ensure that 9212's LEU castings meet the Y-12 Standard Specification, which is relied upon by all purchasers of Y-12 LEU. M3 also relies on the laboratory for sample analysis of LEU scrap material planned for shipment to BWXT to ensure the material conforms with BWXT's facility limits.

  - The Sigma facility at LANL develops and optimizes LEU-Mo fuel fabrication processes.

- **Material Disposition Program**
  - TA-55 PF-4 at LANL disassembles nuclear weapon pits and converts the resulting plutonium metal into an oxide form using the Advanced Recovery and Integrated Extraction System. While this is an Office of Defense Nuclear Nonproliferation program, this equipment set is also used to support pit surveillance and other Office of Defense Programs activities.
  - The K Area Complex at SRS stores surplus plutonium that will be dispositioned. The K Area Complex is a DOE Environmental Management facility; however, DOE/NNSA plans to install equipment for the Surplus Plutonium Disposition Program under the dilute and dispose strategy and completed construction of a transuranic waste storage pad and loading capability for shipping diluted plutonium oxide to the Waste Isolation Pilot Plant.
  - Under the dilute and dispose strategy, the Waste Isolation Pilot Plant is the permanent disposal site for diluted plutonium oxide, along with waste generated by Office of Defense Programs and other nonproliferation activities.
  - The Material Disposition program relies on resources, facilities, and support from Pantex and KCNSC to support the dilute and dispose strategy.
  - DOE/NNSA's Secure Transportation Asset Program will provide resources to ship Security Category I quantities of SNM within the nuclear security enterprise in support of the Surplus Plutonium Disposition Program under the dilute and dispose strategy.
  - The H-Canyon at SRS will be used to disposition portions of the plutonium inventory returned to the United States through the Nuclear Material Removal Program. The Savannah River National Laboratory provides R&D and implements technical solutions for a variety of material disposition activities.
  - Enriched uranium operations at Y-12 allow analysis, processing, and packaging of materials to be downblended or properly disposed. The Material Disposition program also provides inventories of HEU for research reactor and other uses. The Material Disposition program recognizes the same risks listed by the Conversion Program above. Additionally, completing Material Disposition work at Y-12 is heavily leveraged in the low-equity discards work, which relies on the waste management infrastructure managed by Office of Defense Programs at Y-12, as well as disposal sites.

- **Nuclear Material Removal Program**
  - DOE/NNSA's Secure Transportation Asset Program provides resources for multiple material removal campaigns. The DOE/NNSA Office of Secure Transportation facilitates these projects by providing safe and secure transport of nuclear material within the territory of the United States.
  - The L-Reactor basin at SRS, a DOE Environmental Management facility, receives enriched uranium from the Removal Program and stores the material pending disposition.

- The K Area Material Storage facility receives enriched uranium and plutonium from the Removal Program and stores the material pending disposition.
- Savannah River National Laboratory operates the Mobile Plutonium Facility in support of international removal activities and provides other critical support to the Removal Program.
- Oak Ridge National Laboratory (supported by Y-12) operates the Mobile Uranium Facility in support of international removal activities and provides other critical support to the Removal Program.
- The HEU Materials Facility at Y-12 receives enriched uranium from the Removal Program and stores the material pending downblending and disposition.

The Office of Defense Nuclear Nonproliferation's Office of Nonproliferation and Arms Control (NPAC) also relies on the infrastructure maintained by other DOE/NNSA offices, as summarized below.

- NPAC relies on the availability of Category I, II, and III SNM standards and sealed sources for detector and system development, as well as facilities for testing prototype radiation detection monitoring and safeguards equipment and for training U.S. personnel in equipment use and foreign partner personnel in the fundamentals of safeguards and material measurement. While the health of the facility and SNM infrastructure remains sufficient at this time, downsizing over the last decade has required programs to use less Category I and II materials and more Category III and IV materials for detector development and training. As DOE/NNSA recapitalizes facilities that are critical to the NPAC mission, Defense Nuclear Nonproliferation offices will work with the appropriate program managers to ensure NPAC goals are incorporated as resources allow.
- DOE/NNSA infrastructure at all sites ensures NPAC can develop and maintain a U.S. capability to perform on-site verification and monitoring activities at nuclear material production and processing facilities and nuclear explosive testing sites. NPAC uses the DOE/NSNA infrastructure to train U.S. personnel, to develop and validate deployable verification equipment, and to refine on-site verification and monitoring approaches.
- At Pantex and Y-12, NPAC relies on facilities and operational expertise to test warhead monitoring and verification capabilities, and to assess the feasibility of equipment deployment at weapons facilities. Demonstrations and evaluations at operational nuclear weapons facilities are essential for developing potential long-term solutions to the technical challenges of verifying nuclear weapon reductions. They support the United States' ability to engage technically with partner countries under initiatives such as the International Partnership for Nuclear Disarmament Verification.
- NPAC relies on access to nuclear weapons design information and access to weapons activities subject matter experts to help evaluate potential nuclear warhead monitoring and verification capabilities and ensure U.S. weapons design information will be protected as part of any future monitoring initiative.
- NPAC and various U.S. agencies work with DOE/NNSA Defense Programs to support transparency initiatives in fulfilling the Nation's Article VI commitments under the Nuclear Non-Proliferation Treaty.
- NPAC uses KCNSC, LANL, LLNL, SNL, and NNSS to conduct seminars on proliferation-sensitive commodities and technologies, particularly those subject to export controls and related to nuclear weapons and associated delivery systems. These seminars and workshops provide the U.S. agencies with knowledge of these commodities and emerging technologies that is not available

elsewhere. Participants can apply what they learn in their jobs in nonproliferation policy, export licensing, export enforcement, and other functions related to preventing weapons of mass destruction proliferation.

6.8.2 Support of Counterterrorism and Counterproliferation and Emergency Operations Efforts

The Office of Counterterrorism and Counterproliferation (CTCP) heavily leverages infrastructure that is primarily used for stockpile stewardship. These assets ensure CTCP can execute its missions to counter nuclear threats, respond to nuclear incidents and accidents, and deliver an emergency response and consequence management capability for the U.S. Government. CTCP is further able to harness these resources to inform U.S. Government policies and deliver nuclear and radiological emergency preparedness training for the U.S. Government and its foreign partners. From the outset of Russia's full-scale invasion of Ukraine, CTCP has been heavily involved in the crisis, providing technical advice to U.S. Government decision-makers and Ukrainian partners. In particular, CTCP has relied on infrastructure assets to model and plan for a wide range of potential nuclear emergencies ranging from nuclear power plant accidents to Russia's use of nuclear weapons; such contingency planning would inform life-saving responses to nuclear events in Ukraine and beyond.

- **Nuclear Threat Science Program**
  - LANL, LLNL, and SNL support the Nuclear Threat Science Program by maintaining and advancing the U.S. Government's ability to assess potential nuclear threat devices, including improvised nuclear devices or foreign nuclear devices out of state control. CTCP leverages DOE/NNSA infrastructure, originally developed for stockpile stewardship, to enable computational assessment of nuclear threat devices by expanding the HPC code capabilities. This understanding of nuclear threat devices is used to inform broader U.S. Government material security, nuclear incident response, and international nuclear threat reduction efforts.
  - CTCP conducts experiments at all DOE/NNSA national security laboratories and several DOE Office of Science laboratories for the refinement and validation of predictive models.
  - To understand materials not traditionally studied by the U.S. stockpile, LLNL, LANL, and SNL execute foundational science programs to characterize nuclear materials and explosives on similar platforms. For example, CTCP uses diamond anvil cell facilities, gas guns, and other high-pressure facilities to evaluate nuclear materials. Specific unique facilities supporting stockpile stewardship are also used to improve assessment activities, including TA-55 and proton radiography at LANL, Joint Actinide Shock Physics Experiment Research gas gun and High Explosives Applications Facility at LLNL, and Z at SNL. These activities are informed by foundational science that yields a broad understanding of nuclear material behavior. Data from these experiments are used to improve material models, then used in computational codes, which are used across DOE/NNSA programs.
  - LANL, LLNL, and SNL support the development and validation of predictive modeling in support of nuclear incident response, as well as training to the interagency weapons of mass destruction defeat community. Facilities such as the Dual-Axis Radiographic Hydrodynamic Test at LANL, the Site 300 Global Security Campus Facility (Building 850), Contained Firing Facility at LLNL, as well as multiple explosives testing sites across LANL, LLNL, and SNL, support CTCP experimental validation efforts.

  - In cooperation with LANL, LLNL, and SNL, NNSS provides unique facilities and infrastructure to support Nuclear Threat Science experimental validation efforts. Capabilities at NNSS allow experimental efforts on hazardous materials or at threat-representative scale.

- **Nuclear Forensics Program**
  - Technical nuclear forensics performance depends on the core capabilities developed during the U.S. nuclear weapons development and testing program. Weapons design expertise and the simulation tools, manufacturing base, and experimental capabilities required for Weapons Activities provide a strong foundation for the technical nuclear forensics mission. Weapons Activities supports much of the expertise, facilities, nuclear material handling infrastructure, and historic knowledge necessary to perform technical nuclear forensics, including the National Nuclear Materials Archive. DOE/NNSA's Secure Transportation Asset provides safe and secure transportation of nuclear material in the United States and supports the CTCP response teams. The technical nuclear forensics mission also relies on DOE's broader ST&E capabilities, including laboratories maintained by DOE's Offices of Science and Nuclear Energy.

- **Nuclear Incident Response Program**
  - CTCP provides operational support, training, and equipment for major public events and emergencies, both foreign and domestic. CTCP draws upon these activities to aid in the development of effective public policies, medical procedures, and tabletop and field exercises that guarantee a robust multilateral incident preparedness and response for countering nuclear and radiological incidents, accidents, and terror threats.
  - CTCP relies on a diverse base of rapidly deployable assets, including specialized facilities, vehicles, and equipment to support the Nuclear Emergency Support Team (NEST) Technical Reachback and training to build international capacity, as well as the U.S. Government's effective response to a nuclear or radiological incident or emergency. These assets include the Radiological Assistance Program, based at 12 DOE locations around the Nation; the Aerial Measuring System stationed at the Remote Sensing Laboratories at Joint Base Andrews (Washington, DC) and Nellis Air Force Base (Las Vegas, Nevada); the National Atmospheric Release Advisory Center at LLNL; the Nuclear Response Group Readiness Operations Center located on Kirtland Air Force Base; and the Radiation Emergency Assistance Center/Training Site at the Oak Ridge Institute for Science and Education in Oak Ridge, Tennessee. The NEST Technical Reachback Home Teams are a virtually connected capability that has static nodes located at and operated by LANL, LLNL, SNL, Pantex, and both Remote Sensing Laboratory locations. When activated, Home Teams provide the necessary remote technical assistance to the deployed NEST assets as well as their interagency partners from the Federal Bureau of Investigation, the Department of Defense, Department of Homeland Security, and other Federal, state, and local agencies. The Nuclear Incident Team at DOE Headquarters Forrestal building and its alternate location at the DOE facility in Germantown, Maryland, also receives remote technical assistance via Home Teams. The NEST relies heavily on expertise built across the Laboratories, specifically the nuclear weapons programs, to ensure superior knowledge of nuclear weapons designs, effects of incidents or accidents on safety, and hazards associated with radiological and nuclear material. Stockpile stewardship activities for surveillance, testing, evaluation, modeling, and simulation of these scenarios is critical to the success of the Nuclear Incident Response Program.

- **Nuclear Incident Policy and Cooperation Program**
  - CTCP builds partnerships and capabilities for security, preparedness, and response against radiological and nuclear threats. CTCP strengthens domestic and international capabilities for radiological and nuclear incident, accident, and terrorism preparedness and response, and to increase awareness about the nuclear and radiological terrorism threat.
  - CTCP, in cooperation with NNSS, Idaho National Laboratory and LLNL, provides unique facilities and infrastructure to support capacity building training, workshops, and conferences. Capabilities at NNSS and Idaho National Laboratory allow for realistic training on actual radioactive contamination using ground and aerial assets.

Chapter 7 Workforce

The Department of Energy's National Nuclear Security Administration (DOE/NNSA) workforce[1] is the nuclear security enterprise's most critical asset. DOE/NNSA's ability to meet all its nuclear security missions requires a unique, diverse, and highly skilled workforce with expertise across a broad range of disciplines. DOE/NNSA and its management and operating (M&O) partners are working diligently to recruit and retain the workforce essential to meeting the enduring national security missions that face growing demand from weapons and physical infrastructure modernization programs and from emerging needs. Retention is critical since some of the required skills cannot be learned in the classroom and are not directly transferable from other industries. Just as DOE/NNSA is modernizing the stockpile and its infrastructure, it is also working to modernize its approach to the workforce.

Workforce Snapshot (Enterprise-Wide)
(October 1, 2021–September 30, 2022)

- *Total Headcount: 57,498*
- *Average Age: 44.6*
- *Average Years of Service: 10.2*
- *Retirement-Eligible Population: 21.6%*
- *Hires: 8,260*
- *Separations: 5,592*
- *Net Change: 2,668*

Competition for skilled workers across multiple disciplines and job categories increased over the last 2 years due to a changing national job landscape, and DOE/NNSA is actively working to hire and retain personnel. For example, in 2022, DOE/NNSA's M&O contractors experienced an increase in attrition rates above historical norms, which drove increased hiring. NNSA authorized multiple actions related to compensation and benefits to help curb the rising attrition, and 2023 attrition rates are returning to historically normal levels. Despite challenges, DOE/NNSA laboratories, plants, and sites succeeded in on-boarding and integrating large numbers of new workers while maintaining productivity and meeting safety and security requirements. They now must build on this hiring success by retaining workers, which is critical in roles that require years of training.

Over the past 2 years, M&Os, in collaboration with DOE/NNSA, implemented two major initiatives to enhance retention and transfer knowledge from experienced staff to newer employees or those who have taken new roles within the enterprise. First, flexible work schedules and locations have been implemented at a majority of sites. These initiatives were initially started to mitigate Coronavirus Disease 2019 risks but will likely remain in place for positions whose responsibilities allow for remote work or hybrid schedules. Flexible work schedules are an attraction and retention tool for the workforce. DOE/NNSA continues to innovate its approach to workforce management to meet the challenge of maintaining a highly skilled population across all capabilities and locations. Second, engagement with students and early-career science, technology, engineering, and math (STEM) employees exposes them to the unique mission of DOE/NNSA and the variety of opportunities available within the nuclear security enterprise. DOE/NNSA recently moved Academic Programs from a subprogram of the Office of Defense Programs' Stockpile Research, Technology, and Engineering program to an integrated program in the Office of the Chief Science and Technology Officer, demonstrating its commitment to investing in scientific research and developing a pipeline of talented individuals who can contribute to the nuclear security enterprise of the future. M&Os engage in numerous academic collaborations to introduce young talent

[1] This workforce discussion primarily speaks for the Weapons Activities account.

to the nuclear security enterprise and to leverage academia to advance the science and technology that underpins science-based stockpile stewardship. Each M&O laboratory, plant, and site has strong student, postdoctoral, and vocational training, as well as early career engagement to attract future workers.

Additionally, DOE/NNSA's senior leadership is committed to advancing diversity, equity, inclusion, and accessibility throughout the Federal workforce. In September 2022, DOE published its first-ever Diversity, Equity, Inclusion, and Accessibility Strategic Plan, which outlines actions to strengthen the department's efforts to recruit, hire, develop, promote, and retain the Nation's talent; remove inequitable barriers to career and advancement opportunities; and build and sustain an inclusive and accessible work environment. The plan answers the call issued by President Biden in Executive Order 14035, *Advancing Diversity, Equity, Inclusion, and Accountability Within the Federal Government*, that directs all Federal agencies to provide a roadmap to ensuring the Federal workforce reflects the full diversity of the American people and ensure that public servants at all levels have an equal opportunity to succeed and lead.

This chapter provides an overview of the composition, status, demographics, and accomplishments of the workforce. It covers challenges and strategies used to address those challenges. Appendix F, "Workforce and Site-Specific Information," covers the missions, capabilities, and workforce data for each of the eight nuclear security enterprise laboratories, plants, and sites as well as the Federal workforce.

In collaboration with M&Os, DOE/NNSA expanded workforce data collection to include regular, limited term, and protective force employees in an effort to better capture information on all types of personnel who support DOE/NNSA's mission. Additionally, students and interns are now counted throughout the year to better describe the national security enterprise's early engagement with students. These students are not included in the charts and statistics shown throughout this chapter; they are instead shown in callout boxes and in Appendix F. All charts and statistics in this chapter rely on workforce data as of September 30, 2022.

A Collaborative Workforce

DOE/NNSA's workforce consists of three essential integrated components, forming one team:

- *The Federal workforce leads planning, programming, budget formulation (and execution), and evaluation activities for DOE/NNSA's national security programs and provides other supporting roles. It provides strategy, direction, and priorities to accomplish the mission the sites implement.*
- *The M&Os perform the full spectrum of technical activities in support of DOE/NNSA's nuclear security missions while the Federal workforce provides oversight. The M&Os and Federal workforces collaborate to develop and implement strategic planning for the nuclear security enterprise.*
- *Non-M&Os enable mission success by providing materials, components, and specialized services; access to supplemental experimental assets; and use of academia's R&D resources.*

Personnel exchange and embedding programs foster deeper understanding of partner roles and mission critical contributions while strengthening communication lines within and between partner organizations.

7.1 Workforce Composition

DOE/NNSA's workforce has three components: the Federal workforce, the eight M&O-operated sites,[2] and a wide variety of non-M&O entities that provide support to DOE/NNSA's missions.

7.1.1 Federal Workforce

The Federal workforce is situated at DOE/NNSA Headquarters in Washington, DC; Germantown, Maryland; and Albuquerque, New Mexico, as well as field offices located across the nuclear security enterprise.

The Federal workforce is responsible for program and project management, as well as Federal contractor assurance and oversight of the national security missions across the enterprise. They are responsible for performing inherently

[2] M&Os are consortia of industrial and academic contractors. More detail on these contractors may be found in Appendix F.

governmental functions[3] such as planning, programming, and budgeting activities; fiduciary oversight; risk prioritization product acceptance; supply chain management; legal; human resources; acquisition; and environmental, safety, and health oversight duties. This workforce comprises highly educated and experienced civil servants from a variety of backgrounds.

As of September 30, 2022, DOE/NNSA's Federal workforce had a headcount of 2,421 employees. This number does not include DOE-funded Federal personnel within the Office of Naval Reactors, but does contain Federal staff within the Office of Secure Transportation, as discussed in Chapter 5. Of the 2,421 employees, approximately 1,200 are directly working on, or playing a supporting role in, the Weapons Activities programs discussed throughout this plan. The rest are involved in areas such as Defense Nuclear Nonproliferation, Counterterrorism and Counterproliferation, Management and Budget, General Counsel, Public Affairs, Congressional and Intergovernmental Affairs, Field Offices, and others. The Federal workforce tends to skew heavily towards the general management labor category, although engineers and physicists are represented as well.

The average age of the Federal workforce is 47 years old, with approximately 15 percent eligible for retirement. The average employee has 14.5 years of service. Attritions increased from the historical trend of about 8 percent to 10.4 percent in fiscal year (FY) 2021 and 11.8 percent in FY 2022;[4] however, hiring has resulted in a slight increase in the total number of Federal employees. Projected needs will increase gradually over the next 5 years, topping out at a headcount of 2,671.

7.1.2 Management and Operating Workforce

The M&O workforce is situated at the eight government-owned or -leased nuclear security enterprise laboratories, plants, and sites discussed in Chapter 1, Section 1.2, of this report and depicted in **Figure 7–1**. These partners each bring unique capabilities to the nuclear security enterprise. Each specializes in certain areas–for instance, weapon design, warhead assembly, subcritical experiments, engineering and production–and contributes to the science, research, and production that culminate in delivery of warheads to the Department of Defense (DoD).

The M&O workforce contains the bulk of the enterprise's scientists, engineers, operators, technicians, and craft labor personnel, who are integral to achieving DOE/NNSA's national security missions as it performs the design, testing, production, procurement, surveillance, and assessment of the warheads, their components, and the associated science and engineering required. The M&Os maintain the talented workforce and the facilities necessary for science-based stockpile stewardship. Additionally, they support nuclear non-proliferation, global material security, and other national security programs.

The laboratories, plants, and sites reported 55,077 employees as of September 30, 2022. The national security laboratories[5] and the Nevada National Security Site reported 36,125 employees, while the production plants[6] reported 18,952 employees. Similar to Federal headcount, some employees perform work in support of other DOE/NNSA missions, such as Defense Nuclear Nonproliferation. **Figure 7–2** displays the breakdown of workforce in terms of headcount across the national security enterprise.

[3] As defined in Section 5 of the Federal Activities Inventory Reform Act, Public Law 105-270, these are functions that are so intimately related to the public interest that they require performance by Federal Government employees.

[4] Attrition is 12.6 percent in FY 2022 if calculated using an average of workers over the course of the year from Federal Salaries and Expenses, which excludes the Office of Secure Transportation.

[5] Los Alamos National Laboratory, Lawrence Livermore National Laboratory, and Sandia National Laboratories

[6] Kansas City National Security Complex, Pantex Plant, Savannah River Site, and Y-12 National Security Complex

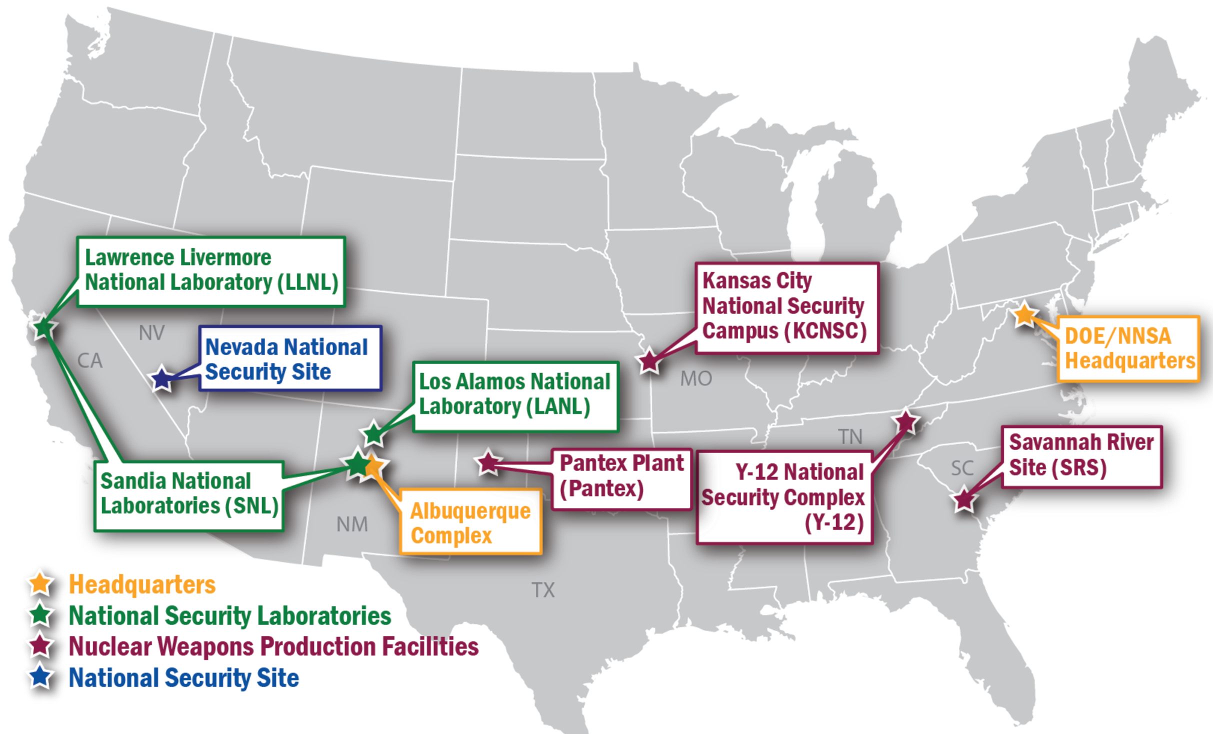


Figure 7–1. The DOE/NNSA nuclear security enterprise

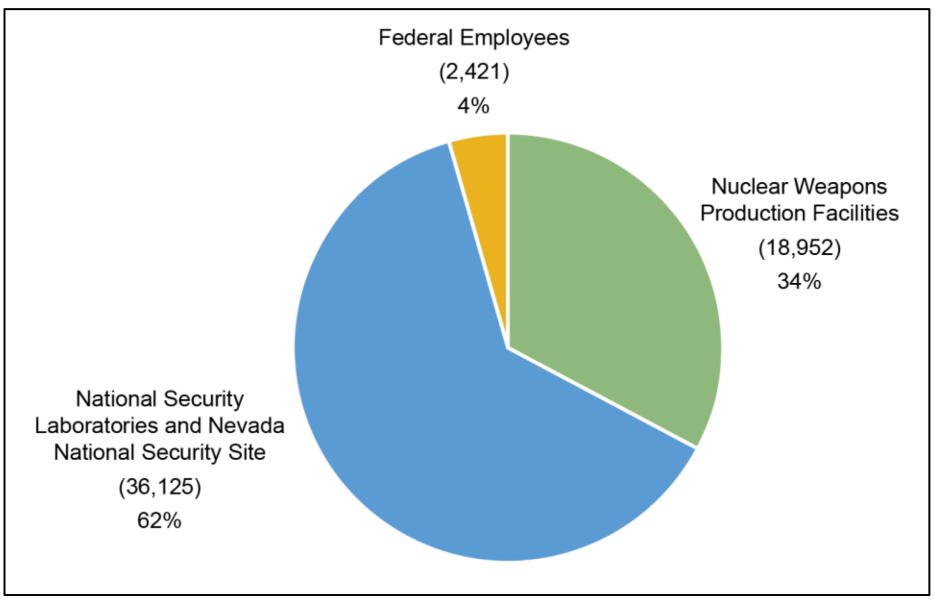


Figure 7–2. M&O and Federal share of total Weapons Activities workforce

7.1.3 Non-Management and Operating Workforce

The nuclear security enterprise also requires significant contributions from other people and corporations to fulfill its mission. The numerous line-item construction projects require hundreds of construction crews skilled in architecture, concrete fabrication; electrical engineering; plumbing; heating, ventilation, and air conditioning; masonry; and other trades. These trades are in high demand and may require innovative approaches to ensure their availability. For instance, Savannah River Nuclear Solutions entered into a project labor agreement with the Augusta Building and Construction Trades Council, which is comprised of 19 local unions and supports the construction of the Savannah River Plutonium Processing Facility (SRPPF). The project agreement guarantees Savannah River Nuclear Solutions access to more than 2,500 skilled trades and craft employees, whose work is crucial to completing this large and complex construction project.

Production and design agencies rely on complex supply chains to provide everything from supercomputers to raw materials. These suppliers must meet quality standards that exceed normal industry needs, and they must meet export control and other requirements. Many M&Os hire staff augments through subcontracts to provide key skills and assist permanent employees, while the Federal workforce similarly relies on support service contractors to fill numerous roles. Academic institutions that support DOE/NNSA through the academic alliances and partnerships are integral in providing a pipeline of highly skilled and educated talent into the enterprise. These individuals are not captured in the data and statistics displayed in this chapter, though their contributions are significant.

7.2 Status

DOE/NNSA must have a sufficient workforce with the right expertise and competencies to ensure it can not only carry out its Stockpile mission but the full scope of DOE/NNSA's missions as described in Chapters 1–6 of the *FY 2024 Stockpile Stewardship and Management Plan* and *FY 2022 – FY 2026 Prevent, Counter, and Respond – NNSA's Plan to Reduce Global Nuclear Threats*.

Along with the rest of the United States, the nuclear security enterprise experienced the "Great Resignation," with turnover rates[7] for voluntary and involuntary attrition rising to nearly 11 percent from historic levels of approximately 6–7 percent. Retirement has historically been about half of the attrition rate across the laboratories, plants, and sites. As retirement eligibility continues to stand around 21.6 percent and the percentage of employees classified as having 0–5 years of service rises to over 50 percent, M&Os must grapple with the challenge of retaining personnel. For some programs, the process of getting a security clearance, getting cleared for the Human Reliability Program, and training to a basic level of competence takes 3 years. If DOE/NNSA does not retain a high percentage of these employees for extended periods of time, it will be difficult to guarantee a workforce with the necessary experience and technical judgment to perform the nuclear security mission. Each employee is valuable to the nuclear security enterprise, and as they build their skill sets though training and gaining experience, their value is enhanced. When an employee separates, it leaves a work gap that has to be filled by people busy with other jobs, and more training is required for someone else to fill that position. This results in an increased workload to the remaining staff.

As seen in **Figure 7–3**, although the attrition rate of 0–5 years of service is relatively consistent with the other groups in the top graph, the bottom graph shows that the sheer number of 0–5 years of service employees separating far exceeds the other groups since they comprise a disproportionately large segment of the workforce. The number of workers leaving the nuclear security enterprise is large and increased the past two years. The steep increase in separations of workers with 0–5 years of service corresponds with an even greater increase across the enterprise in new hires, so overall workforce numbers are still growing. Although DOE/NNSA is hiring more employees than ever before, it is struggling to retain those new hires.

[7] Turnover rate was calculated by dividing the number of employees who separated during a given FY by the total number of employees at the beginning of that FY.

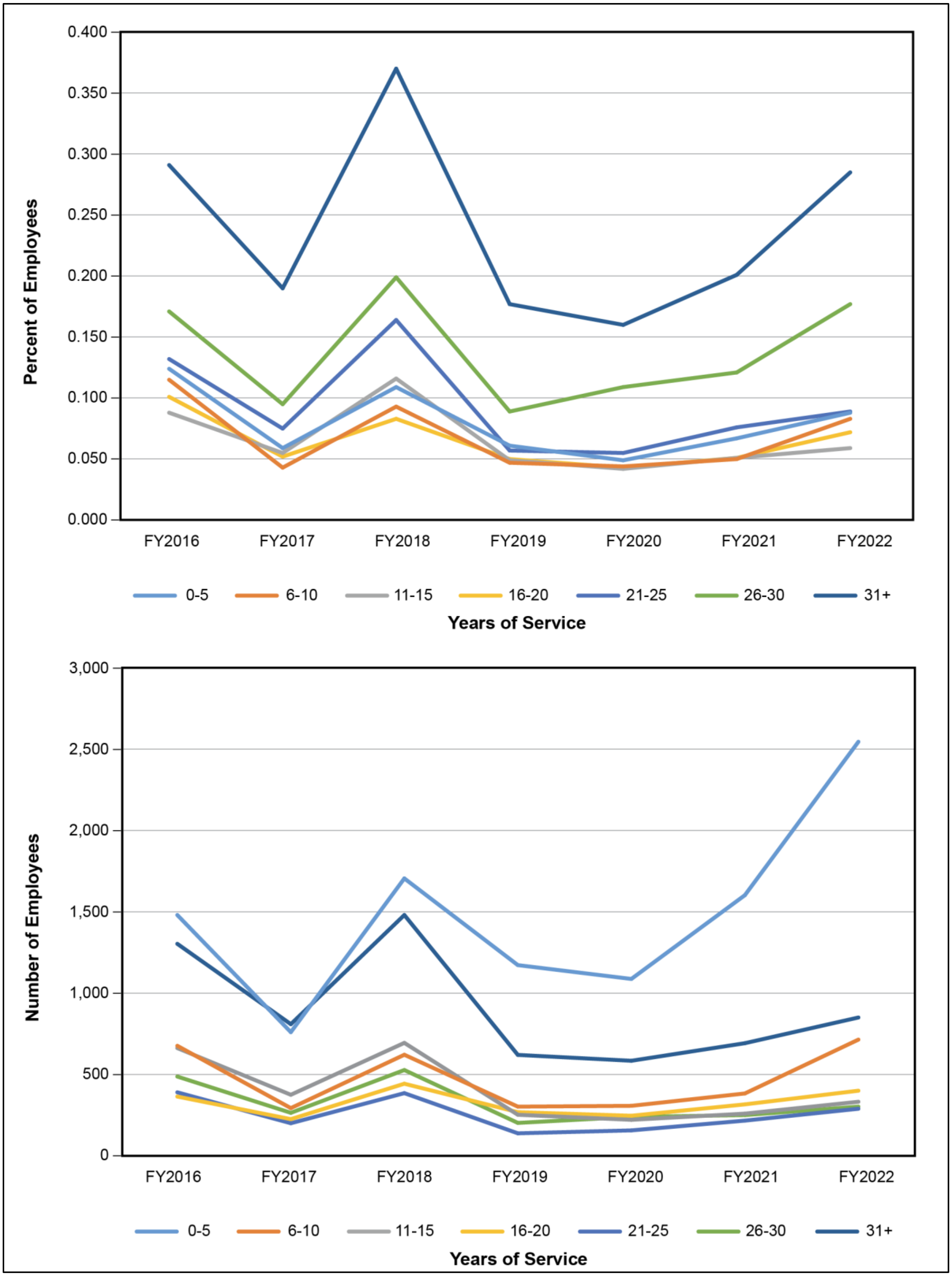


Figure 7–3. Turnover rate trends

DOE/NNSA is simultaneously losing its most experienced talent as retirements in the 26–30 years of service and 31+ years of service groups continue increasing. While the total number of separations from those two groups is constant, the percent of employees retiring is increasing because there are fewer employees left in those groups. The total years of experience across all M&Os is decreasing as the most experienced workers retire and fewer people with high levels of experience remain to replace them. Without cadres of workers staying long enough to learn from career workers that are retiring, new workers 20 years from now will have fewer mentors who fully understand the complex processes involved with design, manufacture, and testing of nuclear weapon components or of their assembly and disassembly. Commercial industry similarly is struggling to retain early career employees. M&Os have taken steps to help retain employees, such as implementing a mid-year compensation adjustment, using retention bonuses, authorizing larger merit increases, increasing promotion funds, and modernizing benefit offerings. The combination of these changes have proven effective as attrition rates have returned to historical norms. In addition, M&Os are working hard to determine the reasons employees are leaving so they can continue to offer desirable work environments.

7.2.1 Workforce Demographics

As of September 30, 2022, the nuclear security enterprise consisted of 57,498 Federal and M&O employees.[8] Since the last detailed workforce data reported in the *FY 2022 Stockpile Stewardship and Management Plan* (SSMP),[9] the nuclear security enterprise added over 8,260 employees during FY 2022 and over 5,538 employees in FY 2021. During FY 2022, the enterprise experienced just under 5,592 separations. Though there has been significant success in hiring, the required hiring targets increased in FY 2022 due higher-than-normal attrition. Hiring targets have started to decline as M&Os' attrition has stabilized.

It should be noted, all demographics discussions in the SSMP are based on headcount. Headcount includes every individual employee, each counted as "one" person, which is a useful measure for workforce discussions since it counts human beings. Counting full-time equivalent focuses on hours worked rather than individual employees, and is helpful when judging the level of effort required for a program. To illustrate, if there are two employees working part-time (for example, 20 hours per week) on a given weapons activities program, they add up to one full-time equivalent, while the headcount value would be two. Since many employees work on multiple programs, the sum of full-time-equivalents will generally match headcount.

7.2.1.1 Common Occupational Classification System

DOE/NNSA uses the Common Occupational Classification System, which provides a set of mutually exclusive occupation titles and definitions that cover the broad range of activities present in the DOE/NNSA complex, to consistently categorize workers across the nuclear security enterprise.[10] As shown in **Figure 7–4**, the largest group comprises Engineers, followed by Professional Administrators, General Management, and Scientists. Technicians, Operators, and Crafts provide valuable hands-on work and together account for nearly 25 percent of the workforce.

[8] This number does not include the Naval Reactors workforce nor support service contractors/augmented labor.

[9] The FY 2023 SSMP contains a focused summary of separations and retention data, different from the detailed information required in even-year documents.

[10] *Common Occupational Classification System*, Revision 3. Pacific Northwest National Laboratory, May 1996. This classification system was developed to assist DOE's Environmental Management and DOE/NNSA's Defense Programs jointly managed workforce planning as production sites closed and Environmental Management work increased.

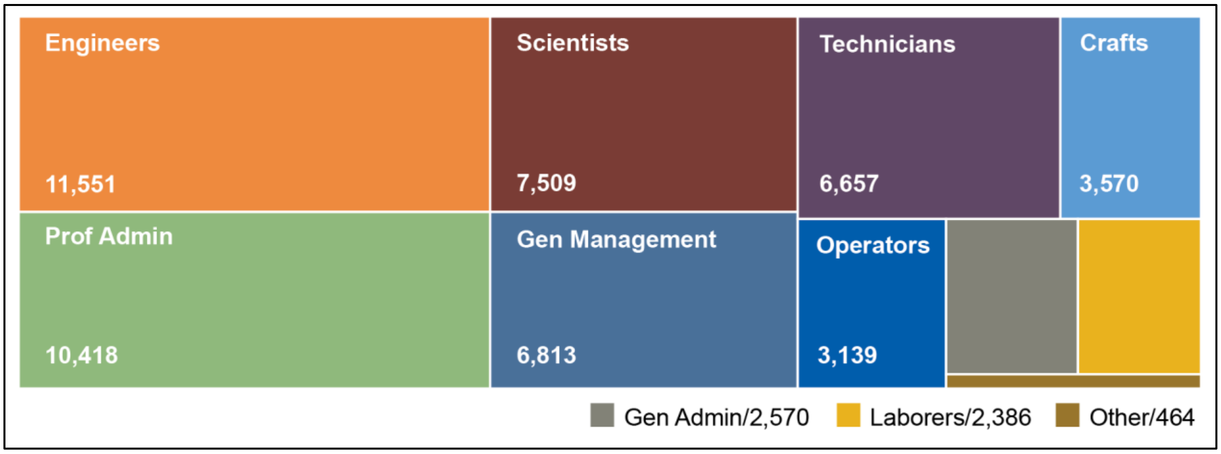


Figure 7–4. M&O Workforce breakdown by Common Occupational Code

7.2.1.2 Age

The enterprise workforce, when viewed in total, has a fairly even distribution across age groups from 26–60 years old. A review of **Figure 7–5** displays a slightly more even age distribution for the production sites, while the national security laboratories have a slightly higher number of younger employees.

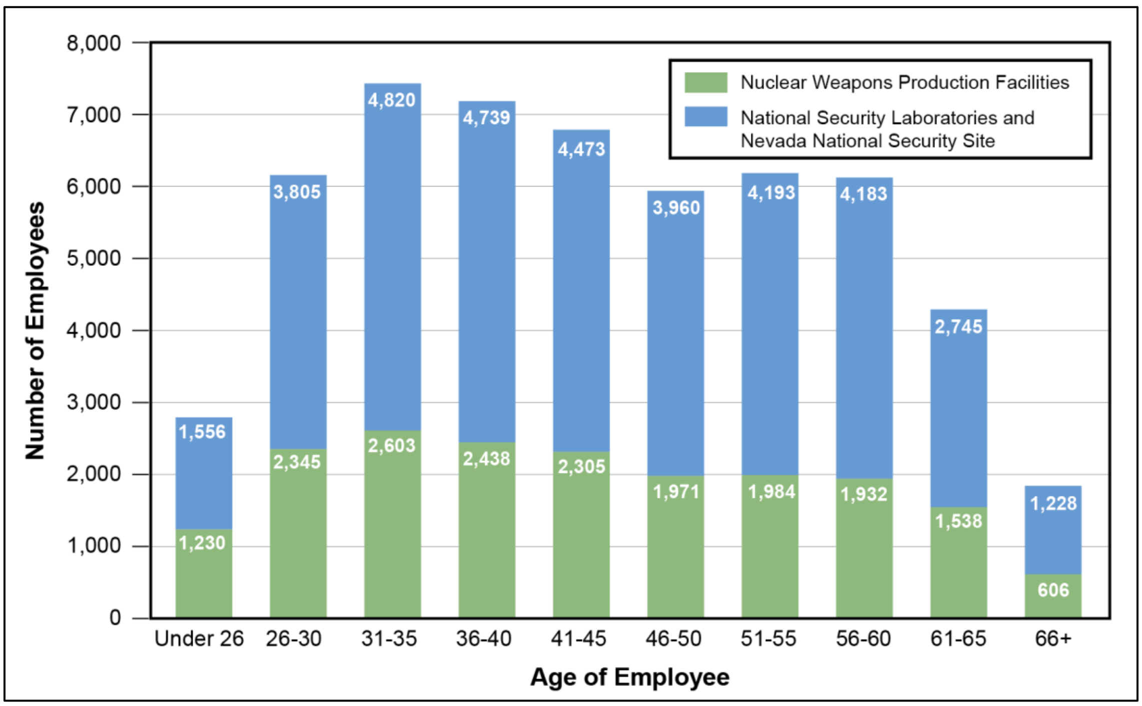


Figure 7–5. Workforce breakdown of national security laboratories, the Nevada National Security Site, and weapons production facilities by age group

7.2.1.3 Years of Service

Due to increased hiring to support the growing scope of weapons modernization programs, nearly 67 percent of the workforce has 10 or fewer years of service as shown in **Figure 7–6**. Over the last 2 years, the M&O workforce grew from a total of 46,762 employees at the end of FY 2020 to 55,077 at the end of

FY 2022. As reflected in the relatively even age distribution as compared to the more skewed years of service distribution, many new hires may be new to the enterprise but bring experience from a previous industry or position to specialized nuclear weapons work. It should be noted that workforce data is reported by each M&O, so if a person moves from a national security laboratory to a production plant, for example, they will appear in the data as a new hire. Whether an employee is recently graduated or new to the nuclear security enterprise, the lack of experience within weapons programs necessitates accelerating knowledge transfer activities and training for younger and/or less experienced personnel before specialized knowledge is lost due to retirements and separations. Once these new personnel are trained, retaining them is essential.

Comparatively, the Federal workforce shows a more even distribution in years of service, with many personnel having 11–15.[11]

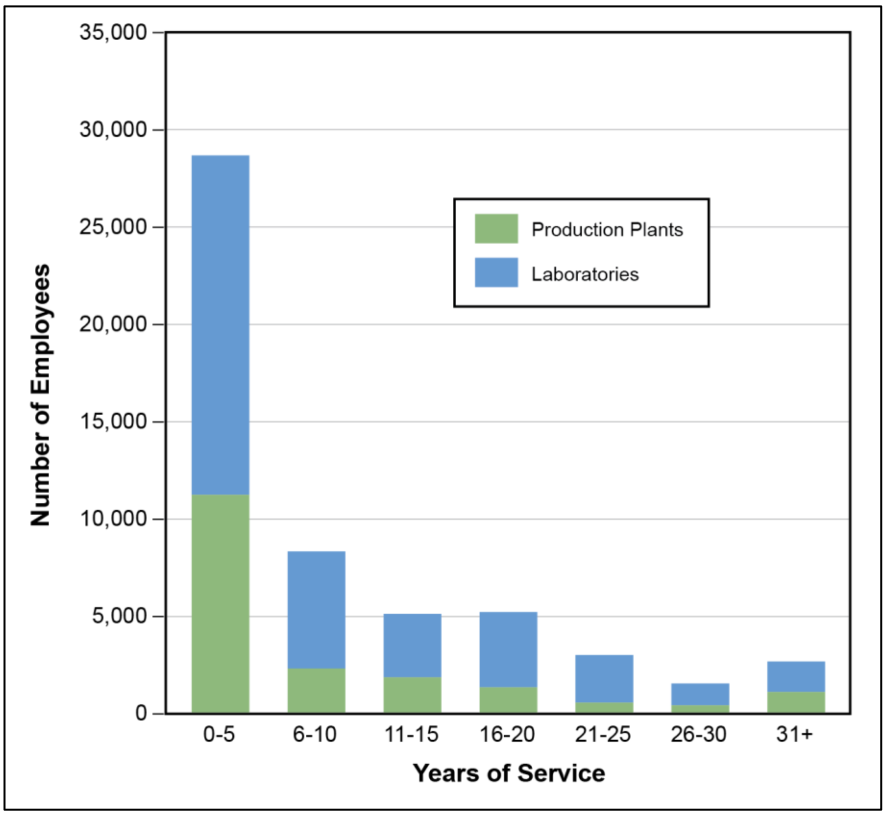


Figure 7–6. Workforce breakdown of national security laboratories, the Nevada National Security Site, and weapons production facilities by years of service

7.2.1.4 Separations

For separations, many of those with higher years of service are leaving due to retirement, as expected, and shown in **Figure 7–7**. However, as previously noted, 71 percent of non-retirement, voluntary separations are in the 0–5 years of service category, as shown in **Figure 7–8**. Separations, both voluntary and retirements, have increased over the last two years, indicating the nuclear security enterprise faces increased competition for skilled labor and is struggling to retain the talent that it hires and trains.

[11] Federal workforce data, including a graphic representation of years of service, can be found in Appendix F.

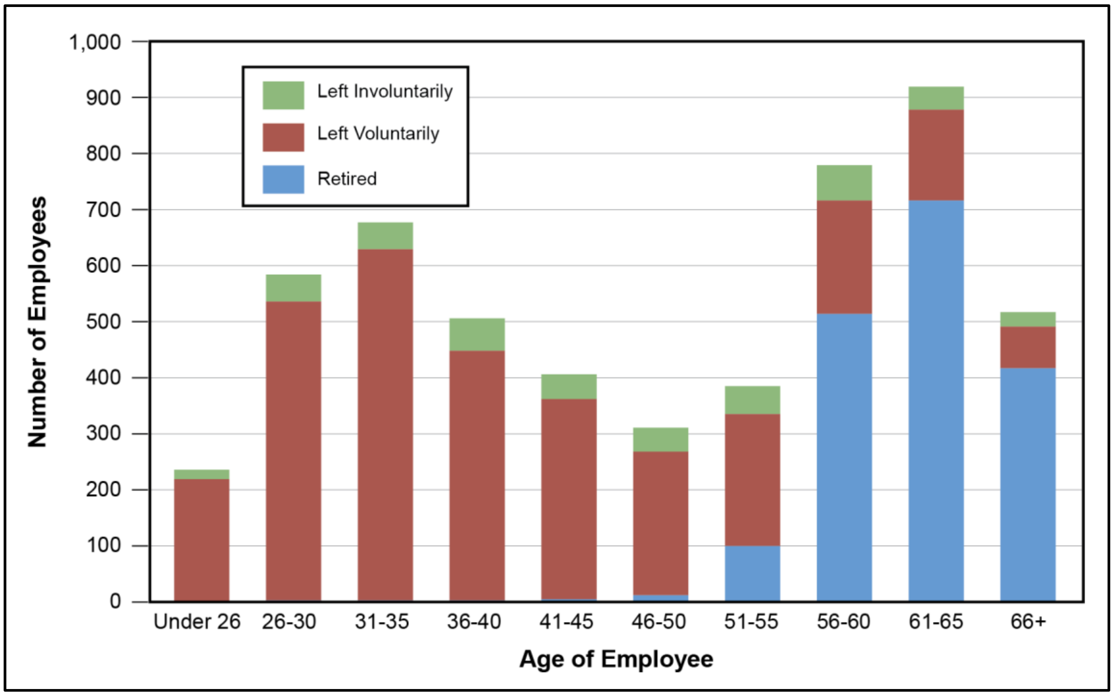


Figure 7–7. Total M&O separations by age group

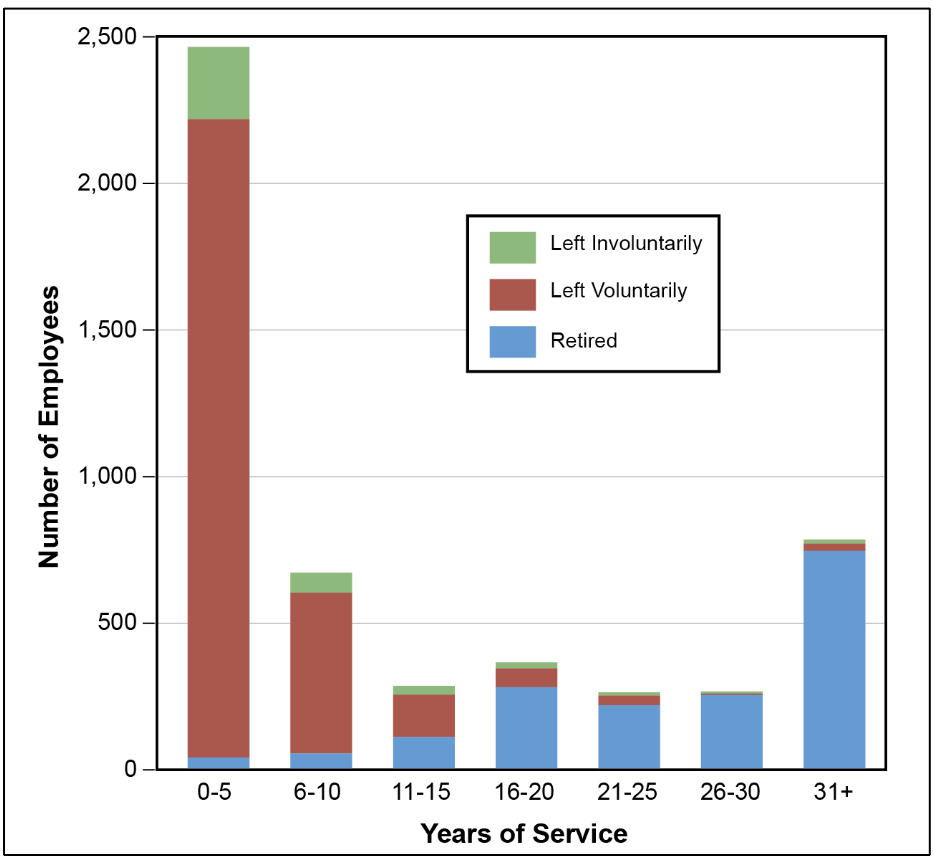


Figure 7–8. Total M&O separations by years of service

7.3 Managing the Workforce Career Cycle

The nuclear security enterprise population comprises highly skilled workforce with specialized training in technical, safety, security, and operational requirements. In many areas, these skills cannot be learned in the classroom and are not directly transferable from other industries. Areas in which specialized knowledge/experience is required include, but are not limited to, weapons design, high explosives manufacturing and surveillance, weapons system engineering, nuclear criticality safety engineering, radiation effects sciences, toolmakers, quality control and assurance, data science and high-performance computing, cybersecurity, welding, radar, and optics. This unique specialization of the enterprise workforce means that high retention rates, beyond what may be standard or desired in private industry, are essential for capability continuity. New staff require specialized training upon joining the nuclear security enterprise to augment their technical, vocational, or professional experiences prior to joining the nuclear security enterprise. These additional requirements include obtaining a security clearance, safety and security training, and, for many job categories, multi-year training and on-the-job internships. Retaining these uniquely qualified workers must be a priority.

Managing the entire career cycle—from early engagement, to recruiting and hiring, to developing and training, to retaining and, eventually retirement—requires dedicated human resources programs and mentorship, and strong consideration of new initiatives to meet the needs of the current workforce and to adapt to a changing environment. External factors, such as the availability of housing or childcare, also affect hiring and retention. Preferences for flexibility in location and schedule, more responsibility, and quick advancement challenge current models. The changing demographics, increasing separation between experienced workers and early-career staff, and increasing safety and security requirements place additional stress on workforce training and development.

During 2022, DOE/NNSA implemented many immediate initiatives and policy changes to help M&Os attract and retain talent. Some examples include:

- Implementing a first ever mid-year compensation adjustment to react in real time to the impact of the “Great Resignation”
- Increasing promotion budgets
- Modifying the policy for benefits to allow laboratories, plants, and sites to modernize their benefit offerings as appropriate
- Introducing new provisions for compensation increases

Implementing these changes contributed to helping curb the increasing attrition rates across the enterprise. DOE/NNSA have continued to partner with the M&Os to determine reasonable ways to modernize policies for compensation and benefits throughout 2023 to ensure the M&Os have the tools needed to attract and retain talent.

In recognition of the importance of looking ahead at the workforce that will be required in the future, DOE/NNSA commissioned the 2022 Strategic Outlook Initiative to focus on workforce. Sponsored by the NNSA Administrator with active engagement from all of the laboratories, plants, and sites, the Strategic Outlook Initiative sponsors enterprise-wide, strategic-level studies that look “over-the-horizon” to identify cross-cutting issues for DOE/NNSA over the next 5–20 years. The 2022 study concerning the nuclear security enterprise workplace of the future explores enterprise workforce needs 15–20 years from now and forecasts the character of that workforce within a range of work environments. The study recommends a number of ways individual laboratories, plants, and sites can strengthen their workforces and collaborate, as well as what DOE/NNSA can do to support the workforce of the future.

7.3.1 Early Engagement

> ***Enterprise-Wide Student and Early Engagement (October 1, 2021–September 30, 2022)***
>
> - *Total Interns: 431*
> - *Total Postdoctoral Fellows: 1,550*
> - *Total Students: 4,722*
> - *NGFP Fellows: 60*
> - *MSIPP/TEPP Interns: 245*

The nuclear security enterprise operates early engagement programs and initiatives to attract talent from a broad set of disciplines and specialties. Federally sponsored Academic Programs as well as site-specific programs engage promising candidates with technical and/or trade skills. Examples of engagement activities include participation in internal and external career fairs, high school outreach activities, trade and vocational programs, student (undergraduate, graduate, and postdoctoral) appointment offerings, and partnerships with local colleges and universities. Each M&O has established technical and strategic programs to attract the skills critical to their specific missions.[12] DOE/NNSA continues to recruit jointly at university hiring fairs and virtual fairs, which are designed to show candidates the breadth of options for geographic location or career specialization that the nuclear security enterprise offers. Early engagement is critical to maintain a robust pipeline of individuals with the skills and motivation to contribute to national nuclear security missions.

Both DOE/NNSA and M&O senior leadership have expressed serious concerns about the future of the STEM workforce. DOE/NNSA must prioritize investments in undergraduate, graduate, and postdoctoral researchers, particularly those performing research of interest to DOE/NNSA, taking into consideration that the requirement to attain and hold a security clearance makes the pool of potential candidates smaller. DOE/NNSA continues its six strong Academic Programs that support a host of different science and engineering fields, including materials science, high energy density physics, nuclear science, computational science, modeling, and simulation. These programs, in particular the Minority Serving Institution Partnership Program (MSIPP) and the Tribal Education Partnership Program (TEPP), lead nationally in promoting diversity, equity, inclusion, and access in STEM research.

DOE/NNSA identified a need to expand its programs and is working to attract STEM talent from numerous institutions. DOE/NNSA has launched the Apprenticeships for Complete and Committed Employment for Specialized Skills (ACCESS) Program to bolster existing and create new apprenticeship programs to develop the technicians and skilled craft trade workers needed to meet the ongoing and emerging needs of the complex. In FY 2023, Academic Programs supported 18 Centers of Excellence, 62 grants, 33 consortia, and 150 fellows engaged in research relevant to the nuclear security mission. In FY 2024, the addition of Pipeline Development will increase DOE/NNSA's presence within the scientific community and expand the pool of STEM talent throughout the nation who are identified, recruited, cleared, and retained in the nuclear security enterprise.

7.3.1.1 Academic Programs

Academic Programs is designed to support investments in science and engineering disciplines of critical importance to DOE/NNSA's nuclear security enterprise, including nuclear science, radiochemistry, materials at extreme conditions, high energy density science, advanced manufacturing, and high-performance computing. The program's grants, centers, fellowships, and other funding options offer an introduction to the mission and people in the national laboratories, establishing a workforce pipeline to strengthen the future enterprise. The programs focus on quality science through competitive award,

[12] Site-specific early engagement initiatives and academic alliance programs are in Appendix F.

connection with DOE/NNSA mission work at the national security laboratories and nuclear weapons production facilities, and a view to the nuclear security enterprise's future needs and opportunities.

Academic Programs has three goals:

1. Develop the next generation of diverse, highly trained technical workers able to support DOE/NNSA's core missions
2. Maintain technical expertise external to the nuclear security enterprise for providing valuable oversight, cross-check, and peer review
3. Enable innovation to enhance nuclear security enterprise missions and to strengthen key fields of research relevant to DOE/NNSA

The Academic Programs comprises six subprograms:

1. Stewardship Science Academic Alliance: This program supports scientific academic research programs to develop the next generation of highly trained technical workers able to support the core DOE/NNSA mission and to ensure there is a strong community of technical peers (external to the NNSA national laboratories) capable of providing peer review and scientific competition to strengthen the basic fields of research relevant to the nuclear security enterprise. Stewardship Science Academic Alliance funding supports research at approximately 80 universities, including training of over 200 graduate students and postdoctoral researchers. This program includes the Stewardship Science Graduate Fellowship and Laboratory Residency Graduate Fellowship programs.
2. MSIPP: This program provides competitive, consortia-based grant awards with a 3- to 5-year period of performance to minority-serving institutions who partner with the nuclear security enterprise to prepare DOE/NNSA's next-generation workforce in the STEM disciplines.
3. TEPP: Similar to MSIPP, this program provides 3- to 5-year grants to tribal serving institutions who partner with the nuclear security enterprise. MSIPP and TEPP continue to expand the nuclear security enterprise's STEM pipeline while improving the diversity of the workforce by recruiting from underrepresented populations.
4. Joint Program in High Energy Density Laboratory Plasmas: This program is designed to steward the study of laboratory high energy density plasma physics by funding academic research of ionized matter in laboratory experiments where the stored energy reaches approximately 100 billion joules per cubic meter (i.e., pressures of approximately 1 million atmospheres).
5. Computational Science Graduate Fellowship: This program cultivates the next generation of scientists and engineers in computational sciences, physical sciences, engineering, mathematics, and data science fields including artificial intelligence and machine learning. For DOE/NNSA, it supports the Advanced Simulation Computing and Stockpile Modernization missions by establishing academic programs for multidisciplinary simulation science and providing students an opportunity to collaborate with world-class researchers and scientists on high performance computing subjects for solving complex science and engineering problems develop weapons codes through open science applications.
6. Predictive Science Academic Alliance Program: This program engages with leading U.S. universities, focusing on the development and demonstration of technologies and methodologies to solve open science and engineering application problems. Predictive science is based on verification, validation, and uncertainty quantification methodologies for large-scale simulations.

A recent addition to the Academic Programs is the National Lab Jobs ACCESS Program that provides apprenticeships in the skilled and cyber trades needed to fill a widening gap in the workforce at the nuclear security enterprise laboratories, plants, and sites. The ACCESS Program also funds pre-apprenticeship and apprenticeship programs to train a skilled workforce in the trades needed at by DOE/NNSA, such as machinists, welders, information technology and cybersecurity professionals, fissile material handlers, and industrial hygienists. The ACCESS Program requires a partnership between pre-apprentice or apprentice program sponsors and a national laboratory, site, or plant to define the skillsets needed by technicians at those facilities and then provides funding to tailored training programs.

7.3.1.2 NNSA Graduate Fellowship Program

The NNSA Graduate Fellowship Program has been administered by Pacific Northwest National Laboratory for over 25 years with a goal of identifying and developing the next generation of diverse and talented leaders to strengthen the nation through nuclear security work. The program routinely brings in top talent and provides several opportunities for fellows to work alongside experts, support major events, and engage in professional development opportunities. The fellows are assigned to work with a program office, field office, M&O, or other agency involving nuclear issues for a one-year term. The program has steadily grown over the years, from an initial cohort of 3 fellows in 1995 to recent cohorts of 60 fellows, and has over 500 alumni. Over the life of the program, about 90 percent of the NNSA Graduate Fellowship Program fellows continue to serve the Nation in a national security capacity (see **Figure 7–9**).

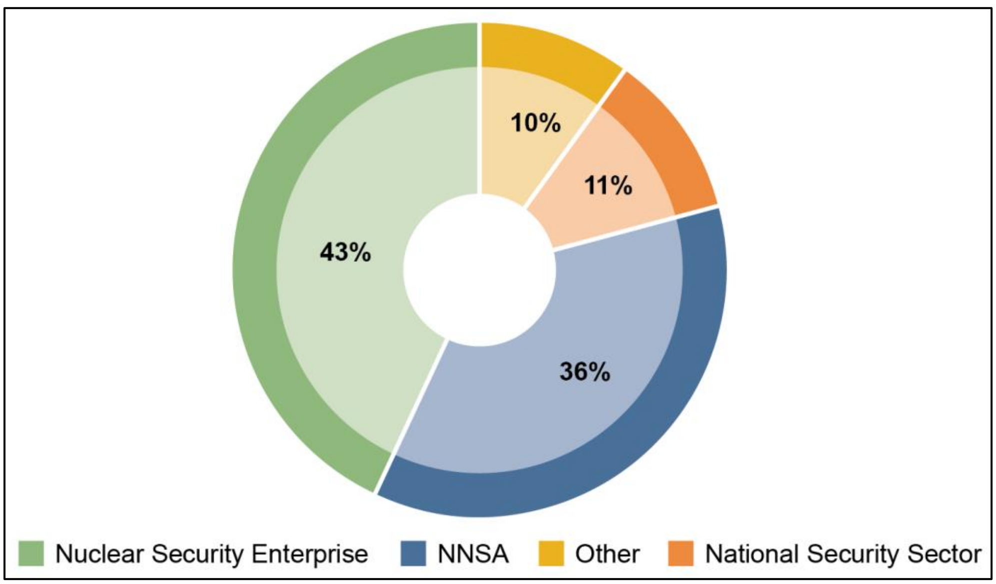


Figure 7–9. NNSA Graduate Fellowship Program Class of 2021–2022 Post-Fellowship Employment[13]

7.3.2 Recruitment and Hiring

DOE/NNSA and its M&Os continue to increase hiring to meet mission requirements, adding over 8,260 employees during FY 2022 and over 5,538 employees in FY 2021.[14]

[13] In this graph, NNSA represents Federal hires; nuclear security enterprise represents fellows hired by DOE, national laboratories, and DOE/ NNSA contractors; National Security Sector represents fellows who accepted employment with other national security stakeholders such as Department of State or Defense Threat Reduction Agency; and Other represents fellows who returned to academia or whose employment was unavailable at the time of publication.

[14] Data for the FY 2024 SSMP was collected as of September 30, 2022.

DOE/NNSA and M&Os have changed their recruiting strategies based on the demands of the job market to conduct more proactive sourcing, allowing them to reach the passive and active candidates as well as better compete with industry. DOE/NNSA has focused on recruiting a diverse Federal workforce, and leverages its excepted service hiring authority to hire uniquely qualified candidates for specialized roles. Each M&O employs strategies that address its unique recruiting and hiring challenges. For instance, the Kansas City National Security Campus (KCNSC) launched an initiative to recruit and hire graduating high school students who have no prior work experience. As a result, future generations can now start a career, gain experience, and develop useful skills in an advanced manufacturing facility, while earning a competitive salary. For more recruitment and hiring strategies, see Table 7–1.

7.3.3 Developing and Training

Since the DOE/NNSA workforce requires unique skills, many of which must be acquired through on-the-job training or through learning from experienced mentors, it is imperative to build programs that support this capability development, training, and knowledge transfer.

Implementing training and knowledge-transfer programs to mitigate the loss of expertise through the retirement of experienced personnel continues to be an area of emphasis for the enterprise. Increased stockpile modernization workloads provide increased opportunity for new employees to learn on the job. This approach must be done in tandem with adequate mentoring and guidance to be an effective method of knowledge transfer. Many M&Os, especially the national security laboratories, have mentoring programs in place as part of employees' career development. Once new employees are trained in a program, they must be retained for these programs to achieve long-term benefit. Additionally, each laboratory, plant, or site must look ahead to determine future need so that trained personnel will be available and will have had time to learn from experienced personnel.

7.3.3.1 Laboratory, Plant-, and Site-Directed Research and Development

Laboratory-directed R&D programs play a significant role in the development of the workforce. These programs fund high-risk and potentially high-payoff research projects aimed at developing science and technology tools and capabilities to meet future national security challenges and create vibrant R&D communities that are attractive to high caliber personnel, including both new and experienced researchers. Consequently, DOE/NNSA benefits not only from the expertise of the individuals, but also the establishment of long-term relationships with future recruits and the academic institutions at which they study. These programs have developed postdoctoral paths that help transition in-demand researchers to full-time career employees and provide opportunities to introduce new hires to the nuclear security enterprise. The ability to conduct R&D in DOE/NNSA's state-of-the-art facilities is attractive, and these programs pave the way for early career scientists and engineers to find a lifelong professional home where their knowledge will be utilized in mission-relevant research. For instance, Lawrence Livermore National Laboratory (LLNL) recently opened the Advanced Manufacturing Lab, where employees collaborate with industry to "spin in" and "spin out" advanced manufacturing technologies.

Plant- and Site-directed R&D, which contribute to developing future capabilities, have historically been directed by Federal Program Managers to address specific needs. Plant- and Site-directed R&D leverages the knowledge and talent of skilled professionals to find solutions to relevant challenges. Plant-directed R&D proposals engage in research, development, and demonstration activities with respect to engineering and manufacturing capabilities related to DOE/NNSA missions. Many of these activities not only support DOE/NNSA missions, but also include academic partnerships as a workforce pipeline, bringing university talent into the plants. This partnership permits students working on research at their universities to continue that research after graduation with full time employment at a plant.

7.3.3.2 Training Initiatives

DOE/NNSA sponsors several training programs for Federal employees, from "NNSA 1st Year" that introduces new employees to the agency to Supervisory Training that provides senior employees with the tools and skills to promote a positive workplace. DOE/NNSA's Learning and Career Management sponsors opportunities in numerous Leadership Development Programs as well as rotations or details to other offices within DOE/NNSA. These programs promote learning, development, and training to all Federal employees for their and the organization's benefit.

M&Os are taking innovative approaches to training to meet the demands of onboarding numerous new hires. For instance, KCNSC deployed four extended reality applications to safely and effectively enhance employee onboarding, with more applications in development. The four applications are Visually Enhanced Guidance Application, a virtual reality roller mill training, a virtual reality electrical tester training and a virtual reality forklift training. All applications are currently deployed to new employees in specific job classifications (inspectors, production fabricators, assemblers, transportation personnel) so they can safely train in a virtual environment, allowing learners to build muscle memory for expected behaviors. Significant results from these applications include:

- Zero safety incidents have occurred on the Roll Mill since implementing the training
- Virtual Reality training contributed to a 66 percent reduction in training cycle time for electrical inspectors
- Number of average instructor interventions during electrical tester training decreased from 16.37 to 2
- Visually Enhanced Guidance Application increased inspector efficiency by eliminating or reducing questions to engineers

As part of its plutonium pit production recovery strategy, DOE/NNSA is continuing to work with LLNL and Los Alamos National Laboratory (LANL) to capture efficiencies based on knowledge gained from pit production efforts. Lessons learned from production experience at LANL will be used to minimize the time needed to produce the first War Reserve pit and achieve full capacity at SRPPF after the completion of construction. A key part of the knowledge-transfer plan is construction of a High-Fidelity Training and Operations Center at Savannah River Site (SRS), which will be completed and begin its pit development and training mission several years before Savannah River Plutonium Processing Facility's main processing building is completed.

7.3.3.3 Knowledge Preservation

In recognition of the need to transfer knowledge from senior to junior staff, DOE/NNSA established the Knowledge Preservation Initiative as part of the NNSA 2021 Safety Roadmap. One of the key elements is to capture and retain the crucial knowledge and experiences of DOE/NNSA subject matter experts, senior leaders, and managers, all of whom have a wealth of experience in a multitude of challenges DOE/NNSA has faced over the decades. As DOE/NNSA is currently experiencing a large talent turnover, this experience must be captured and retained for the benefit of incoming staff. The National Training Center partnered with the NNSA Safety Roadmap initiative to capture and retain these knowledge elements, creating media that will be used to enhance current training efforts and to provide content for new and innovative approaches to retain and transfer knowledge. Additionally, DOE/NNSA contracted TechSource, Inc. to develop curriculum for the Weapons Knowledge Preservation and Transfer Program, a series of courses presented by subject matter experts. These efforts will contribute to DOE/NNSA maintaining a Federal staff in the top tier technically.

Sandia National Laboratories (SNL) sponsors the Weapon Intern Program (WIP) to benefit the entire nuclear security enterprise. WIP was created in 1998 to accelerate the learning process and transfer decades of knowledge and experience in all phases of the nuclear weapon life cycle, from experienced weaponeers to the new generation of stockpile stewards. With over 450 program graduates, the WIP turns out about two dozen students each year from all sites in the nuclear security enterprise, DOE/NNSA, and DoD officers/civilians. Topics include various weapon technology, design, development, evaluation, production, operations, process, policy, and management areas. SNL leverages this program to transfer decades of nuclear weapon-related knowledge and experience to new generations of nuclear weaponeers. The primary objective of the WIP is to significantly accelerate the process of providing this understanding to individuals who are new to the nuclear weapons area. This transfer of knowledge and experience is delivered through a blended learning environment consisting of live and multimedia-based classroom instruction and briefings, individual and team research projects, hands-on activities, and site visits to various DOE/NNSA and DoD facilities and operations. The live instruction is provided by a large contingent of subject matter experts in the various weapons technology, design, development, evaluation, production, operations, policy, and management areas. The WIP also includes a strong senior mentor element that helps the interns directly link the past to the present and the future. The curriculum continuously evolves to better address the challenges of maintaining the nation's nuclear deterrent for the future.

Sites also maintain knowledge preservation programs unique to the technical knowledge required to accomplish their missions. For instance, the Y-12 National Security Complex (Y-12) Knowledge Preservation Management System allows for the capture, management, and web-based access of manufacturing operations information. In one use case, the Knowledge Preservation Management System interviewed technicians who had retired from Y-12 in preparation for re-starting the wet chemistry process to support producing lithium-based materials. Reference Appendix F for additional site-specific details.

7.3.3.4 Pipeline Changes

Changes in workforce dynamics, and specifically the high percentage of workers who have 0–5 years of experience, necessitate changes in training pipelines. Whereas previous models may have relied on one-on-one mentoring over the course of years, modern programs must reach a larger number of new employees and must help new employees up the learning curve more quickly. After considering the time required to obtain a security clearance, get certified through the Human Reliability Program to interact with nuclear materials, and conduct on-the-job-training, an operator may not be fully ready to work until two or more years after being hired. For instance, SRS operator qualifications take approximately two years to complete, so the site has adjusted its pipeline by hiring in advance of need and by training personnel in an uncleared area so they can begin learning basic skills before receiving a security clearance. Leveraging technology, SRS plans to build an unclassified simulator in a new office building to expedite operator training while clearances are being processed.

Recognizing an increasing need for Radiological Control Technicians, LANL partnered with Northern New Mexico College to establish a training pipeline for Radiological Control Technicians. This competitive academic opportunity provides tuition and fees for a full-time student, a paid student internship at LANL, and transition to full time employment upon graduation with an associate degree, providing the student meets all LANL eligibility requirements. DOE/NNSA must continue modernizing its training pipelines to adapt to workforce realities and meet mission needs while ensuring safety and security.

7.3.4 Retaining and Sustaining

DOE/NNSA's greatest workforce challenge is retaining the talented personnel it hires. As workforce demographics have shifted over time, the proportion of workers with 0–5 years of experience has continued growing and constitutes as much as 70 percent of the population at some M&Os. While the proportion of new workers leaving is somewhat higher than those with 5–10 years of experience and is actually less than those with more than 20 years of experience, their departures are acutely felt since their numbers are largest. As shown earlier in Figure 7–3, the nuclear security enterprise is experiencing a sharp rise in turnover rate, necessitating a renewed focus on retention.

Numbers alone cannot tell the full story of retention challenges since they do not reflect the vital skills or level of experience that people take with them when they leave. Additionally, retaining early career workers is important for long-term knowledge preservation; without cadres of workers growing experienced, the new workers 20 years from now will have fewer mentors who fully understand the complex processes involved with design, manufacture, and testing of nuclear weapon components or of their assembly/disassembly. In anticipation of future needs, the Strategic Outlook Initiative for 2022 is developing recommendations to ensure the workforce of the future will be ready to carry out the mission.

In response to this increased turnover rate, M&Os are tailoring approaches to address the needs of their unique workforces. SNL held an internal hiring fair to advertise openings to current employees, allowing them to continue growing in their careers or to seek new challenges while staying at SNL. Recognizing the burden of commuting to a remote location, Nevada National Security Site offers additional paid time off for employees who are required to work on site in an effort to retain the employees. KCNSC is leveraging DOE/NNSA's unique mission as a retention strategy for employees. As examples, KCNSC is hosting Mission Engagement Series classes and bringing in guest speakers to discuss current events (these can potentially reach nearly 1,800 employees), hosting a Nuclear Policy Book Club, and running a U.S. Strategic Command-like tabletop exercise.

DOE/NNSA also recognizes the value of flexible schedules and work-life balance, and is striving to modernize its approach. The last several years have seen the rise of remote work and hybrid work, initially in response to Coronavirus-related risks, for those workers whose positions permit it. DOE Headquarters has transitioned to a hybrid workplace, which can expand the hiring pool, attract high-talent job candidates, retain talent and maintain a work-life balance, and has curated a collection of resources to help navigate working, collaborating, and leading in a hybrid workplace. M&Os are adapting as well; for instance, SNL officially implemented a hybrid work model and currently has nearly 4,000 employees under a telecommuting agreement or a remote work agreement. M&Os whose missions require onsite work have instead offered different schedules, such as a 4-day workweek composed of 10-hour workdays, or 9 days of work totaling 80 hours over the course of two workweeks. To permit even more workers to take advantage of remote opportunities, DOE/NNSA is investigating the possibility of computing hubs and other resources, and must continue to modernize its approach to workforce management.

7.4 Challenges and Strategies

While recruiting, developing, and retaining the specialized workforce needed to accomplish the mission is a challenge, DOE/NNSA and its M&Os are employing tailored strategies to meet the demands of the weapons program. The nuclear security enterprise sites operate under individual M&O contracts and budgets, with unique compensation and benefit offerings determined by their site. Yet all the laboratories, plants, and sites are held to the same requirements, with flexibility in implementation based on their distinct requirements. DOE/NNSA requires similar deliverables from its laboratories, plants, and sites with the same due date, which allows DOE/NNSA to consider and review all requests with an enterprise-wide view to ensure decisions are made for the collective good. There have been multiple collaborations across the sites to discuss retention concerns and to share ideas and best practices in benefits, compensation, and remote work. Additionally, DOE/NNSA has created sub-teams made up of representatives from the sites to further evaluate compensation, benefits, and general retention; their suggestions resulted in changes to the contracts and/or processes.

Table 7–1 provides a summary challenges and strategies for recruiting, developing, retaining, and sustaining the workforce. Several current and future strategies come from the Enhanced Mission Delivery Initiative, a study team commissioned by the Office of the Administrator to identify obstacles to agility and responsiveness across the nuclear security enterprise and to assess the state of relationships between the Federal and the M&O workforce. The Enhanced Mission Delivery Initiative's goal is to develop actionable solutions and determine which Departmental authorities should implement them, enhancing DOE/NNSA's ability to meet near- and mid-term deliverables. Since several of their recommendations pertain to workforce, they are included in Table 7–1 and marked with an asterisk.

Table 7–1. Summary of challenges and strategies for recruiting, developing, retaining, and sustaining the workforce

Topic Area	Challenges	Strategies	
		Current Strategy Being Implemented	Future Strategies Needed
Recruitment and Hiring	Competition for high-demand disciplines and limited availability of qualified candidates with advanced engineering degrees	• Expand recruiting capability by partnering with local academic institutions • Increased emphasis on internships and apprenticeships • Modernize talent acquisition model • Engage employees with the mission and work-life balance	• Continue building relationships with academic institutions • Develop pipelines that reach potential candidates early in their careers • Develop postgraduate programs with opportunities to become career employees • Relocation benefits to allow national recruitment of high-demand/hard to find disciplines
	Increasing demand for employees due to growing missions	• Allow recruiting teams to increase efforts in ability to offer on the spot job offers • Nuclear security enterprise-wide hiring fairs to help candidates find their right fit	• Expand use of on-the-spot job offers • Further expand joint hiring events for the nuclear security enterprise
	Attractive, market competitive salary and benefit packages Employee and candidate expectations for remote work, inclusivity and engagement have increased	• NNSA – Demonstration Project, performance pay • NNSA authorized a mid-year compensation adjustment for all laboratories, plants, and sites to help stem attrition	• NNSA evaluate ways to reduce and/or remove certain controls on M&O employee compensation[a] • NNSA evaluate ways direct compensation and variable compensation can be applied to attract and retain employees[a]
	Hiring people with the right skills in anticipation of future mission needs	• Laboratories, plants, and sites complete workforce plans to determine needs of the site	• Continue honing projections and skill sources
	Remote geographic location of some sites, results in difficulty recruiting nationally	• Target qualified candidates via university partnerships • Increase emphasis on local hiring and training, as well as internships and apprenticeships to increase the local pool of technologists and craft workers • Partner with civic organizations to leverage a marketing about locations	• Ensure appropriate and competitive pay is provided to employees in dispersed geographic regions

Topic Area	Challenges	Strategies	
		Current Strategy Being Implemented	*Future Strategies Needed*
Development and Training	Increasing turnover of key talent in mission-critical weapons work strains ability to develop the next generation of experienced engineers Knowledgeable members of the workforce with unique experiences are retiring	• Knowledge preservation initiatives, which are operating at varying levels of success at each location within the nuclear security enterprise • Implementation of retention programs across the nuclear security enterprise to improve retention for critical work in the weapons modernization programs	• NNSA work with the M&Os to develop a common plan to allow M&O annuitants and retirees to be compensated fairly for post-retirement service that contributes to the delivery of the primary NNSA missions • Development of a comprehensive knowledge management strategy
	Desire for mentorship	• NNSA – Learning and Career Management offers mentoring, coaching, and other development programs • Developing programs for employees for mentorship and career growth	Enhance mentoring programs and career ladder opportunities
	Infrastructure needed to train a growing workforce are already near or at capacity, causing delays	• Smaller class size, off-site locations, and room to room virtual presentation • Leverage online training capabilities to support increased demand	• Dedicated training space for new and uncleared personnel • Integrate needs for both training and execution spaces in future infrastructure investments
Retaining and Sustaining	Retain the talent DOE/NNSA has trained within the enterprise	• Enhancements to compensation and retention programs • Integrated workforce planning • Enhanced pre-onboarding/on-boarding program	Evaluate NNSA policy for M&O service credit recognition policy across the enterprise
	Continued attrition due to increased commercial opportunities outside of nuclear security enterprise Attrition is most acute for those with less than 5 years of service	• Modernize employee benefit offerings • Continue conducting exit surveys, engagement surveys, and stay surveys • Evaluate compensation surveys used to ensure survey data is accurate of industry competitors	• Improve organizational culture • Enhance employee recognition programs and employee engagement programs

M&O = management and operating
[a] Indicates a recommendation from the Enhanced Mission Delivery Initiative

7.5 Workforce Accomplishments

The technical accomplishments of the nuclear security enterprise workforce enable DOE/NNSA to meet its mission while providing significant contributions to research and development of new science and technologies. These accomplishments are cutting-edge, far-ranging in scope and effect, and indicative of the uniquely talented, highly educated, and highly trained workforce. The quality of the work being accomplished is also evident from the numbers of publications, awards, patents, and other external recognitions that have been bestowed on members of this workforce.

Workforce Accomplishments (2021–2022)

- *Journal Articles Published: approx. 5,000*
- *Patents Granted: approx. 150*
- *Technical Fellows: 16*
- *R&D 100 Awards: 30*
- *Diversity Awards: over 40*

Collectively, the sites have had more than 5,000 technical, peer-reviewed journal articles published over the last two years. At least 20 employees have been granted fellowship in several prestigious technical societies, such as the American Association for the Advancement of Science, the American Physical Society, and the Institute of Electrical and Electronic Engineers. Over a dozen employees or teams received accolades on their efforts to promote diversity, equity, and inclusion. Members of the nuclear security enterprise led projects that won R&D 100 awards, awards from the American Physical Society and American Nuclear Society, DOE's Ernest O. Lawrence Award, and numerous other recognitions from national and local technical organizations.

The innovation and intellectual capital of the enterprise is also apparent in the number of patents and invention disclosures attributable to the nuclear security enterprise. Together, the sites were granted more than 150 patents in the last two years and filed applications for many times that number. These patents and innovations benefit not only the nuclear weapons enterprise but the broader R&D community.

Chapter 8
Budget and Fiscal Estimates

The Fiscal Year (FY) 2024 President's Budget for Weapons Activities supports the nuclear stockpile and associated programs that provide required capabilities. The FY 2024 President's Budget provides an increase of 7.6 percent[1] for the Department of Energy's National Nuclear Security Administration (DOE/NNSA) and an increase of 10 percent for Weapons Activities above the FY 2023 enacted appropriation. DOE/NNSA developed the FY 2024 Future Years Nuclear Security Program (FYNSP) budget request for Weapons Activities by evaluating the resources necessary to support the plans described in the previous chapters, which synchronize DOE/NNSA's warhead deliveries with the modernization of Department of Defense (DoD) delivery platforms.

The first part of this chapter displays budgetary information for the FY 2024 budget request based on the program of record described in the previous chapters of this *Fiscal Year 2024 Stockpile Stewardship and Management Plan* (FY 2024 SSMP). Sections 8.4–8.8 compare the FY 2024 budget request to the FY 2023 enacted budget by program/budget line and present key milestones, showing progress toward program goals. Key milestones beyond the next 5 years show planned activities to meet DoD requirements and are contingent on future decisions and funding levels.

Section 8.9 describes cost projections for selected programs beyond FY 2024 and the basis of those cost projections. The cost-estimating techniques supporting the budget request are consistent with Government Accountability Office best practices, and the estimates have been updated with current requirements for each weapon system. The chapter concludes with an overview of the 25-year plan and an analysis of the affordability of the Weapons Activities program.

8.1 Planning, Programming, Budgeting, and Evaluation

DOE/NNSA employs a Planning, Programming, Budgeting, and Evaluation (PPBE) process similar to processes in use across the U.S. Government. DOE/NNSA's PPBE process has four major phases for each budget cycle:

- The Planning phase of the PPBE process evaluates the range of work required in a manner that is fiscally informed, but not constrained, to ensure all requirements and mission needs are considered. This phase is guided by strategic goals and objectives specified in Department-level and NNSA-level strategic planning documents. These internal strategic documents are aligned with and support the mission priorities in the *National Security Strategy*, *National Defense Strategy*, and *Nuclear Posture Review*. Internal documents are also developed in consultation with the program offices and management and operating (M&O) contractor partners to ensure they reflect a complete set of requirements. This phase drives the development of a range of strategies, alternatives, and plans that accomplish timely execution of key mission priorities and enables DOE/NNSA to achieve its mission.

[1] The FY 2023 enacted level for NNSA does not reflect the mandated transfer of $99.75 million from Naval Reactors to the Office of Nuclear Energy for operation of the Advanced Test Reactor.

- The Programming phase is the decision-making process that aligns available program resources with priorities, resulting in a balanced, integrated, executable FYNSP to be proposed by DOE to the Office of Management and Budget (OMB) as the basis for that year's congressional budget request. This phase is primarily a Headquarters-driven process that allocates resources and integrates the funded activities to ensure accomplishment of the highest priority efforts.
- The Budgeting phase involves the production of a formal budget request and associated justifications to OMB and to Congress as well as execution of appropriated funds. DOE/NNSA develops budget justification materials for the FYNSP that describe work scopes and schedules corresponding with the funding request. Budgeting includes formulation, justification, execution, and control of the budget. This process describes to Congress the resources necessary to execute the mission and then ensures DOE/NNSA spends those resources in accordance with the law. Budget Formulation is the development of fund estimates that support the plans and programs and obtains resources for program execution. Budget Justification includes the development of the budget and supporting documentation that allows the stakeholder to understand the program, or function, and the resources required to accomplish the effort. Budget Execution is the phase in which appropriated resources are distributed and controlled to achieve their approved purpose. After Congress passes and the President signs appropriations bills, the apportionment process makes funds available to DOE for obligation and expenditure. Appropriation legislation and accompanying tables are the controlling documents for funds distribution and display the budgetary resources available. Execution is the consistent monitoring of expenditures and obligations.
- Evaluation is the assessment of progress made toward achieving identified performance measures at multiple levels within DOE/NNSA, including evaluation of the performance of the M&O contractors.

At any time, multiple PPBE phases for different budget cycles are ongoing concurrently.

8.2 Portfolio Management

DOE/NNSA continues to implement portfolio management, leveraging best practices from industry and recommendations from the Government Accountability Office.

Portfolio managers monitor, evaluate, and validate the portfolio components—such as programs and projects—that comprise their portfolios with respect to alignment with organizational strategy and objectives; they also manage resource distribution across these portfolio components. The President's Budget for Weapons Activities funds a set of programs based on analysis of what actions are necessary to accomplish DOE/NNSA's statutory mission to manage the current and future stockpile without nuclear explosive testing. During the programming process, funding levels are established at various levels of detail for the FYNSP period to align anticipated resources with DOE/NNSA priorities.

8.3 Fiscal Year 2024 Future Years Nuclear Security Program

The FY 2024 FYNSP budget request supports the current stockpile, warhead modernization activities, recapitalization and modernization programs for infrastructure, and reestablishment of necessary production capabilities. It also supports research and development (R&D) efforts and implementation of enhanced experimental and computational capabilities.

Table 8–1 displays the FY 2023 enacted budget, and the program budget requests for Weapons Activities for FY 2024 to FY 2028. The structure of the budget request in Table 8–1 reflects the major programs, which are described in Chapters 2–7. The figures and narrative that follow describe the FY 2024 budget request in more detail.

Table 8–1. Overview of Future Years Nuclear Security Program budget request for Weapons Activities in fiscal years 2023–2028[a]

	FY (dollars in millions)					
Activity	***2023 Enacted***	***2024 Request***	***2025 Request***	***2026 Request***	***2027 Request***	***2028 Request***
Stockpile Management	4,954.1	5,204.9	5,088.4	4,987.1	5,205.6	5,273.9
Production Modernization	5,116.7	5,555.9	5,560.5	5,732.8	5,847.2	6,134.2
Stockpile Research, Technology, and Engineering	2,950.0	3,196.6	3,493.9	3,477.6	3,454.7	3,436.5
Academic Programs and Community Support	111.9	152.3	172.8	193.9	194.9	202.4
Infrastructure and Operations	2,602.6	2,767.1	2,943.3	3,198.2	3,214.2	3,309.6
Secure Transportation Asset	344.4	357.1	391.0	413.2	460.6	464.7
Defense Nuclear Security	872.1	1,016.8	1,020.5	1,025.4	1,104.5	1,127.9
Information Technology and Cybersecurity	445.7	578.4	664.4	726.6	763.1	758.7
Legacy Contractor Pensions and Settlement Payments	114.6	65.5	56.3	64.2	40.9	39.4
Adjustments	(396.0)	(61.6)	0.0	0.0	0.0	0.0
Weapons Activities Total	**17,116.1**	**18,832.9**	**19,390.9**	**19,818.9**	**20,285.7**	**20,747.4**

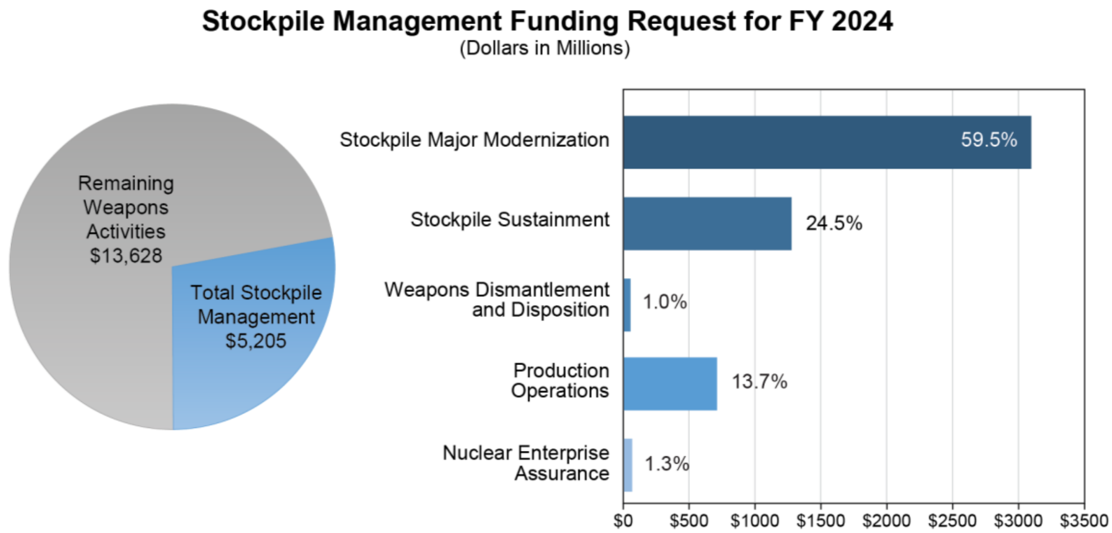
[a] Totals may not add because of rounding.

8.4 Stockpile Management

Stockpile Management encompasses five major subprograms that directly support the Nation's nuclear weapons stockpile: (1) Stockpile Major Modernization, (2) Stockpile Sustainment, (3) Weapons Dismantlement and Disposition, (4) Production Operations, and (5) Nuclear Enterprise Assurance (NEA). Additional information about the Stockpile Management program can be found in Chapter 2, "Stockpile Management."

8.4.1 Budget

The budget request for Stockpile Management increased 5.1 percent from the FY 2023 enacted budget and is illustrated in **Figure 8–1**.



Fiscal Year ($M)

	2023 Enacted	2024	2025	2026	2027	2028
Stockpile Major Modernization	2,897.2	3,097.2	2,887.0	2,774.4	2,971.4	3,069.2
Stockpile Sustainment	1,321.1	1,276.6	1,335.7	1,313.2	1,303.7	1,253.3
Weapons Dismantlement and Disposition	56.0	53.7	54.1	58.1	59.4	60.1
Production Operations	630.9	710.8	741.6	768.4	794.7	811.2
Nuclear Enterprise Assurance	48.9	66.6	70.0	72.9	76.4	80.1
Total Stockpile Management	4,954.1	5,204.9	5,088.4	4,987.1	5,205.6	5,273.9

Note: Numbers may not add due to rounding

Figure 8–1. Fiscal year 2024 President's Budget Request for Stockpile Management

8.4.2 Fiscal Year 2024 Budget Request Compared to Fiscal Year 2023 Enacted Budget

8.4.2.1 Stockpile Major Modernization

Stockpile Major Modernization extends the lifetime of the nation's nuclear stockpile while addressing required updates; replacing aging, or obsolete, components to ensure continued service life; and enhancing security and safety features. Stockpile Major Modernization includes (1) B61 Life Extension Program (LEP), (2) W88 Alteration (Alt) 370 Program, (3) W80-4 LEP, (4) W87-1 Modification (Mod) Program, and (5) W93 Program.

The budget request for Stockpile Major Modernization increased to support:

- W87-1 execution of Phase 6.3, *Development Engineering*
- W93 ramp-up within Phase 2, *Feasibility Study and Design Option*
- W88 Alt 370 risk mitigation

These increases are partially offset by decreases in the B61-12 LEP due to ramp-down in production activities and in the W80-4 LEP due to completion of some development activities.

8.4.2.2 Stockpile Sustainment

Stockpile Sustainment directly executes maintenance, surveillance, assessment, surety, and management activities for all enduring weapons systems in the stockpile. The program includes the B61, W76, W78, W80, B83, W87, and W88 Stockpile Systems as well as Multi-Weapon Systems.

The budget request for Stockpile Sustainment decreased, reflecting:

- W78 completion of detonator cable production and W78 Integrated Surety Architecture scope shifting out of the current FYNSP
- W80 completion of Multi-Application Transportation Attachment Devise qualification activities and surveillance activities
- B83 reduced program requirements per National Security Memorandum
- W88 Alt 940 project transition from development to initial system-level production

These decreases are partially offset by increases in the B61, W76, W87, and Multi-Weapon Systems for development, procurement, and surveillance activities.

8.4.2.3 Weapons Dismantlement and Disposition

Weapons Dismantlement and Disposition dismantles retired weapons and dispositions retired components from the stockpile. It also provides safety studies on retired systems and technical analysis needed to dismantle, and safely store, weapons being removed from the stockpile. It provides an integrated program to safely dismantle and dispose of weapon components that have been retired, while some limited number of components from the dismantled weapons are preserved for potential reuse in stockpile modernization and safety testing programs.

The budget request for Weapons Dismantlement and Disposition decreased slightly, reflecting a slight ramp-down in dismantlement of components.

8.4.2.4 Production Operations

Production Operations is a multi-weapon system, manufacturing-based program that sustains individual site production capabilities and capacity for the stockpile sustainment and modernization programs, including limited life component production and weapon assembly and disassembly operations. Production Operations also provides programmatic equipment maintenance, and maintenance/calibration services for manufacturing operations to meet DoD War Reserve requirements.

The budget request for Production Operations increased to support:

- Base capability support for Power Sources and Energetics and the Mark Quality Manufacturing Center
- New Brunswick Laboratory Operations
- NNSA Enterprise Capacity Modeling
- Continued hiring of critical skilled labor resources to support increase in production activities

8.4.2.5 Nuclear Enterprise Assurance

The FY 2024 budget request continues funding for this subprogram, first funded in FY 2023, that actively manages adversarial subversion risks to nuclear weapons and associated design, production, and testing capabilities. NEA enables the secure use of digital technologies in the modernization of weapons, facilities, and engineering capabilities by preventing, detecting, and mitigating the consequences of potential subversion. Through nuclear weapon digital assurance, NEA enables risk-managed adoption of leading-edge technologies to meet emerging military requirements and to reduce modernization schedules and costs.

The budget request for NEA increased, reflecting the ramp-up of NEA as it grows into an established program.

8.4.3 Key Milestones

DOE/NNSA plans include the following key Stockpile Management milestones in **Figure 8–2**[2] to sustain and modernize the stockpile. There were two changes from last year's plan:

- The FY 2030 milestone, *Deliver FPU of the W87-1 Modification Program*, is shifted to a FY 2031 to FY 2032 with Nuclear Weapons Council approval based on the Weapon Design Cost Report and schedule risk analysis.
- *Delivery of the new W93 Warhead* was removed from the shaded box, and the new milestone, *Deliver FPU of the new W93 Warhead*, was added to FY 2034 to FY 2036.

One milestone from last year's Stockpile Stewardship and Management Plan (SSMP) anticipated to be completed in FY 2023 is *Begin Phase 6.4 activities for the W80-4 LEP.*

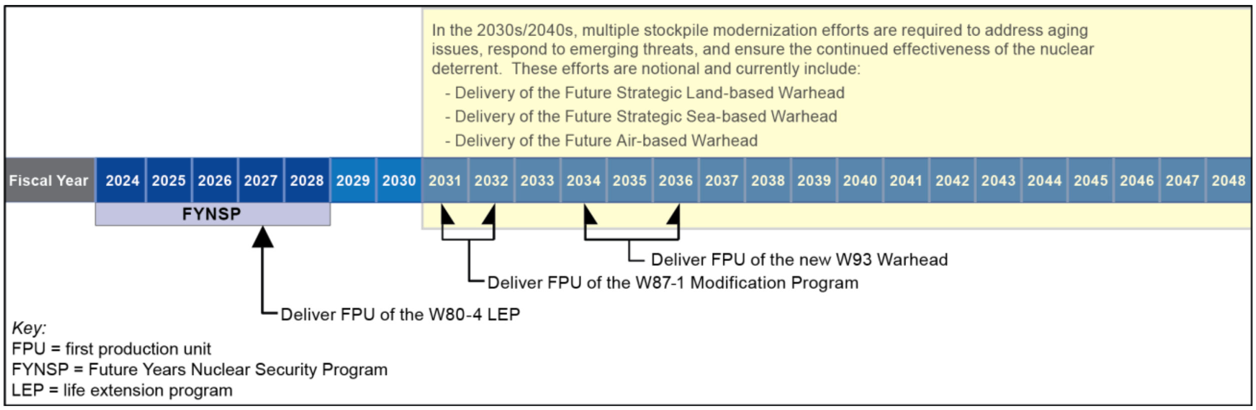


Figure 8–2. Key milestones for Stockpile Management

8.5 Production Modernization

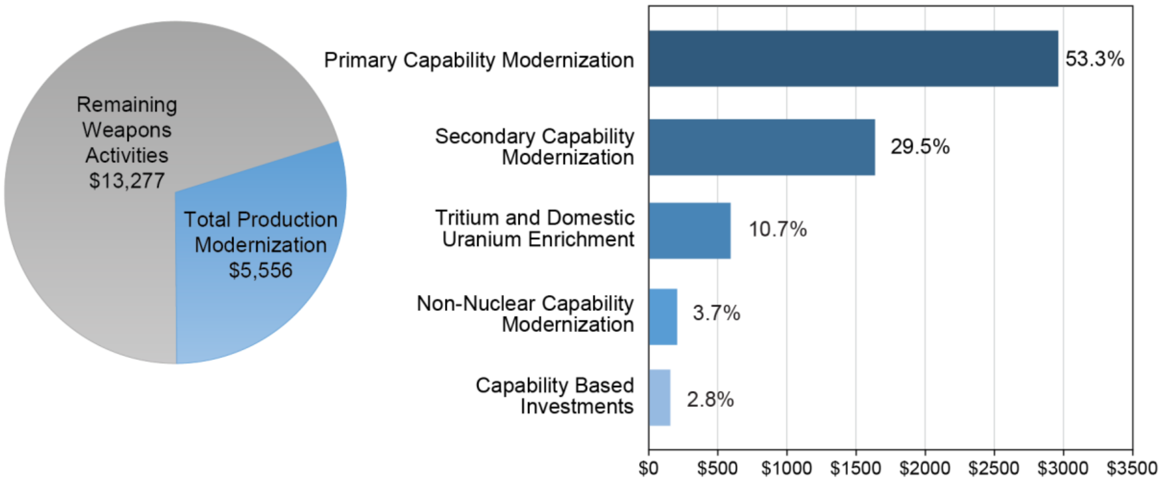
The Production Modernization program is responsible for modernizing the facilities, infrastructure, and equipment that produce materials and components to meet stockpile requirements and maintain the Nation's nuclear deterrent. It consists of five major subprograms: (1) Primary Capability Modernization, (2) Secondary Capability Modernization, (3) Tritium and Domestic Uranium Enrichment, (4) Non-Nuclear Capability Modernization, and (5) Capability-Based Investments (CBI).

8.5.1 Budget

The budget request for Production Modernization increased 8.6 percent from the FY 2023 enacted budget and is illustrated in **Figure 8–3**.

[2] These key milestones do not include key annual deliverables, such as completing the Annual Assessment Process culminating in the national security laboratory (Los Alamos National Laboratory [LANL], Lawrence Livermore National Laboratory [LLNL], and Sandia National Laboratories [SNL]) Directors' letters to the Secretaries of Energy and Defense by the end of each FY; meeting Surveillance Program requirements as approved via the surveillance governance model; and updating system reliability estimates and issuing a Weapons Reliability Report.

Production Modernization Funding Request for FY 2024
(Dollars in Millions)



Fiscal Year ($M)

	2023 Enacted	2024	2025	2026	2027	2028
Primary Capability Modernization	3,144.2	2,963.9	3,012.2	3,167.8	3,247.4	3,670.5
Secondary Capability Modernization	1,115.2	1,637.7	1,522.7	1,473.7	1,350.4	1,101.1
Tritium and Domestic Uranium Enrichment	579.9	593.0	635.7	656.1	790.6	875.1
Non-Nuclear Capability Modernization	123.1	204.9	212.8	218.5	242.3	208.5
Capability Based Investments	154.2	156.5	153.2	154.3	161.5	162.6
Warhead Assembly	0.0	0.0	24.0	62.5	55.0	116.4
Total Production Modernization	5,116.7	5,555.9	5,560.5	5,732.8	5,847.2	6,134.2

Note: Numbers may not add due to rounding

Figure 8–3. Fiscal year 2024 President's Budget Request for Production Modernization[3]

8.5.2 Fiscal Year 2024 Budget Request Compared to Fiscal Year 2023 Enacted Budget

8.5.2.1 Primary Capability Modernization

Primary Capability Modernization consolidates management of primary stage material processing and component production capabilities in the nuclear security enterprise. The program includes (1) Plutonium Modernization and (2) High Explosives and Energetics (HE&E) Modernization. The Plutonium program includes Los Alamos Plutonium Pit Production Project (LAP4), Technical Area (TA)-55 Reinvestment Project Phase 3, Transuranic Liquid Waste Facility, Chemistry and Metallurgy Research Replacement project, and the Savannah River Plutonium Processing Facility (SRPPF). The HE&E program includes the Energetic Materials Characterization Facility, the High Explosives (HE) Synthesis, Formulation, and Production project, and the HE Science and Engineering Facility.

The budget request for the Primary Capability Modernization program decreased due to the use of carryover funding for SRPPF and the deferral of the High Explosive Synthesis, Formulation, and Production

[3] Warhead Assembly is not yet a subprogram of Production Modernization. It is proposed to provide Other Project Costs funding to develop production modernization strategies for material staging and warhead assembly operations at Pantex. Other Projects Costs include costs associated with planning and development, generic research and development, operations support, and one-time startup costs.

Facility (HESFP) and Energetic Materials Characterization (EMC) projects. Given capacity constraints at both Los Alamos National Laboratory (LANL) and the Pantex Plant (Pantex), the FY 2024 budget proposes to defer HESFP and EMC to ensure higher priority projects (SRPPF and LAP4) have the necessary staffing to maintain schedules. However, the budget requests increased for activities associated with Los Alamos Plutonium Operations, LAP4, and Savannah River Plutonium Operations.

8.5.2.2 Secondary Capability Modernization

Secondary Capability Modernization restores and increases manufacturing capabilities for the secondary stage of nuclear weapons in the nuclear security enterprise. This modernization includes ensuring the availability of strategic materials and other sub-component streams necessary for the secondary stage, as well as modernizing the facilities and operations required to process these materials, fabricate them into parts, and assemble the final components. The program includes several subprograms: (1) Uranium Modernization, including the Uranium Processing Facility; (2) Depleted Uranium Modernization; and (3) Lithium Modernization, including the Lithium Processing Facility.

The budget request for Secondary Capability Modernization increased to support construction of the Uranium Processing Facility.

8.5.2.3 Tritium and Domestic Uranium Enrichment

Tritium and Domestic Uranium Enrichment (DUE) consist of two parts: (1) Tritium Sustainment and Modernization, which produces, recovers, and recycles tritium to support national security requirements, and includes the Tritium Finishing Facility project, and (2) the DUE Program, which is responsible for providing unobligated, low-enriched uranium for tritium production, and preserving and advancing uranium enrichment technology for potential future deployment to meet national security needs.

The budget requests for Tritium and DUE increased to support:

- Labor and material purchases for DUE centrifuge development as the program advances towards larger-scale R&D demonstrations
- Initiation of design activities for a DUE Pilot Plant

These increases are partially offset by the proposed deferral of the Tritium Finishing Facility project to prioritize SRS design and construction capacity for the SRPPF project.

8.5.2.4 Non-Nuclear Capability Modernization

Non-Nuclear Capability Modernization consolidates management and oversight of strategic investments to modernize the extensive suite of infrastructure and equipment required to support the non-nuclear component lifecycle inclusive of design, development, qualification, production, and surveillance. This program is responsible for all non-nuclear components external to the primary or secondary stage in the nuclear explosive package. It also includes the Power Sources Capability line-item.

The budget request for this program increased to support:

- Equipment procurement for the Kansas City National Security Campus (KCNSC) expansion efforts
- Modernization of equipment to develop and produce trusted radiation-hardened microelectronics at Sandia National Laboratories (SNL)
- A return to project execution for Power Sources Capability, which took a temporary pause to evaluate scope and cost options

8.5.2.5 Capabilities-Based Investments

The CBI program executes projects to replace or enhance core enterprise capabilities through recapitalization of high risk of failure test, measurement, and production equipment. CBI addresses enduring, multi-program requirements through discrete, short-duration projects. These investments recapitalize scientific and manufacturing capabilities that have degraded due to aged, broken, or outdated equipment and supporting systems. CBI activities primarily involve capital equipment purchases and minor construction projects that ensure needed capabilities are available for stockpile stewardship, sustainment, and modernization.

The budget request for this program did not change significantly.

8.5.3 Key Milestones

Key milestones for Production Modernization are presented by program in Sections 8.5.3.1–8.5.3.5.

8.5.3.1 Primary Capability Modernization

Key milestones for Primary Capability Modernization are in **Figure 8–4**. Major changes from last year's plan related to Primary Capability Modernization are:

- The FY 2023 milestone, *Obtain Critical Decision (CD)-1 for Energetic Materials Characterization*, is delayed to FY 2027 due to reprioritization across the Production Modernization construction portfolio, recognizing the nuclear security enterprise's capacity to execute construction and maintaining a focus on finishing projects currently under construction.
- The FY 2023 milestone, *Obtain FPU for pit production at LANL*, is delayed to FY 2025 to incorporate design changes.
- The FY 2024 milestone, *Obtain CD-2/3A for SRPPF*, is renamed *Obtain CD-2/3 for SRPPF* and is delayed to FY 2025 to reflect the risk-informed schedule estimate.
- The FY 2024 milestone, *Achieve 10 pits per year production capability at LANL*, is removed as new metrics for interim milestones are under development.
- The FY 2026 milestone, *Achieve 30 pits per year production capability at LANL*, is delayed to FY 2028 based on the LAP4 30 Base subproject individual equipment schedules as well as updated LANL program schedules.
- The FY 2030 milestone, *Obtain CD-4 for High Explosives Synthesis, Formulation, and Production*, is delayed to FY 2034 due to reprioritization across the Production Modernization construction portfolio, recognizing the nuclear security enterprise's capacity to execute construction and maintaining a focus on finishing projects currently under construction.
- The FY 2027 milestone, *Obtain CD-4 for High Explosives, Science, and Engineering*, is delayed to FY 2028 due to a delay associated with the rebid and replan for CD-3A work after termination of the early works contractor and due to a required redesign for the HE Lab Blast Wall.
- The FY 2028 milestone, *Obtain CD-4 for LAP4*, covers all LAP4 subprojects and is delayed to FY 2031 due to the approved LAP4 30 Base subproject performance baseline.
- The FY 2030 milestone, *Obtain CD-4 for Energetic Materials Characterization*, is delayed to FY 2034 due to reprioritization across the Production Modernization construction portfolio, recognizing the nuclear security enterprise's capacity to execute construction and maintaining a focus on finishing projects currently under construction.

- There is one new milestone: Procure first lot of TATB (triaminotrinitrobenzene) from the Naval Surface Warfare Center Indian Head Division prototype manufacturing facility in FY 2026.

One milestone from last year's SSMP, *Obtain CD-2/3 for LAP4 30 base equipment*, was completed in FY 2023.

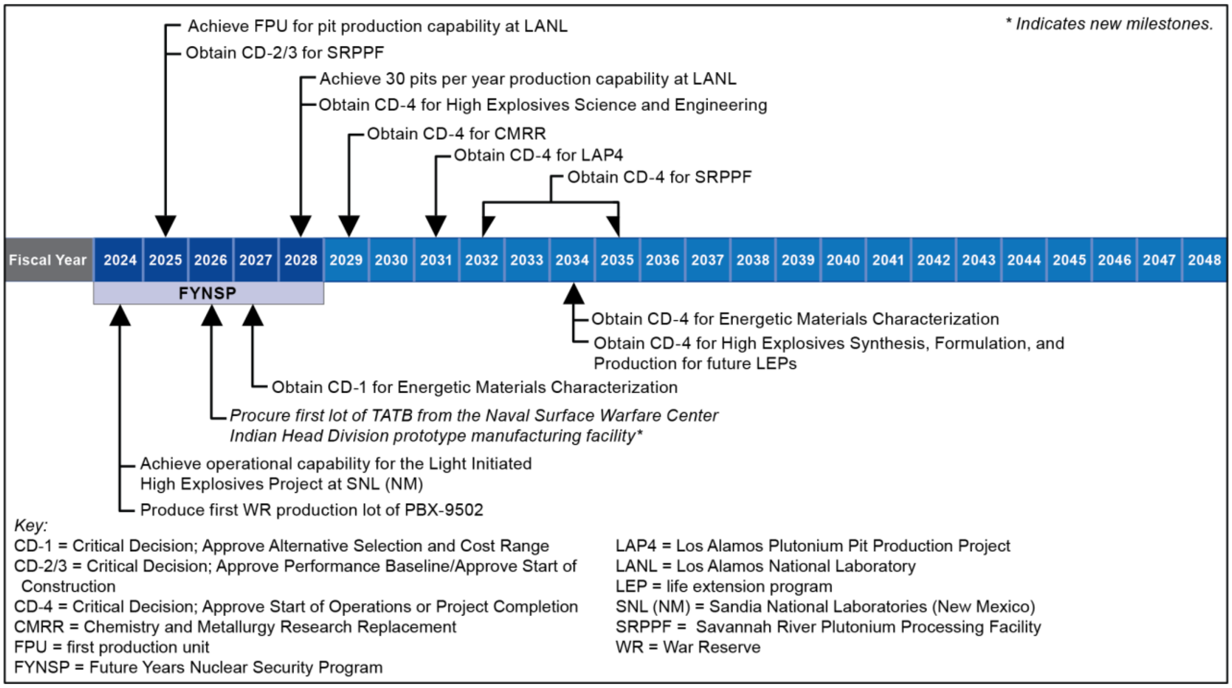


Figure 8–4. Key milestones for Primary Capability Modernization

8.5.3.2 Secondary Capability Modernization

Key milestones for Secondary Capability Modernization are in **Figure 8–5**. Major changes to the Secondary Capability Modernization milestones from last year's SSMP are:

- The FY 2023 milestone, *Obtain CD-4 for Y-12 Calciner project*, is delayed to FY 2026 due to delays in receiving equipment from the fabrication vendor.
- The milestones, *Obtain CD-0 for Depleted Uranium Manufacturing Capability* and *Obtain CD-1 for Depleted Uranium Manufacturing Capability*, are removed. The program is currently conducting an Analysis of Alternatives and evaluating a phased and modular approach to achieve this new capability.
- The FY 2023 milestone, *Obtain CD-4 for Y-12 electrorefiner*, is delayed to FY 2024 due to inadequate chilled water supply and the need for component replacement.
- The FY 2027 milestone, *Obtain CD-4 for Uranium Processing Facility*, is delayed to 2029 due to contractor performance that was below expectations, direct and indirect impacts from the Coronavirus Disease 2019 pandemic, and labor availability and procurement costs. The project is undergoing a Federal re-baseline.

Two milestones from last year's SSMP are anticipated to be completed in FY 2023:

- *Obtain CD-3A for Lithium Processing Facility*
- *Achieve technology readiness level 5 for Cold Hearth Melting*

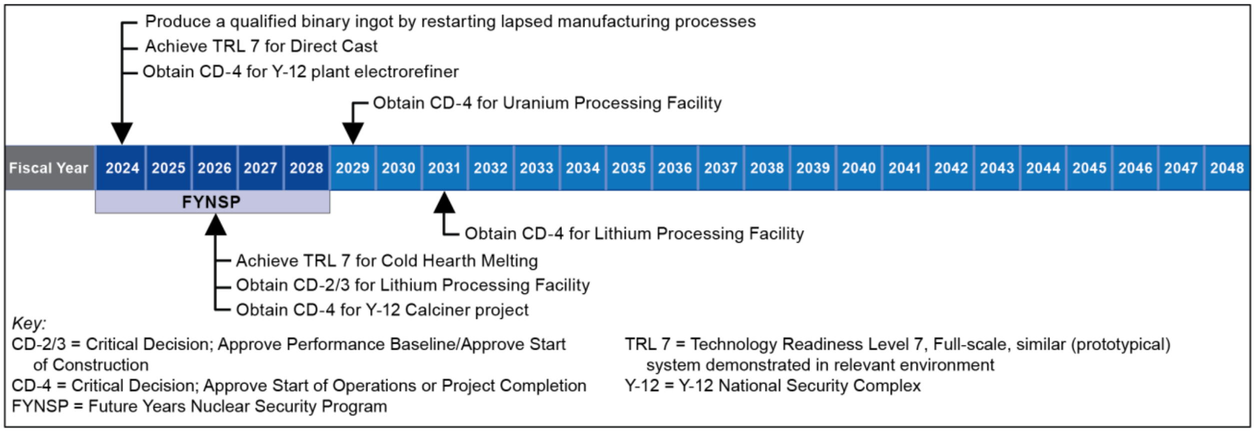


Figure 8–5. Key milestones for Secondary Capability Modernization[4]

8.5.3.3 Tritium and Domestic Uranium Enrichment

Key milestones for Tritium and DUE are shown in **Figure 8–6**. Major changes from last year's plan related to Tritium and DUE are:

- The FY 2023 milestone, *Complete facility modifications to prepare for future demonstration of the ORNL small centrifuge*, is delayed to 2024 due to a 1-month delay that pushes the project into the first quarter of FY 2024.
- The FY 2025 milestone, *Reliably produce a total of 3,300 grams of tritium using two TVA reactors over their 18-month cycles*, and the FY 2027 milestone, *Reliably extract 3,300 grams of tritium* from TPBARS available at SRS, are changed to … *2,800 grams of tritium…* due to prioritizing other Production Modernization scope.
- The FY 2029 through FY 2031 milestone, *Obtain CD-4 for Tritium Finishing Facility*, is delayed until FY 2033 through FY 2035 due to capacity constraints at Savannah River Site (SRS) and the need to prioritize SRPPF. The current facility will remain operational, supplying tritium-filled reservoirs to the Department of Defense (DoD) until the Tritium Finishing Facility is operational.
- The FY 2026 milestone*, Increase yearly extractions at Tritium Extraction Facility from one to eight*, is renamed *Increase extractions at Tritium Extraction Facility from one to eight in a single FY* for clarity, and is delayed to FY 2029. Eight extractions in a 12-month period were demonstrated between 2022 and 2023, but eight extractions in a single FY are not planned until FY 2029.
- The FY 2026 milestones, *Obtain CD-3A for Tritium Finishing Facility* and *Obtain CD-2/3 for Tritium Finishing Facility*, are removed. With the proposed deferral, NNSA is re-working the schedule for interim milestones, and updated dates are not yet available.

[4] CD-4 is subject to change since the Uranium Processing Facility is undergoing a Federal re-baseline.

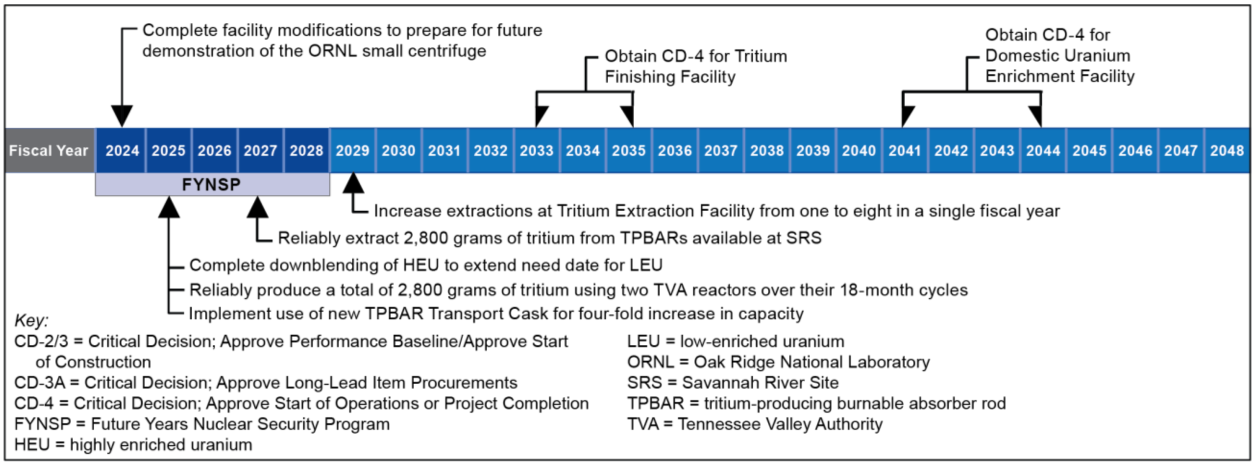


Figure 8–6. Key milestones for Tritium Modernization and Domestic Uranium Enrichment

8.5.3.4 Non-Nuclear Capability Modernization

Key milestones for Non-Nuclear Capability Modernization are in **Figure 8–7**. Major changes from last year's plan are:

- The milestones *Complete KCNSC Short Term Expansion Plan* and *Obtain KCNSC Short-term Expansion Space* are consolidated to *Complete KCNSC Short-term Expansion Plan, including all of Building 23*. The completion date is shifted to FY 2028, reflecting the increased scope of the project since NNSA purchased all of Building 23 in February 2023, which expands the project to include the North portion of the building as well as the South portion.
- The FY 2024 milestone, *Finalize design and obtain CD-2/3 for Power Sources Capabilities*, is delayed to FY 2025 due to a pause taken prior to CD-1 to revisit the conceptual design and identify opportunities for cost avoidance.
- The FY 2026 milestone, *Obtain CD-4 for Power Sources Capability*, is delayed to FY 2030 due to a pause taken prior to CD-1 to revisit the conceptual design and identify additional savings.
- The FY 2023 milestone, *Obtain CD-0 for Microelectronic Component Capabilities (previously named Microelectronics HiFac),* and the FY 2037 milestone, *Obtain CD-4 for Microelectronic Component Capabilities,* are removed. A planning study to determine the best means of addressing the current gap in microelectronic component capability is underway and is expected to be completed in FY 2023.

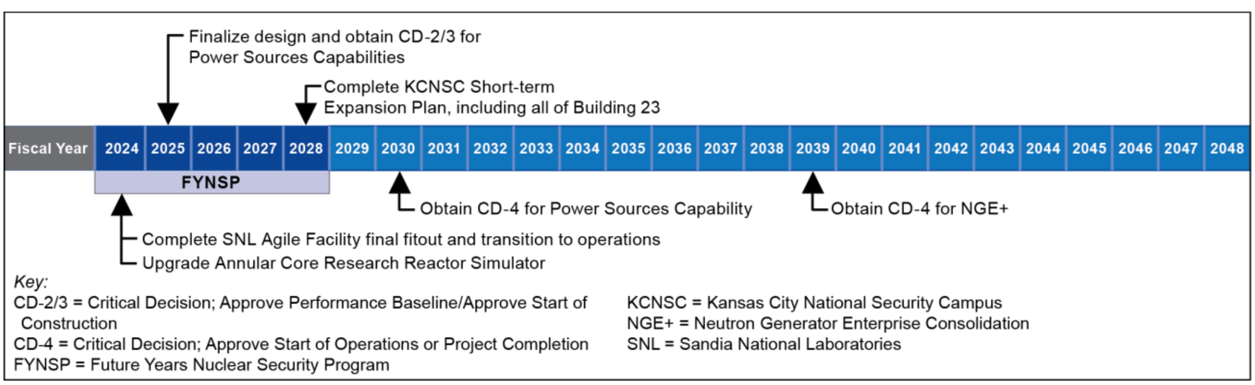


Figure 8–7. Key milestones for Non-Nuclear Capability Modernization

8.5.3.5 Capability-Based Investments

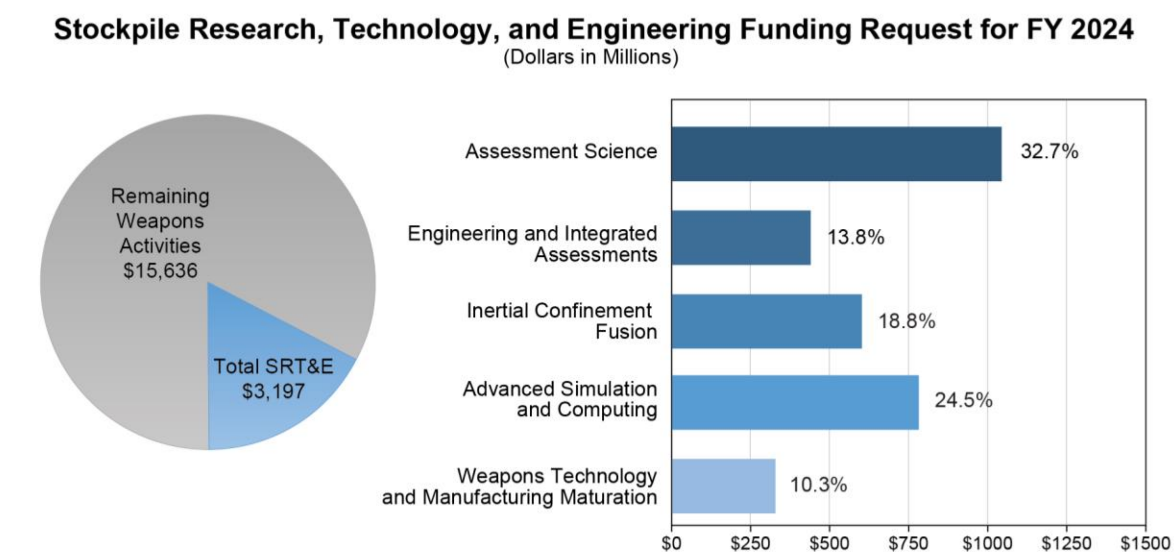
CBI does not have its own milestones since its numerous, relatively low-cost, short-duration projects, enable activities that support other programs' milestones.

8.6 Stockpile Research, Technology, and Engineering

Stockpile Research, Technology, and Engineering (SRT&E) program provides the knowledge and expertise needed to maintain confidence in the nuclear stockpile without additional nuclear explosive testing. SRT&E encompasses five major subprograms: (1) Assessment Science, (2) Engineering and Integrated Assessments, (3) Inertial Confinement Fusion (ICF), (4) Advanced Simulation and Computing (ASC), and (5) Weapon Technology and Manufacturing Maturation. Academic Programs was previously a subprogram of SRT&E, but starting in FY 2024, funding for this program is requested apart from SRT&E under the new Academic Programs and Community Support line item; please refer to Section 8.8.2 for budget information and Chapter 7, "Workforce," for details about grants and scholarships.

8.6.1 Budget

The budget request for SRT&E increased 8.4 percent from the FY 2023 enacted budget and is illustrated in **Figure 8–8**.



Fiscal Year ($M)

	2023 Enacted	2024	2025	2026	2027	2028
Assessment Science	854.8	1,044.3	1,125.4	1,061.3	897.8	862.8
Engineering and Integrated Assessments	389.0	440.5	454.6	495.6	606.6	630.9
Inertial Confinement Fusion	630.0	601.7	688.6	708.5	749.2	729.3
Advanced Simulation and Computing	790.0	782.5	863.8	880.8	884.4	894.8
Weapons Technology and Manufacturing Maturation	286.2	327.7	361.5	331.4	316.7	318.7
Total SRT&E	2,950.0	3,196.6	3,493.9	3,477.6	3,454.7	3,436.5

Note: Numbers may not add due to rounding

Figure 8–8. Fiscal year 2024 President's Budget Request for Stockpile Research, Technology, and Engineering

8.6.2 Fiscal Year 2024 Budget Request Compared to Fiscal Year 2023 Enacted Budget

8.6.2.1 Assessment Science

Assessment Science provides the knowledge and expertise needed to maintain confidence in the nuclear stockpile in the absence of nuclear explosive testing. The program is comprised of six subprograms: (1) Primary Assessment Technologies, (2) Dynamic Materials Properties, (3) Advanced Diagnostics, (4) Secondary Assessment Technologies, (5) Enhanced Capabilities for Subcritical Experiments (ECSE), and (6) Hydrodynamic and Subcritical Experiment Execution Support. The line-item construction projects U1a Complex Enhancements Project and Z-pinch Experimental Underground System Testbed Facilities Improvement are also contained within this program.

The budget request for Assessment Science increased to fully fund the Z-pinch Experimental Underground System Testbed Facilities Improvement project while continuing to support mission-critical activities at Joint Actinide Shock Physics Experimental Research, National Ignition Facility, TA-55 gas gun, and requisite plutonium shots on Z.

8.6.2.2 Engineering and Integrated Assessments

Engineering and Integrated Assessments is responsible for developing the foundational technologies and enterprise capabilities underpinning warhead survivability. These technologies and capabilities are matured and developed from a system agnostic perspective until a warhead's response to the stockpile-to-target sequence is understood, ensuring a responsive nuclear deterrent through collaborative partnerships, proactive integration, and assessments. This program includes seven subprograms: (1) Archiving and Support, (2) Delivery Environments, (3) Weapons Survivability, (4) Studies and Assessments, (5) Aging and Lifetimes, (6) Stockpile Responsiveness, and (7) Advanced Certification and Qualification. The Combined Radiation Environments for Survivability Testing line-item project also resides within this program.

The budget request increase for Engineering and Integrated Assessments reflects programmatic growth in the Aging and Lifetimes, Archiving and Support, Delivery Environments, Studies and Assessments, Advanced Certification and Qualification, and the Stockpile Responsiveness Program.

8.6.2.3 Inertial Confinement Fusion

ICF provides high energy density (HED) science capabilities and expertise that support research and testing across the breadth of stockpile stewardship. Its two-fold mission is to meet immediate, and emerging, HED science needs to support the deterrent of today and to advance the R&D capabilities necessary to meet those needs for the deterrent of the future. The program includes three subprograms: (1) HED and Ignition Science for Stockpile Applications, (2) ICF Diagnostics and Instrumentation, and (3) Facility Operations.

The budget request for ICF decreased, reflecting programmatic prioritization of experimental campaigns and the most important maintenance activities.

8.6.2.4 Advanced Simulation and Computing

ASC provides high-end simulation capabilities (e.g., modeling codes, computing platforms, and supporting infrastructure) to meet stockpile stewardship requirements. ASC provides the weapon codes that provide the integrated assessment capability supporting annual assessment, future sustainment program qualification and certification of warheads on entry into the stockpile. The program includes five subprograms: (1) Integrated Codes, (2) Physics and Engineering Models, (3) Verification and Validation, (4) Computational Systems and Software Environment, and (5) Facility Operations and User Support. The

Advanced Technology Development and Mitigation subprogram is being stood down since it will have achieved the NNSA Exascale Computing Project objectives at end of FY 2023.

The decrease in the budget request for ASC prioritizes facility upkeep, code modernization, and system recapitalization, while continuing to support increased simulation workloads for the nuclear weapons mission and the operation of El Capitan and Crossroads. It also reflects the standdown of the Advanced Technology Development and Mitigation subprogram with the deployment of the El Capitan exascale system.

8.6.2.5 Weapon Technology and Manufacturing Maturation

Weapons Technology and Manufacturing Maturation is responsible for developing agile, affordable, assured, and responsive technologies and capabilities for nuclear stockpile sustainment and modernization to enable the future success of the nuclear security enterprise. It is comprised of three subprograms: (1) Surety Technologies, (2) Weapon Technology Development, and (3) Advanced Manufacturing Development.

The budget request for Weapons Technology and Manufacturing Maturation increased to support:

- Technologies that develop novel manufacturing methods, novel materials, and improve the component design process, ensuring the complex remains responsive and able to address increased demands from the growing number of potential weapon systems
- Maturation of several key technologies that are new to the weapons complex

8.6.3 Key Milestones

The Stewardship Capability Delivery Schedule is used to align SRT&E programs with mission objectives, coordinate efforts across Defense Programs, and communicate with internal and external stakeholders. Other high-level planning activities, such as the National Plutonium Aging Science Plan, serve as vehicles for coordinating work in specific areas of mission need. Key milestones for SRT&E are illustrated in **Figure 8–9**. Major changes from last year's plan are:

- The FY 2023 milestone, *Design and demonstrate a light weight, modular weapon system architecture*, is delayed to FY 2024 due to challenges with staffing and supply chain delivery times.
- The FY 2024 milestone, *Evaluate and implement re-entry concepts/environments within the HOT SHOT initiative*, is renamed, *Evaluate and implement re-entry concepts/environments using technology maturation demonstrators for future stockpile systems* to better reflect use of demonstrator systems.
- The FY 2024 milestone, *Field a neutron source and detectors on an Excalibur experiment (ECSE reactivity),* is delayed to FY 2027 because it relies on the Z-pinch Experimental Underground System Testbed Facilities Improvement project, which requires additional tunneling and was converted to a line-item construction project. Additionally, this milestone is renamed *Field a neutron source and detectors on an Excalibur experiment (ECSE reactivity)* for clarity since Excalibur will be the first subcritical experiment campaign demonstrating this new measurement capability. This capability will then be applied to the plutonium aging mission during the follow-on Durandal campaign. The milestone, *Execute Excalibur Experiment (ECSE reactivity),* is removed since it is addressed by this renaming.
- The FY 2024 milestone, *Execute Excalibur Experiment (ECSE reactivity)*, is removed since it is redundant with the milestone *Field a neutron source and detectors to obtain subcritical experiments reactivity measurements*.

- The FY 2026 milestone, *Complete Red Sage & Nimble subcritical experiment campaigns*, is delayed to FY 2027 due to an updated subcritical experiments schedule.
- The FY 2027 milestone, *Obtain CD-4 for Advanced Sources and Detectors Scorpius*, is delayed to FY 2030 due to updated baseline upon achieving CD-2/3 in November 2022.
- The FY 2028 milestone, *Execute Sherman Experiment (ECSE plutonium radiograph)*, is delayed to FY 2030 since it requires CD-4 for Advanced Sources and Detectors Scorpius.

One milestone from last year's SSMP is anticipated to be completed in FY 2023: *Accept Advanced Technology System-3/Crossroads Phase 1 computing platform*.

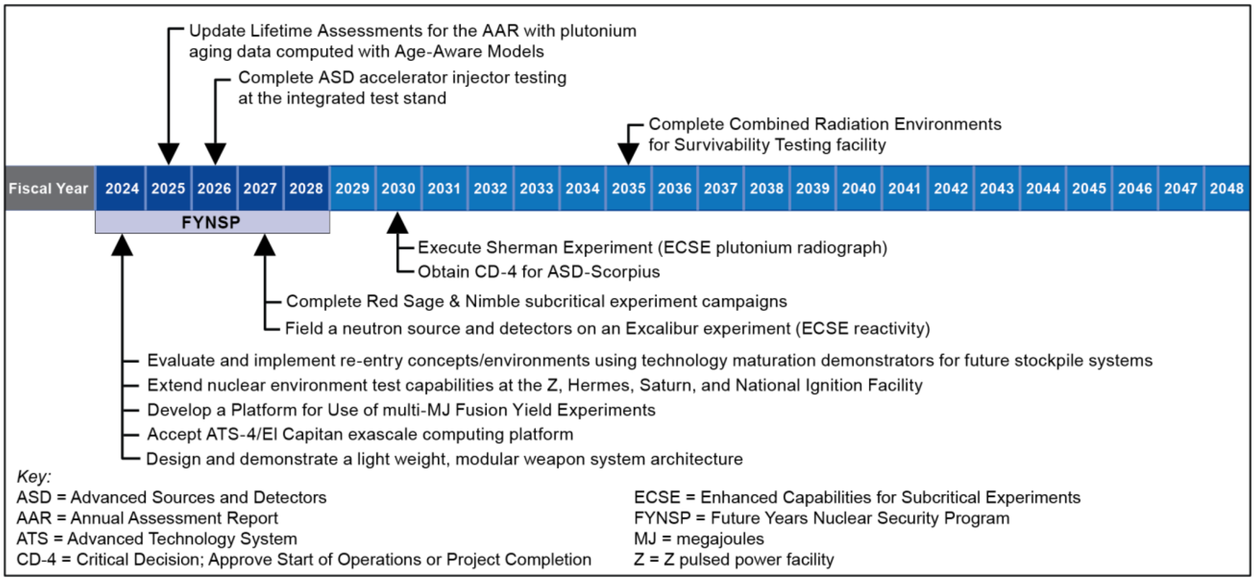


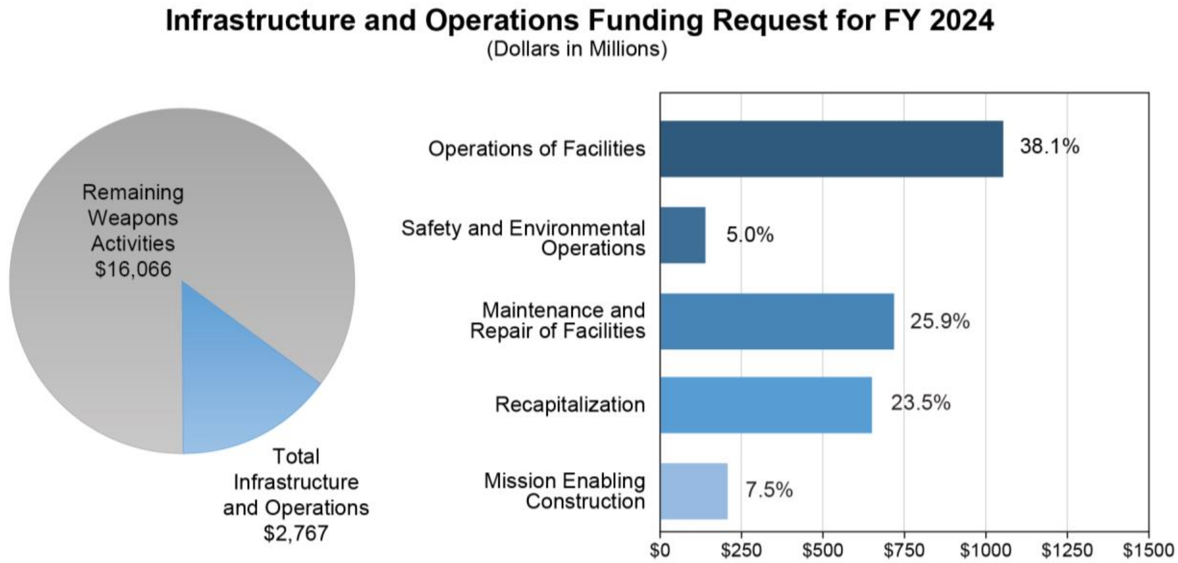
Figure 8–9. Key milestones for Stockpile Research, Technology, and Engineering

8.7 Infrastructure and Operations

Infrastructure and Operations maintains, operates, and modernizes DOE/NNSA's infrastructure in a safe, secure, and cost-effective manner to support all DOE/NNSA programs. Infrastructure and Operations takes a comprehensive approach to modernizing DOE/NNSA's infrastructure while maximizing return on investment, enabling program results, and reducing enterprise risk. The program also plans, prioritizes, and constructs mission-enabling facilities and infrastructure. Infrastructure and Operations includes (1) Operations of Facilities, (2) Safety and Environmental Operations, (3) Maintenance and Repair of Facilities, (4) Recapitalization, and (5) Line-Item Construction. Additional information about Infrastructure and Operations can be found in Chapter 6, "Infrastructure and Operations."

8.7.1 Budget

The budget request for Infrastructure and Operations increased 6.3 percent from the FY 2023 enacted budget and is illustrated in **Figure 8–10**.



Fiscal Year ($M)

	2023 Enacted	2024	2025	2026	2027	2028
Operations of Facilities	1,038.0	1,053.0	1,115.0	1,136.0	1,181.0	1,210.0
Safety and Environmental Operations	162.0	139.1	155.8	154.6	154.5	154.3
Maintenance and Repair of Facilities	651.6	718.0	737.0	752.0	772.0	792.0
Recapitalization	561.7	650.0	786.0	796.9	848.7	838.4
Mission Enabling Construction	189.3	207.0	149.5	358.7	258.1	315.0
Total Infrastructure and Operations	2,602.6	2,767.1	2,943.3	3,198.2	3,214.2	3,309.6

Note: Numbers may not add due to rounding

Figure 8–10. Fiscal year 2024 President's Budget Request for Infrastructure and Operations

8.7.2 Fiscal Year 2024 Budget Request Compared to Fiscal Year 2023 Enacted Budget

8.7.2.1 Operations of Facilities

Operations of Facilities provides the funding required to operate DOE/NNSA facilities in a safe and secure manner and is fundamental to achieving DOE/NNSA's plutonium, uranium, tritium, lithium, HE, and other mission objectives. This program includes essential support, such as water and electrical utilities, safety systems, lease agreements, and activities associated with Federal, state, and local environmental, worker safety, and health regulations.

The budget request for Operations of Facilities increased to support:

- Operating funds for the Plutonium mission, including the production of at least 30 pits per year (ppy) at LANL and the re-establishment of the Waste Characterization, Reduction, and Repackaging Facility as a Hazard Category 3 nuclear facility
- NNSA's direct-funded share of operations and utilities for Savannah River National Laboratory facilities
- Waste activities at the Y-12 National Security Complex due to the resumption of waste shipments

The increase is partially offset by an adjustment to reduce uncosted balances.

8.7.2.2 Safety and Environmental Operations

Safety and Environmental Operations provides DOE's Nuclear Criticality Safety Program, Nuclear Safety Research and Development, Packaging subprogram, Long Term Stewardship subprogram, and Nuclear Materials Integration subprogram. These activities support safe, efficient operation of the nuclear security enterprise by providing safety data, nuclear material packaging, environmental monitoring, and nuclear material tracking.

The decrease to the budget request for Safety and Environmental Operations reflects an adjustment to reduce uncosted balances.

8.7.2.3 Maintenance and Repair of Facilities

Maintenance and Repair of Facilities provides direct-funded maintenance activities across the nuclear security enterprise for the recurring daily work required to sustain and preserve DOE/NNSA facilities in a condition suitable for their designated purpose. These efforts include predictive, preventive, and corrective maintenance activities to maintain facilities, property, assets, systems, roads, and vital safety systems.

The budget request for Maintenance and Repair of Facilities increased to support:

- NNSA's direct-funded share of maintenance for Savannah River National Laboratory facilities
- Site critical infrastructure at Nevada National Security Site (NNSS) along the mission corridor, to include the power backloop
- Global security needs at NNSS for Area 12 Tunnel Complex, Radiological/Nuclear Countermeasures Test and Evaluation, and Desert Rock Airstrip
- Maintenance of the new John M. Googin Technology Development Facility for special materials and the repair needs for key high-risk projects at the Y-12 National Security Complex, to include the site-wide brine system, the West-End facility treatment tanks, and site potable water tower control systems

The increase also reflects the realignment of scope for the maintenance of DOE-owned, Federal Field Office space from Federal Salaries and Expenses to Infrastructure and Operations.

8.7.2.4 Recapitalization

Recapitalization modernizes DOE/NNSA's infrastructure by prioritizing investments, including acquisition of new facilities, to improve the condition and extend the life of structures, capabilities, and systems, thereby improving the safety and quality of the workplace. Recapitalization addresses obsolete support and safety systems; revitalizes facilities that are beyond their design life; and improves the reliability, efficiency, and capability of infrastructure to meet mission requirements. Recapitalization investments help achieve operational efficiencies and reduce safety, security, environmental, and program risk. The Recapitalization program includes minor construction projects, real property purchases, planning, other project costs for Infrastructure and Operations-funded mission enabling infrastructure, and deactivation and disposal of excess infrastructure.

The budget request for Recapitalization increased to support:

- The Kansas City Non-nuclear Expansion Transformation plan
- Deactivation and disposal of excess infrastructure, including stabilization and risk reduction activities at high-risk facilities
- Addition of general contract support for construction project management

The increase also reflects the realignment of scope for the acquisition, sustainment, and disposal of DOE-owned, Federal field office space from Federal Salaries and Expenses to Infrastructure and Operations.

8.7.2.5 Mission Enabling Construction

These line-item projects will replace obsolete, unreliable facilities and infrastructure to reduce safety and program risk while improving responsiveness, capacity, and capabilities. NNSA uses a prioritization methodology for mission enabling line-item construction that evaluates investments on closing mission gaps, reducing infrastructure risk and safety risk, improving sustainability, and reducing deferred maintenance. Programmatic construction line-items fall under the respective programs.

The budget request for Mission Enabling Construction includes funding in FY 2024 for:

- TA-46 Protective Force Facility project at LANL
- Plutonium Production Building project at LANL
- Analytic Gas Laboratory project at the Pantex
- Transition to construction for Electrical Power Capacity Upgrade project LANL

Additional information on planned line-item investments can be found in Chapter 6, "Infrastructure and Operations."

8.7.3 Key Milestones

Key milestones for Programmatic Construction are shown in the relevant program sections within this chapter, as program mission execution often depends on completion of line-item projects. Schedules for the highest priority Programmatic and Mission Enabling project proposals are displayed in Chapter 6, Figures 6–6 through 6–13. Projects proposed within the FYNSP have higher-fidelity estimates, and some planned projects in the out-years may decide to use alternative strategies other than a line-item project once each respective analysis of alternatives is completed.

Per the *National Defense Authorization Act for Fiscal Year 2018*, DOE/NNSA established the Infrastructure Modernization Initiative (IMI) program. Per the *National Defense Authorization Act for Fiscal Year 2022*, Congress amended the IMI to require reducing deferred maintenance (DM) per replacement plant value (RPV) by not less than 45 percent by 2030. Baselined against FY 2017 data, the IMI challenges NNSA to reach a DM to replacement plant value (DM:RPV) ratio of 2.67 percent by 2030. The IMI will be carried out by infrastructure recapitalization, maintenance and repair of facilities, and construction programs. The initial plan was transmitted to Congress in September 2018 and an updated plan was delivered in October 2022.

8.7.4 Infrastructure Maintenance and Recapitalization Investments

As part of the IMI, DOE/NNSA is using BUILDER, a system developed by the U.S. Army Corps of Engineers and recognized by the National Academy of Sciences as a best-in-class practice for infrastructure management. The BUILDER system uses comprehensive inventory, lifecycle, cost, and assessment data and risk-informed standards and policies to recommend repairs, and replacements at the most opportune time, thus improving DOE/NNSA's ability to pinpoint and prioritize investments. Historical approaches greatly underestimated the RPV of DOE/NNSA's facilities. Using BUILDER-based calculations provides a more accurate and transparent understanding of DOE/NNSA's infrastructure. The DM costs are tied to the RPV since it costs more to repair a more expensive facility; therefore, as expected, DM increased with the deployment of the new, more accurate, data-driven approach. The increase in the ratio of DM to RPV from FY 2019 to FY 2020 in **Table 8–2** was a result of these methodology changes. The overall physical condition of NNSA's infrastructure did not decline. Notably, the ratio of DM to RPV has steadily decreased year-over-year since this change, indicating that recent investments have been successful. As shown in Table 8–2, DOE/NNSA's new calculated RPV is $139 billion, of which $5.1 billion represents excess facilities, based on data from the end of FY 2022. In response to Government Accountability Office recommendations, this information is provided to improve transparency in the budget.

Table 8–2. DOE/NNSA deferred maintenance as a percentage of Replacement Plant Value of Active Facilities[5]

Metric	FY 2019	FY 2020	FY 2021	FY 2022
DM	$4.8B	$5.8B	$6.1B	$6.5B
RPV	$124.3B	$116.3B	$124.9B	$133.9B
DM:RPV Ratio	3.85%	4.99%	4.90%	4.84%

B = billion
DM = deferred maintenance
RPV = replacement plant value

Table 8–3 compares investments in Maintenance and Recapitalization to benchmarks (based on the percentage of beginning of the year RPV) derived from the DOE Real Property Asset Management Plan and associated guidance. Recapitalization continues to include deactivation and demolition of excess, and underused, facilities to reduce DOE/NNSA's footprint. Funding for maintenance has grown significantly, but appropriately, over the last several years. This sustained funding level will support current maintenance staffing levels to maintain and preserve facilities in a condition suitable to meet an increasing mission demand. DOE/NNSA also continues to use targeted asset management programs that use supply chain management practices to increase purchasing power for common building components across the nuclear security enterprise (e.g., roofs and heating, ventilating, and air conditioning).

Table 8–3. Projected FY 2024 DOE/NNSA infrastructure maintenance and recapitalization investments

		FY 2022	FY 2023	FY2024
RPV ($B)		133.9	134.9	135.9
Maintenance Benchmark 2%–4% RPV	Infrastructure and Safety Maintenance Investments ($K)	700,000	651,617	718,000
	Other NNSA Maintenance Investments (direct and indirect funded) ($K)	313,295	310,577	343,743
	Total NNSA Maintenance Investments ($K)	1,013,295	962,194	1,061,743
	Maintenance as % RPV	0.76%	0.71%	0.78%
Recapitalization Benchmark 1%	Infrastructure and Safety Recapitalization Investments ($K)	600,000	561,663	650,012
	Other NNSA Recapitalization Investments ($K)	427,956	474,459	500,503
	Total NNSA Recapitalization Investments ($K)	1,027,956	1,036,122	1,150,515
	Recapitalization as % RPV	0.77%	0.77%	0.85%

RPV = Replacement Plant Value
$B = billion dollars
$K = thousand dollars

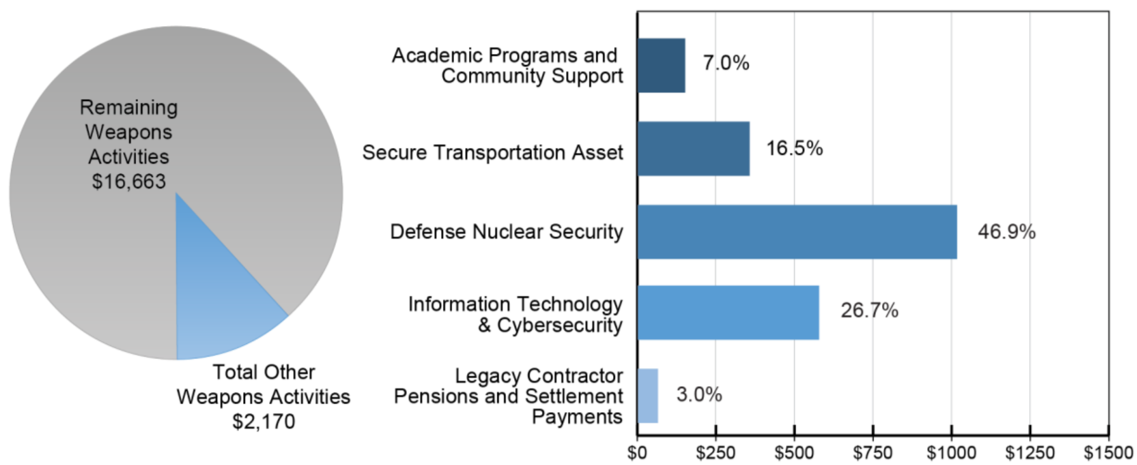
[5] DM and RPV totals exclude excess facilities and include KCNSC leased facilities.

8.8 Other Weapons Activities

8.8.1 Budget

The funding schedule for Other Weapons Activities is illustrated in **Figure 8–11**.

Other Weapons Activities Funding Request for FY 2024
(Dollars in Millions)



Fiscal Year ($M)

	2023 Enacted	2024	2025	2026	2027	2028
Academic Programs and Community Support	111.9	152.3	172.8	193.9	194.9	202.4
Secure Transportation Asset	344.4	357.1	391.0	413.2	460.6	464.7
Defense Nuclear Security	872.1	1,016.8	1,020.5	1,025.4	1,104.5	1,127.9
Information Technology & Cybersecurity	445.7	578.4	664.4	726.6	763.1	758.7
Legacy Contractor Pensions and Settlement Payments	114.6	65.5	56.3	64.2	40.9	39.4
Total Other Weapons Activities	1,888.7	2,169.9	2,304.9	2,423.2	2,563.9	2,593.1

Note: Numbers may not add due to rounding

Figure 8–11. Fiscal year 2024 President's Budget Request for Other Weapons Activities

8.8.2 Academic Programs and Community Support

This program, formerly a subprogram within the SRT&E portfolio, enables robust and diverse science, technology, engineering, and mathematics (STEM) research for educational communities through a variety of methods of support. This budget structure change enables improved program integration, agility, development, and alignment to critical workforce needs. Academic Programs and Community Support is made up of eight subprograms: (1) Stewardship Science Academic Alliance, (2) Minority Serving Institution Partnership Program, (3) Tribal Education Partnership Program, (4) Joint Program in High Energy Density Laboratory Plasmas, (5) Computational Science Graduate Fellowship, (6) Predictive Science Academic Alliance Program, (7) Pipeline Development, and (8) Community Capacity Building Program. Pipeline Development and Community Capacity Building Program are new subprograms proposed for FY 2024.

8.8.2.1 Fiscal Year 2024 Budget Request Compared to Fiscal Year 2023 Enacted Budget

In FY 2023, Academic Programs was funded as a subprogram of SRT&E. With the change from subprogram to program, the budget request for Academic Programs and Community Support increased 36.1 percent from FY 2023.

8.8.2.2 Key Milestones

Academic Programs and Community Support does not have its own milestones since it focuses on long-term investments in academic consortia and fellowships to provide relevant research and build a pipeline of talent to support the nuclear security enterprise.

8.8.3 Secure Transportation Asset

Secure Transportation Asset (STA) provides safe, secure transport of the Nation's nuclear weapons, weapon components, and special nuclear material throughout the nuclear security enterprise. STA includes two subprograms: (1) Operations and Equipment and (2) Program Direction. Operations and Equipment provides the transportation service infrastructure required for STA to meet DOE/NNSA's nuclear security activities. Program Direction provides salaries, travel, and other related expenses for Federal Agents and the secure transportation workforce.

8.8.3.1 Fiscal Year 2024 Budget Request Compared to Fiscal Year 2023 Enacted Budget

The budget request for STA increased 3.7 percent from FY 2023, driven by an increased budget request for Operations and Equipment to support Mobile Guardian Transporter schedule deliverables, including:

- Test Article 2 Head-On Crash Test
- Continued development of Engineering Releases Pre-Production Unit Assembly
- Continued Pre-Production Unit stage builds Production Readiness Review
- Beginning Advanced Engineering Releases and Post-Crash Test reports

The budget request for Program Direction decreased to account for carryover since there are fewer Federal Agents due to two cancelled Nuclear Material Courier Basic courses in FY 2020-2021.

8.8.3.2 Key Milestones

Aging transportation assets must be replaced to meet, and maintain, convoy safety and security requirements. The STA milestones in **Figure 8–12** will enable DOE/NNSA to support evolving transportation requirements for the current and future stockpile.

There were no milestones in last year's SSMP scheduled for completion in FY 2023.

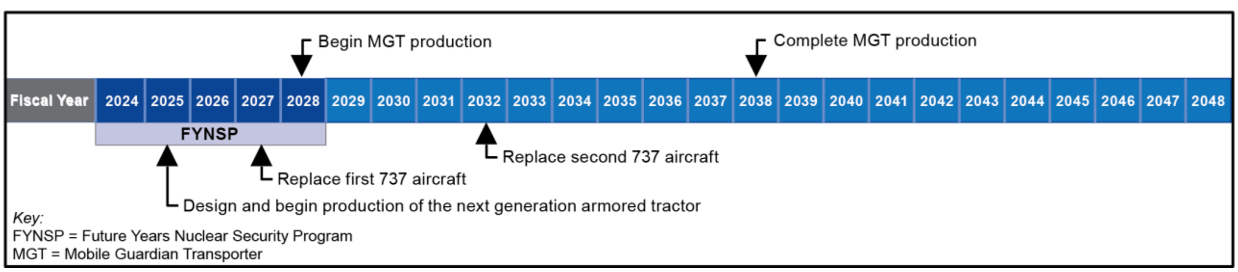


Figure 8–12. Key milestones for Secure Transportation Asset

8.8.4 Defense Nuclear Security

DOE/NNSA missions must be carried out in a secure environment protected by safeguards and security personnel, layers of physical security systems and technology, and sophisticated cybersecurity systems. Defense Nuclear Security (DNS) provides protection across the nuclear security enterprise for DOE/NNSA personnel, facilities, nuclear weapons, and materials from a full spectrum of threats, ranging from minor security incidents to acts of terrorism. The West End Protected Area Reduction (WEPAR) line-item project is also included within DNS.

8.8.4.1 Fiscal Year 2024 Budget Request Compared to Fiscal Year 2023 Enacted Budget

The budget request for DNS increased 16.6 percent from FY 2023 to support:

- Refined security requirements associated with growth across the nuclear security enterprise, including plutonium pit production, Kansas City expansion efforts, and the Uranium Processing Facility
- The transfer of all Safeguards and Security scope to the M&O Contractor Partner at the NNSS
- Funding the WEPAR project above the CD-2/3 Total Project Cost, which is needed to address issues experienced with delays in projects outside WEPAR's scope as well as contractor performance issues within the WEPAR project

8.8.4.2 Key Milestones

The Security Infrastructure Revitalization Program refreshes aging security infrastructure across the enterprise based on a long-range plan that is modified periodically based on DOE/NNSA's budget, mission, and needs.

The DNS milestones in **Figure 8–13** are directly linked to modernization of the national security infrastructure and will assure that DOE/NNSA mission requirements for the current and future stockpile are carried out in a safe and secure environment. There were two changes from last year's plan:

- The FY 2023 milestone, *Complete Caerus development*, is shifted to FY 2024 due to an 11-month delay in receiving network hardware due to supply chain challenges.
- The FY 2027 milestone, *Complete critical Security Infrastructure Revitalization Program (SIRP) priorities* is removed to better reflect the SIRP projects occurring at multiple sites. Site-specific information on SIRP projects is in Section 5.2 *Defense Nuclear Security,* Section 6.4.2 *Defense Nuclear Security Minor Construction Investment,* and the classified annex.

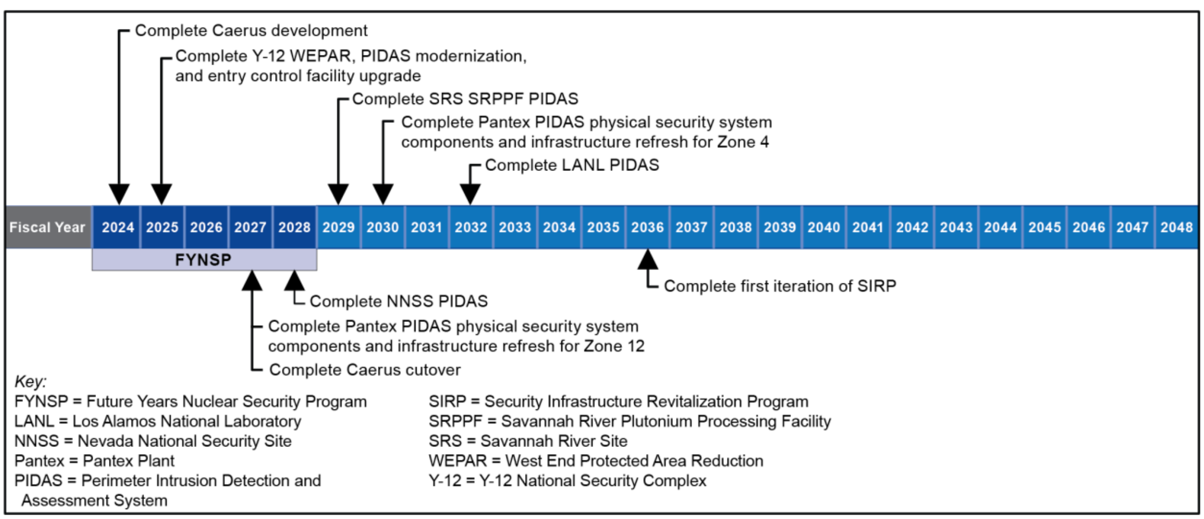


Figure 8–13. Key milestones for Defense Nuclear Security[6]

[6] The FY 2025 milestone, *Complete Y-12 WEPAR, PIDAS modernization, and entry control facility upgrade*, is subject to revision with the forthcoming project re-plan, as noted in the FY 2024 Construction Project Data Sheet.

8.8.5 Information Technology and Cybersecurity

The DOE/NNSA Office of the Associate Administrator for Information Management and Chief Information Officer supports information management, information technology (IT), and cybersecurity services and solutions to help meet security challenges. IT and Cybersecurity program provides a set of capabilities that enable the mission by increasing organizational efficiency, protecting information assets, enhancing communication with internal and external partners, ensuring continuous monitoring, and supporting effective incident response. This program funds ongoing operations and invests in improvements across the nuclear security enterprise to meet the requirements of Executive Order 14028, *Improving the Nation's Cybersecurity*.

8.8.5.1 Fiscal Year 2024 Budget Request Compared to Fiscal Year 2023 Enacted Budget

The budget request for IT and Cybersecurity increased 29.8 percent from FY 2023 to support:

- Investments in cybersecurity tools and services provided to the enterprise
- Workforce growth
- Technology modernization investments for critical classified and unclassified systems

8.8.5.2 Key Milestones

The milestones in **Figure 8–14** are necessary steps toward achieving a modernized IT infrastructure and cybersecurity posture for the nuclear security enterprise. There were no changes to last year's plan, and there were no milestones in last year's SSMP scheduled for completion in FY 2023.

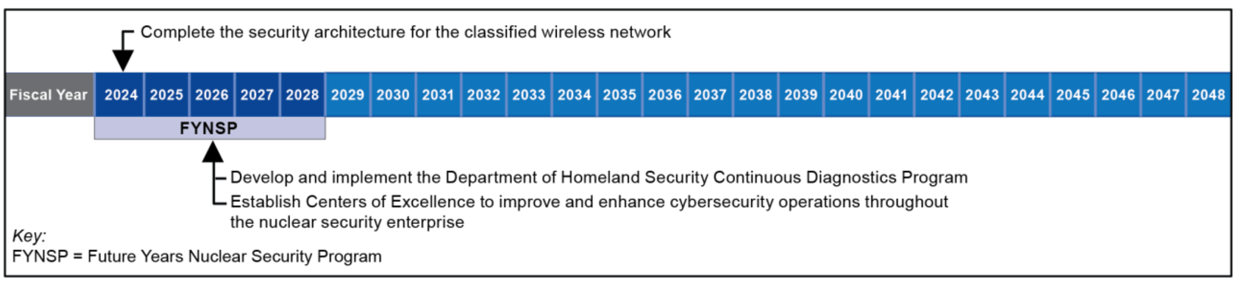


Figure 8–14. Key milestones for Information Technology and Cybersecurity

8.8.6 Legacy Contractor Pensions and Settlement Payments

Starting in FY 2022, Legacy Contractor Pensions and Settlement Payments includes funding to reimburse the University of California for a portion of a settlement reached in 2019 with former University of California employees of Lawrence Livermore National Laboratory (LLNL) related to health care plans, as well as funding for DOE/NNSA's share of the unfunded liability of the Savannah River Nuclear Solutions pension plan. This budget line also continues to include the Weapons Activities share of the DOE's annual reimbursement made to the University of California Retirement Plan for former University of California employees and annuitants who worked at the LLNL and LANL.

8.9 Weapons Activities Cost Beyond the FYNSP Period

This section explains the cost estimation methodology that DOE/NNSA uses to create an estimate of the aggregate cost of continuing the program described in this SSMP beyond the FYNSP period for which the budget request was prepared. This projection is used to evaluate, over a longer timeframe than considered in the FYNSP and during programming activities, the total required resources to accomplish the program of record, how those resources are allocated, and the overall affordability of the program (see Section 8.10).

8.9.1 Basis for Budget Projections

The FY 2024 to FY 2028 FYNSP was generated as part of the DOE/NNSA programming process and reflects a roll-up of individual estimates developed interactively by Federal Program Managers and DOE/NNSA's M&O partners using historical cost data, current plans for programs and projects, and expert judgment.

The budget estimates for FY 2029 and beyond reflect the costs of continuing the FYNSP program described in this SSMP.

Some elements of the Weapons Activities portfolio are assumed to continue beyond the FYNSP at the same level of effort as during the FYNSP.[7] For these cost projections, such as for Stockpile Sustainment, an escalation factor of 2.1 percent was applied.

Other parts of the program, primarily Stockpile Major Modernization programs and major programmatic construction projects, will not proceed at the same level of effort from FY 2029 through FY 2048; they will instead use funding profiles unique to each project. The estimates and the basis for each of these elements of the Weapons Activities portfolio are described in Sections 8.9.2–8.9.3.

8.9.2 Stockpile Major Modernization

Stockpile Major Modernization programs have the goal of extending the lifetime of the nation's nuclear stockpile while addressing required updates and improving their safety and security as possible. Figure 2–2 in Chapter 2, "Stockpile Management," provides a summary of planned Stockpile Major Modernization activities. The next sections summarize cost estimates for Stockpile Major Modernization programs within the current 25-year period.

8.9.2.1 Cost Estimates across the *Phase X/6.X Process*

The basis for the cost estimates varies from those using top-down cost models (e.g., analogy comparisons to past work completed, parametric relationships, and subject matter expert judgment) to those using bottom-up models (e.g., deterministic, unit cost, and activity based). The decision to use the top-down cost model versus the bottom-up model is made depending on where the warhead program is in the *Phase X/6.X Process*, reflecting the maturity of the process. **Figure 8–15** shows the governing cost estimate type for each phase of the *Phase 6.X Process* and the *Phase X Process*. DOE/NNSA works in conjunction with DoD and M&O partners to develop, refine, and update the estimates throughout these processes.

Phase 1/6.1	Phase 2/6.2	Phase 2A/6.2A[1]	Phase 3/6.3[1]	Phase 4/6.4[1]	Phase 5/6.5[1]	Phase 6/6.6	Phase 7
Concept Assessment	Feasibility Study & Design Options	Design Definition and Cost Study	Development Engineering	Production Engineering	First Production	Full-Scale Production/ Sustainment	Retirement, Dismantlement and Disposal
Planning Estimate		Weapons Design and Cost Report	Baseline Cost Report reported as part of the Selected Acquisition Report				

[1]The Office of Cost Estimating and Program Evaluation conducts the DOE/NNSA independent cost review prior to Phase 2/6.2 and independent cost estimates prior to entry in Phases 3/6.3, 4/6.4 and 5/6.5.

Figure 8–15. Cost estimates across the *Phase X/6.X Process*

[7] Projecting budget estimates for these efforts in this way assumes the continued manageability of whatever risks are present during the FYNSP with the same level of effort; this assumption escalates projections for inflation off of the funding level for the last year of the FYNSP. A 2.1 percent escalation rate was used.

The DOE/NNSA OMB Office of Programming, Analysis, and Evaluation develops and publishes major modernization planning cost estimates for the SSMP. These cost estimates are initiated at very early program maturity, often well before Phase 6.1, *Concept Assessment*, and are planning estimates for alternatives analysis and early programming. These planning estimates for Stockpile Major Modernization assume scopes that are in line with current policy objectives for the modernization effort and updated annually for the SSMP.[8] They are not constrained by future budget availability, and include both warhead modernization program (development and production) and non-warhead modernization program line-item costs that are critical to program success (namely Other Program Money and DoD costs).[9] These cost estimates are used to reflect the anticipated cost of each modernization program in the SSMP until the Weapon Design and Cost Report (WDCR) is approved for the effort. The estimate methodology is described in more detail in Section 8.9.2.2.

The WDCR is developed by the program teams responsible for the warhead modernization programs and provides cost estimates for design, qualification, production, and lifecycle activities. The WDCR includes detailed multi-site input and, although primarily performed using a bottom-up approach, may contain other methodologies (e.g., parametric, analogous, and subject matter expertise). The WDCR developed during Phase 6.2A, *Design Definition and Cost Study,* is a key input into the Phase 6.2A study report to the Nuclear Weapons Council and is required prior to entry to Phase 6.3. Once approved by the Nuclear Weapons Council, the WDCR becomes the basis for the Selected Acquisition Report (SAR) to Congress required upon entry into Phase 6.3.

The Baseline Cost Report (BCR), which is also developed by the program team, formally updates the WDCR based on development and pre-production activities. The BCR is updated based on refined scopes and schedule definitions (reflecting the increased maturity of the program) and represents a more definitive cost estimate than either the planning estimate or WDCR. The NNSA Administrator approves a program baseline, including the BCR, prior to Phase 6.3. The BCR supersedes previous cost estimates and becomes the program of record, which is transmitted annually to Congress as part of the SAR.

The DOE/NNSA Office of Cost Estimating and Program Evaluation conducts an independent cost review prior to Phase 6.2A, and independent cost estimates prior to entry into Phase 6.3, Phase 6.4, *Production Engineering*, and 6.5, *First Production*.

8.9.2.2 DOE/NNSA Office of Management and Budget Cost Estimating Methodology

The DOE/NNSA OMB Office of Programming, Analysis and Evaluation planning estimates for Stockpile Major Modernization programs are developed in the following manner:

- Performed using a "top-down" analogy method that is consistent with early-stage planning[10]
- Informed by ongoing and past program costs (such as the development and production of the W76-1, B61-12, W88 Alt 370) and the evaluation of the relative complexities of future systems[11]

[8] The Nuclear Weapons Council approves the specific scope for the weapon modernization program based on the alternatives developed during Phase 6.2/2. The cost estimate range used in a planning estimate reflects the uncertainty in implementing a single assumed point solution, rather than the range of every possible design solution.

[9] In estimating the cost of a warhead modernization program, the weapon programs depend on an adequately funded base of other DOE/NNSA capabilities, are incremental to that base, and reflect both each program's budgeted line-item and increments to other critical activities (such as early-stage technology maturation [called Other Program Money]). As the overall program integrator, the Federal Program Manager identifies the funding streams needed for the program to be successful.

[10] Additional detail on the cost estimating methodology of DOE/NNSA's planning estimates is in the technical paper, "Planning for the Future: Methodologies for Estimating U.S. Nuclear Stockpile Cost" (Lewis et al. 2016; Cost Engineering, 58 [5], pp. 6-12).

[11] These program and subject matter experts evaluate the relative scope complexity of the complete W76-1 and near-complete B61-12 LEP and W88 Alt 370 compared to each planned future warhead modernization program, which aids in providing a cost estimate range based on underlying technical and cost uncertainties.

- Based on time-phased development costs using a standard profile,[12] as well as production costs using a nonlinear cost growth profile similar to that of the W76-1
- Based on technical and programmatic inputs from Federal Program Managers, Federal field offices, and subject matter experts across the national security laboratories and nuclear weapons production facilities

Cost ranges reflect the underlying technical and modeling uncertainties of the programmatic scope at the time. During the early stages of warhead acquisitions (Phases 1/6.1 and 2/6.2), designs may experience scope changes due to ongoing down-select decisions regarding threshold and objective requirements, which may result in cost changes compared to those reported in previous SSMPs. These ranges will typically be greatest for earlier-stage programs and narrow over time. The cost estimates for future systems with little design definition are based on the W87-1 and W93 estimates, with an expanded range due to uncertainty in scope and quantities and in the escalation rate so far in the future.

8.9.2.3 Current Estimates

Figures 8–16 through 8–20 and Tables 8–4 through 8–12 provide cost estimates for each Stockpile Major Modernization program for the next 25 years. **Table 8–4** delineates the type of cost estimate for each of the warhead modernization programs included in the 25-year plan. Additional details on the basis for each estimate are provided for each individual program in Sections 8.9.2.4–8.9.2.9.

Table 8–4. DOE/NNSA cost estimates for Stockpile Major Modernization Programs[13]

Stockpile Major Modernization Program	*Type of Cost Estimate*	*Total Estimated Cost (FY 2023 dollars in billions)*	*Total Estimated Cost (then-year dollars in billions)*
B61-12 LEP	BCR/SAR	9.5	8.3
W88 Alteration Program	BCR/SAR	3.3	2.8
W80-4 LEP	BCR/SAR	11.2	12.3
W87-1 Mod Program	WDCR	12.1	15.9
W93 Program	Planning Estimate	16.2	22.9
Future Strategic Land-Based Warhead	Planning Estimate	15.9	32.4
Future Strategic Sea-Based Warhead	Planning Estimate	21.6	37.1
Future Air-Delivered Weapon	Planning Estimate	19.3	47.3
Future W76-1/2 Replacement	Planning Estimate	23.4	55.1

BCR = Baseline Cost Report SAR = Selected Acquisition Report
LEP = life extension program WDCR = Weapon Design and Cost Report

Each Stockpile Major Modernization program section contains a summary table with high, low, and nominal (proposed budget or BCR/SAR value) estimates for DOE/NNSA, in constant FY 2023 and then-year dollars. Where appropriate, the tables also include pre-SAR values for pre-Phase 6.2 costs. The low estimates presented in the tables and shown in graphs as a green line represent the mid-point (50 percent) of the cost estimate. The high estimates represent the 85th percent for the B61-12, W88 Alt 370, W80-4, W87-1, and W93; the estimate increased to the 90th percent for the future systems to reflect the greater uncertainty.

For early-stage programs using planning estimates, the figures and tables reflect the proposed FY 2024 FYNSP budget and, for years beyond FY 2028 the midpoint between the high and low estimates.

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12 Lee, David. *The Cost Analyst's Companion*, 3rd ed., McLean, VA: Logistics Management Institute, McLean, VA.

13 For programs pre-phase 1/6.1, the 90th percent value of a representative design and quantity is provided. Tables 8–5 through 8–13 provide values for a high and low estimate range, in addition to the SAR, WDCR, or planning estimate totals.

Items to consider when comparing estimates to one another:

- The constant-year cost totals in the tables are the most comparable because inflation effects become significant over warhead modernization activity timeframes. Consideration should also be given to the varying quantities of warheads being refurbished for each system. The FY 2024 SSMP's classified Annex provides additional information on production quantities.
- The then-year planning estimates in the tables and figures are derived from constant-year estimates using escalation rates provided in NNSA NAP 413.6. The outyear rate of 2.9% percent rate represents an average of the individual site escalation rates. The WDCR and BCR program office estimates are developed at the site and component level, and therefore use the escalation rates specific to each site and function rather than an average.
- Published estimate ranges are meant to reflect the underlying technical and cost uncertainty of the assumed scope. Early-stage programs, particularly those before Phase 6.3, may experience significant scope changes because the Nuclear Weapons Council may update and/or down-select design options that significantly impact the work scope and cost estimate.
- Only the planning estimates include pre-Phase 6.2 costs. The WDCR and BCR/SAR estimates do not include these costs since they are prepared during Phase 6.2 or beyond.

8.9.2.4 B61-12 Life Extension Program Cost Estimate

The B61-12 LEP received authorization to enter Phase 6.5 in FY 2021 and achieved first production unit in November 2021. In 2022, the Nuclear Weapons Council formally accepted the B61-12 into the stockpile and authorized Phase 6.6, *Full-Scale Production*. The values for development and production costs in **Figure 8–16** and **Table 8–5** reflect DOE/NNSA's FY 2020 BCR update issued in November 2020, with an overall cost estimate of $8.3 billion (then-year dollars) and are unchanged from last year's SSMP. The B61-12 LEP completed its use of Other Program Money for multi-system production process improvements in FY 2022. The costs of these related programs are estimated to be $648 million.

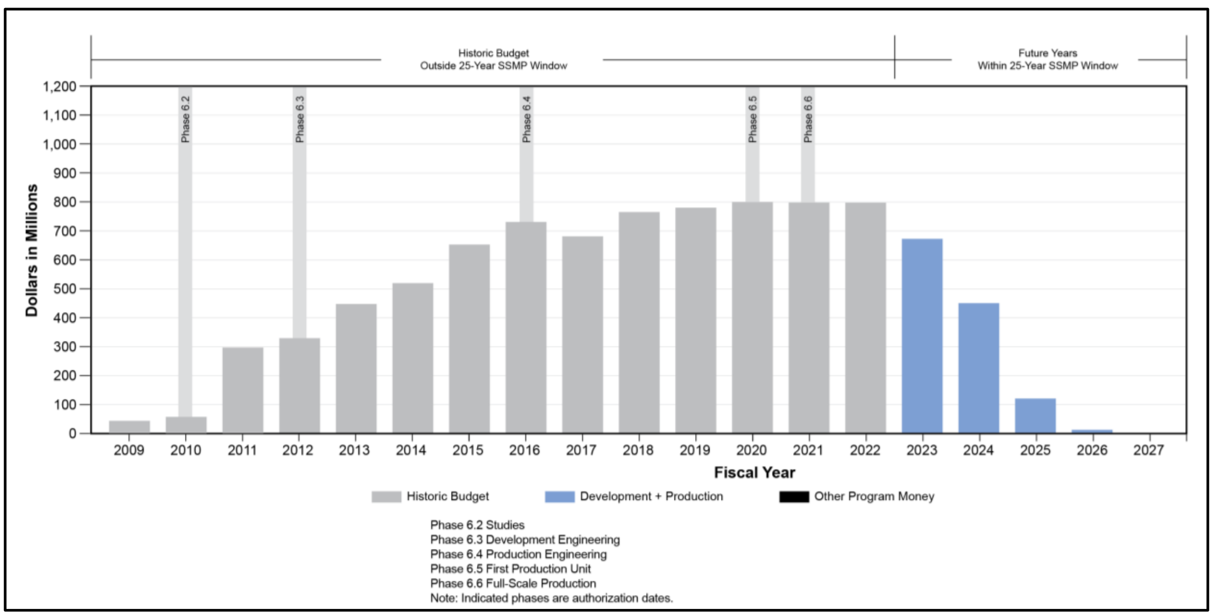

Figure 8–16. B61-12 Life Extension Program cost from fiscal year 2009 to completion

Table 8–5. Total estimated cost for B61-12 Life Extension Program

FY 2012–FY 2027 Dollars in Billions	FY 2023 Dollars	Then-Year Dollars
Pre-SAR Cost	0.5	0.4
SAR Total	9.5	8.3
SAR OPM Total	0.8	0.6
Planning Estimate (High)[a]	9.9	8.8
Planning Estimate (Low)[a]	9.3	8.2

OPM = Other Program Money
SAR = Selected Acquisition Report
[a] Excluding OPM

8.9.2.5 W88 Alteration 370 Cost Estimate

The W88 Alt 370 Program received authorization to enter Phase 6.5 in FY 2021 and completed the July 2021 first production unit per the baseline schedule. The Nuclear Weapons Council formally authorized Phase 6.6 entry in 2022 and accepted the W88 Alt 370 into the stockpile. The current estimate is unchanged from the updated BCR issued by DOE/NNSA in September 2020, with an estimate of $2.8 billion (then-year dollars). The revised BCR was reconciled with the independent cost estimate performed by DOE/NNSA's Office of Cost Estimating and Program Evaluation. The W88 Alt 370 Program is continuing to use other DOE/NNSA programs for multi-system production process improvements. The estimated costs of these related programs (such as Other Program Money) remain unchanged at $171 million. The numbers in **Figure 8–17** and **Table 8–6** reflect the BCR update.

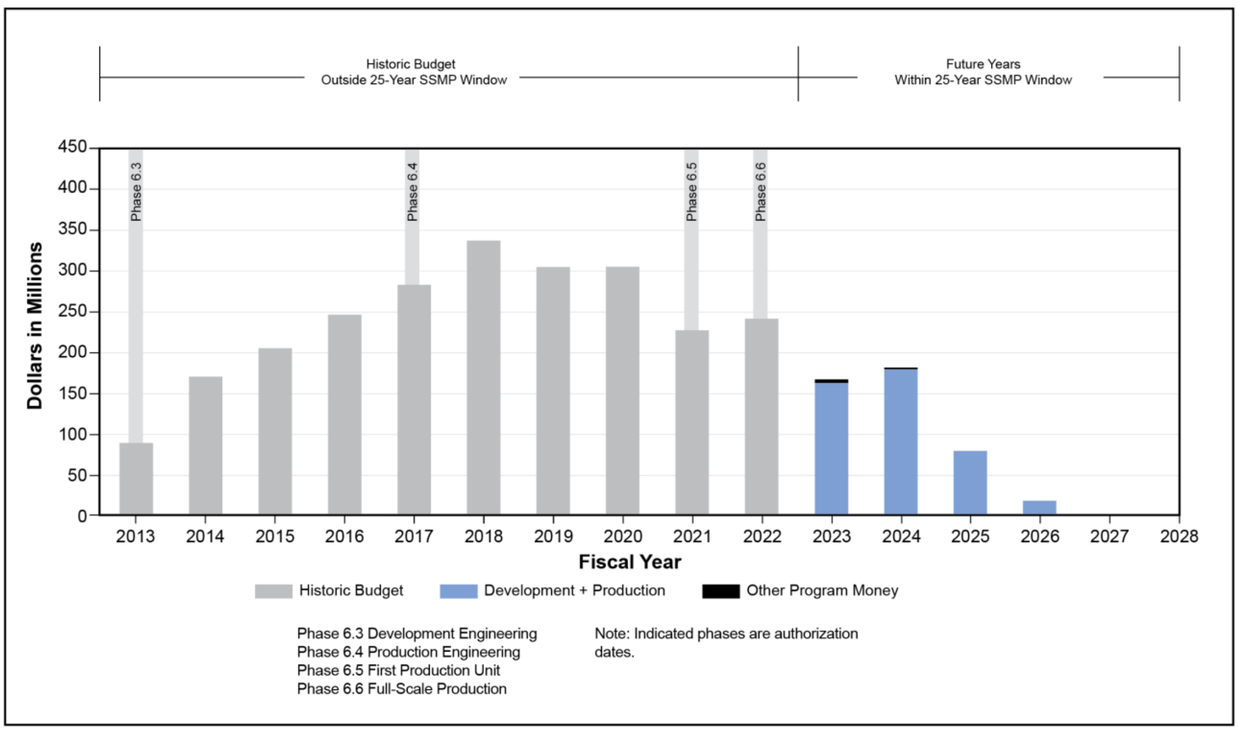

Figure 8–17. W88 Alteration 370 Program (with conventional high explosive refresh) from fiscal year 2013 to completion

Table 8–6. Total estimated cost for W88 Alteration 370 Program (with conventional high explosive refresh)

FY 2013–FY 2027 Dollars in Billions	*FY 2023 Dollars*	*Then-Year Dollars*
Pre-SAR Cost	0.1	0.1
SAR Total	3.3	2.8
SAR OPM Total	0.2	0.2
Planning Estimate (High)[a]	3.3	2.8
Planning Estimate (Low)[a]	3.2	2.7

OPM = Other Program Money
SAR = Selected Acquisition Report
[a] Excluding OPM

8.9.2.6 W80-4 Life Extension Program Cost Estimate

In FY 2023, the W80-4 received authorization to enter Phase 6.4, and published its BCR and an update to its WDCR. The W80-4 LEP is on track to support fielding the Air Force's scheduled Long Range Standoff cruise missile initial and final operational capability dates. The current cost estimate is displayed in **Figure 8–18** and **Table 8–7**.

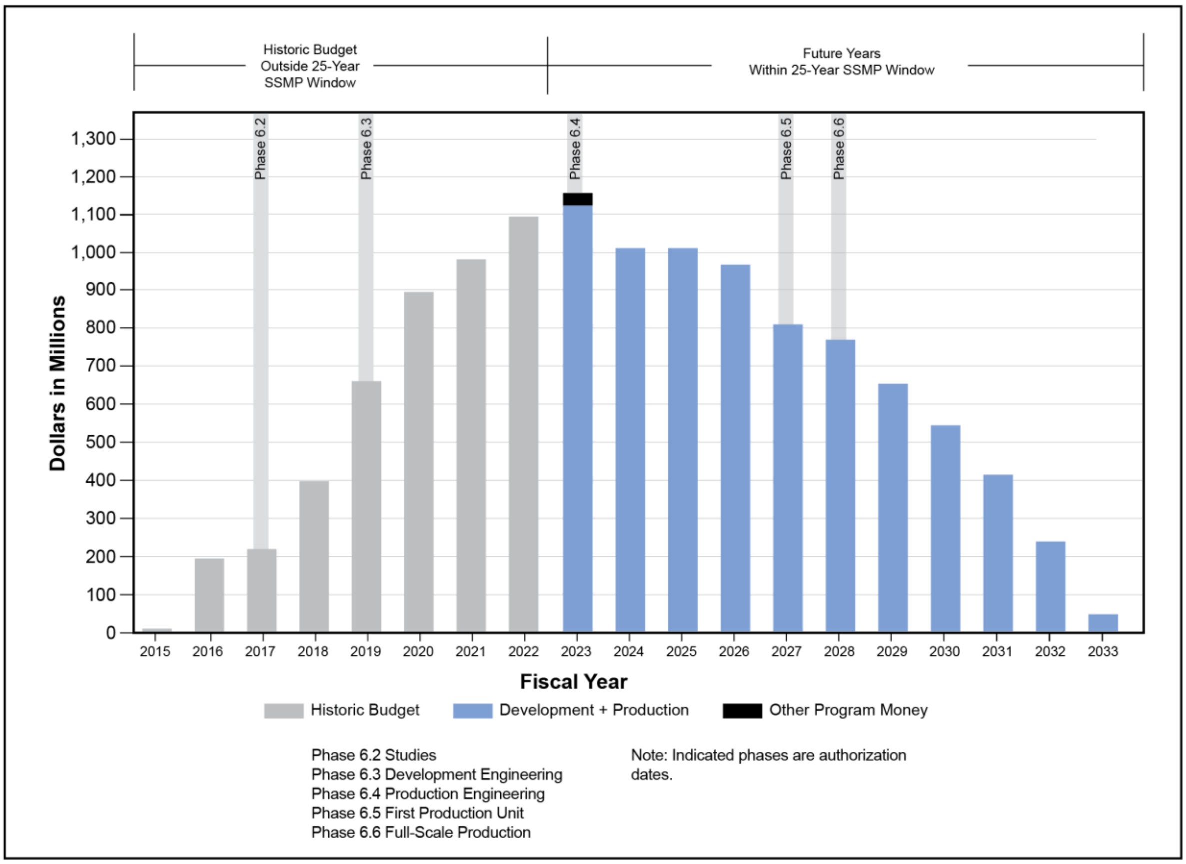

Figure 8–18. W80-4 Life Extension Program cost from fiscal year 2015 to completion

Table 8–7. Total estimated cost for W80-4 Life Extension Program

FY 2015–FY 2032 Dollars in Billions	FY 2023 Dollars	Then-Year Dollars
Pre-SAR Cost	0.9	0.7
SAR Total	11.2	12.3
SAR OPM Total	0.2	0.2
Planning Estimate (High)[a]	13.1	14.3
Planning Estimate (Low)[a]	11.4	12.3

OPM = Other Program Money
SAR = Selected Acquisition Report
[a] Excluding OPM

8.9.2.7 W87-1 Modification Program Cost Estimate

In February 2019, the Nuclear Weapons Council authorized a restart of Phase 6.2 activities for the W87-1 Modification Program, and the program is slated to deploy on the LGM-35A Sentinel in the early 2030s. In 2019, the Nuclear Weapons Council reviewed a series of surety architecture design options, to include detailed risk/benefit and cost analyses, before selecting a single surety option for W87-1 Mod Program. DOE/NNSA continues to evaluate other component design options and trades. In FY 2021, the W87-1 Mod Program completed Phase 6.2 and entered Phase 6.2A. In FY 2023, the W87-1 entered Phase 6.3 and completed its WDCR, and the associated cost estimate is shown in **Figure 8–19**. The estimates in Figure 8–19 and **Table 8–8** do not include costs associated with the production of plutonium pits for the W87-1 Mod Program after the capability to produce 30 ppy is demonstrated at LANL and 50 ppy at SRS; those costs are contained in Plutonium Modernization.

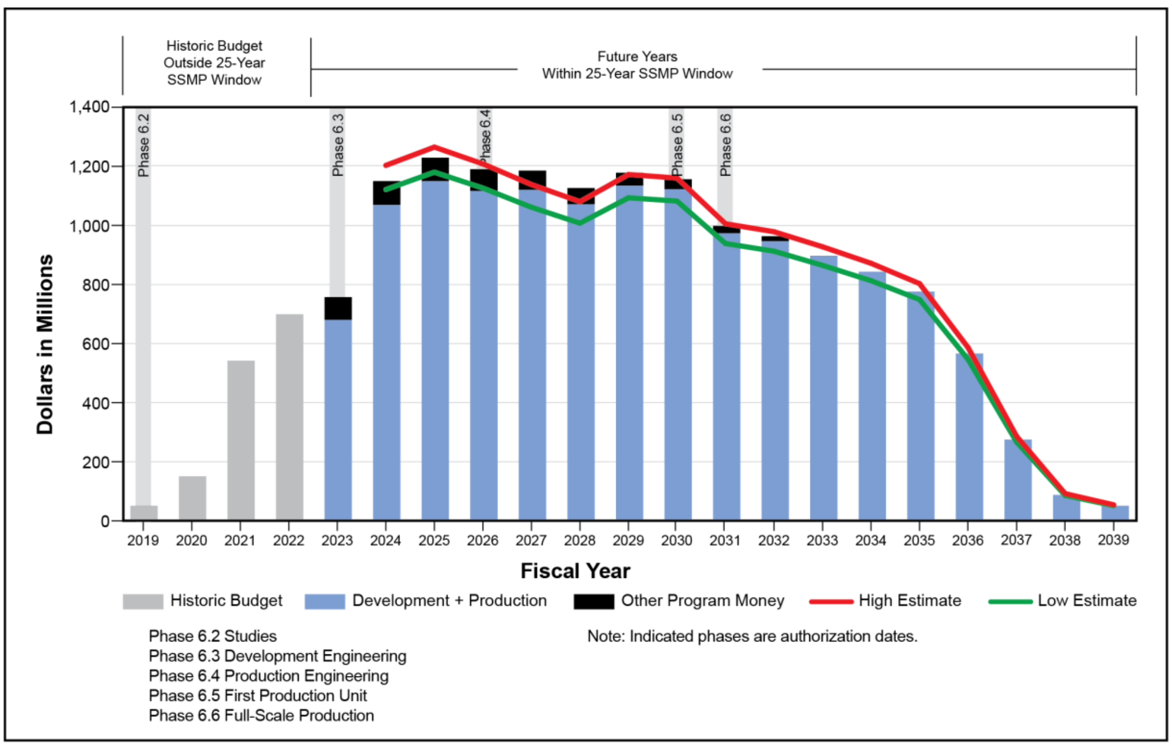

Figure 8–19. W87-1 Modification Program cost from fiscal year 2019 to completion[14]

[14] The W87-1 WDCR includes both a point estimate and Management Reserve and Contingency at the 20th percent and 80th percent levels based on risk assessments. The high and low values displayed in this graphic show that uncertainty range.

Table 8–8. Total estimated cost for W87-1 Modification Program

FY 2019–FY 2037 Dollars in Billions	*FY 2023 Dollars*	*Then-Year Dollars*
WDCR Estimate	12.1	15.9
Planning Estimate (High)[a]	11.9	14.1
Planning Estimate (Low)[a]	10.1	11.9
Proposed Budget	10.4	12.5

[a] Excluding OPM

8.9.2.8 W93 Program Cost Estimate

The W93 Program will mitigate future risk to the sea leg of the nuclear triad and address the changing strategic environment. DOE/NNSA is coordinating with DoD on specific requirements and design options for the W93 Program, which entered Phase 2 in FY 2022. The W93 Program cost estimate (see **Table 8–9** and **Figure 8–20**) is based on preliminary assumptions for one of the W93 designs and provides a planning estimate only. The midpoint of the estimates (average of 50 percent and 85 percent) for the entire list of options analyzed in the Phase 1 study ranged from $17.1 billion to $26.1 billion in then-year dollars, including Other Program Money. These estimates will change as requirements and schedules are refined and will be updated in future versions of the SSMP.

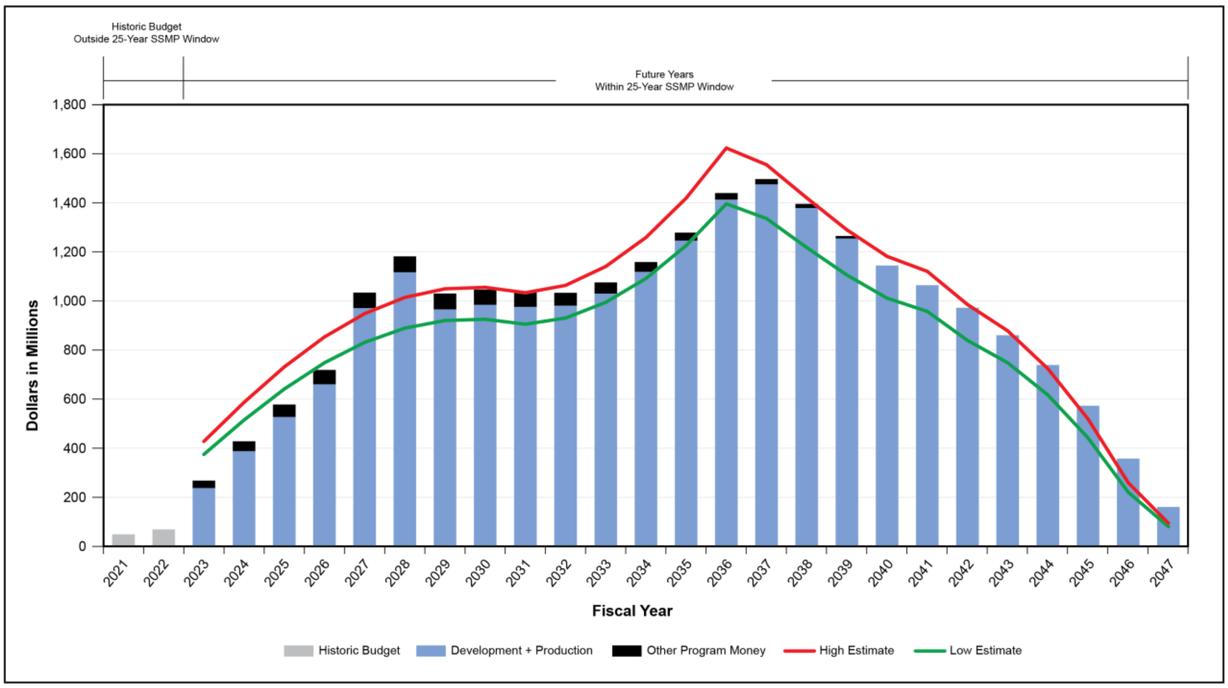

Figure 8–20. W93 Modification Program cost from fiscal year 2021 to completion

Table 8–9. Total estimated cost for W93 Program

FY 2021–FY 2047 Dollars in Billions	*FY 2023 Dollars*	*Then-Year Dollars*
Planning Estimate (High) [a]	17.5	24.8
Planning Estimate (Low) [a]	14.9	20.9
Proposed Budget	16.2	22.9

[a] Including Other Program Money

8.9.2.9 Future Strategic Missile Warhead Cost Estimates

DOE/NNSA is coordinating with DoD to define the appropriate ballistic missile warheads to support anticipated future threats. These warheads currently include the Future Strategic Land-Based Warhead, the Future Strategic Sea-Based Warhead, the Future Air-Delivered Warhead, and a Submarine-Launched Warhead (to replace the W76-1/2) that will be needed in the 2040s. The military capabilities required from the Future Strategic Land-Based Warhead and the Future Strategic Sea-Based Warhead, formerly referred to as Interoperable Warheads or Future Ballistic Missile Warheads, are being analyzed, and appropriate requirements are being developed to address emerging threats.

The Future Strategic Missile Warhead cost estimates (see **Table 8–10**, **Table 8–11**, **Table 8–12**, and **Table 8-13**) provide a planning estimate for notional systems. These estimates are based on an existing stockpile weapon with increased uncertainty in design scope and quantities, adjusted for out-year escalation and are informed by the W93 planning estimate. The planned timelines for these future warheads are also under consideration and have shifted later than shown in previous SSMPs. These estimates will change as requirements and schedules are refined and will be updated in future versions of the SSMP.

Table 8–10. Total estimated cost for Future Strategic Missile – Land-Based Warhead

Dollars in Billions	*FY 2023 Dollars*	*Then-Year Dollars*
Planning Estimate (High) [a]	17.6	36.0
Planning Estimate (Low) [a]	14.1	28.9
Proposed Budget	15.9	32.4

[a] Including Other Program Money

Table 8–11. Total estimated cost for Future Strategic Missile – Sea-Based Warhead

Dollars in Billions	*FY 2023 Dollars*	*Then-Year Dollars*
Planning Estimate (High) [a]	24.2	41.6
Planning Estimate (Low) [a]	19.0	32.7
Proposed Budget	21.6	37.1

[a] Including Other Program Money

Table 8–12. Total estimated cost for Future Air-Delivered Weapon

Dollars in Billions	*FY 2023 Dollars*	*Then-Year Dollars*
Planning Estimate (High) [a]	21.8	53.6
Planning Estimate (Low) [a]	16.7	40.9
Proposed Budget	19.3	47.3

[a] Including Other Program Money

Table 8–13. Total estimated cost for Future W76-1/2 Replacement

Dollars in Billions	*FY 2023 Dollars*	*Then-Year Dollars*
Planning Estimate (High) [a]	26.5	62.4
Planning Estimate (Low) [a]	20.3	47.8
Proposed Budget	23.4	55.1

[a] Including Other Program Money

8.9.2.10 Summary of Cost Estimates

Figure 8–21 represents the aggregation of cost estimate ranges for all presently known warhead modernization programs from FY 2023 through FY 2048 based on schedule assumptions that are subject to change. The differences in the values from the FY 2023 SSMP reflect refined estimates for W80-4 and W87-1 as well as increases in new estimates from the W93, and also the estimates for other future systems. Changes to proposed schedules for the Future Strategic Missile Warheads, whose estimates use an escalation of 2.9 percent[15], caused the funding profile to shift right by several years from last year's plan.

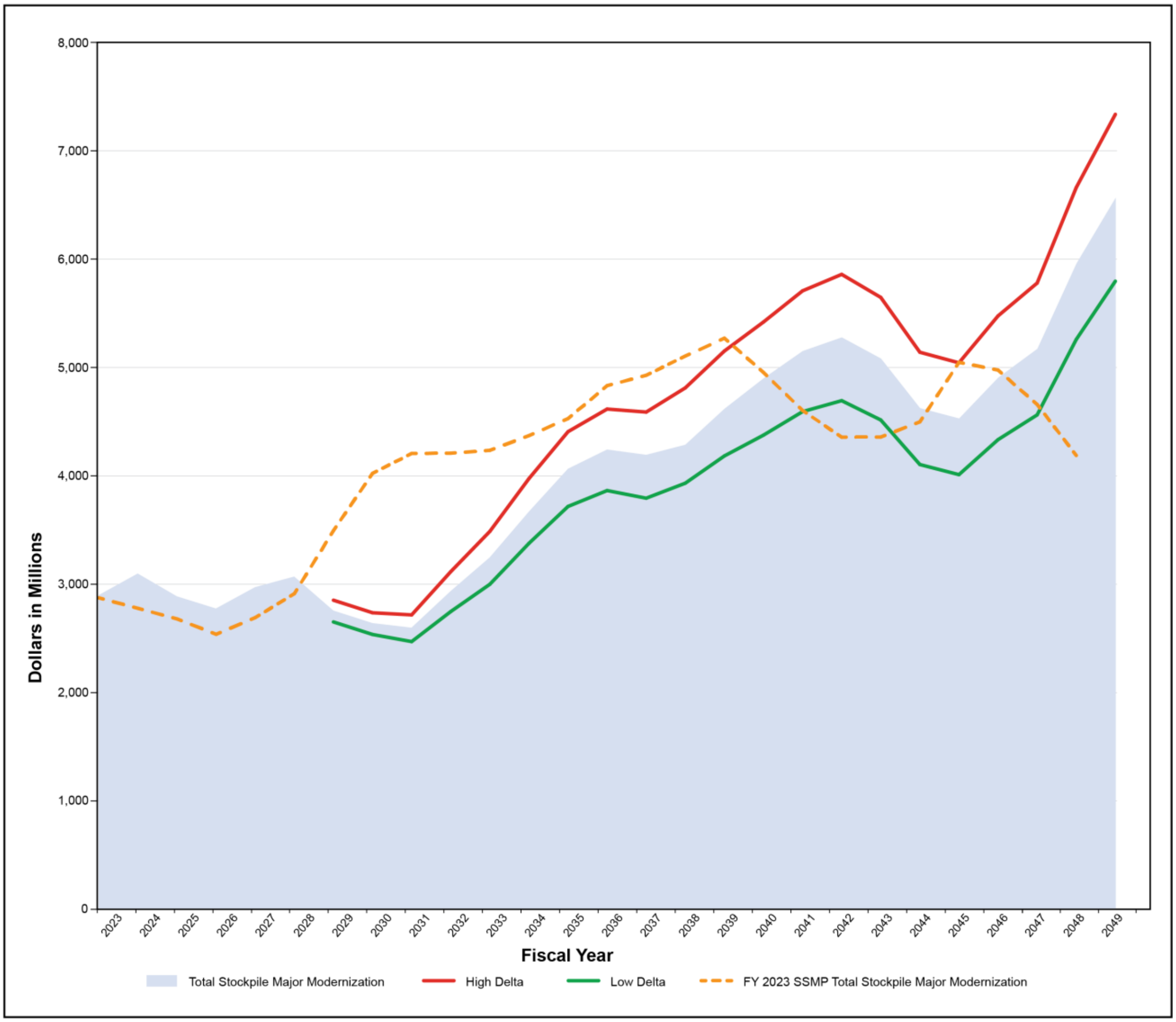

Figure 8–21. Total projected Stockpile Major Modernization costs for fiscal years 2022–2047 with high and low estimates (then-year dollars)

[15] Per NAP 413.6, *Confidence Levels and Escalation for Cost Estimating.*

8.9.3 Construction

8.9.3.1 Cost Estimation for Capital Acquisitions

In FY 2020, DOE/NNSA began publishing cost estimates for early-stage capital acquisitions. These early planning estimates, published as much as a decade or more before a project's initial mission approval, primarily inform long-term cost projections for programmatic construction and are supplemental to DOE acquisition requirements outlined in DOE Order 413.3B.

Notably, these cost estimates are:

- Performed by an organization separate from the Federal program office[16]
- Performed using a top-down parametric method consistent with early-stage planning
- Based on historic DOE/NNSA project schedules, costs, and project phasing
- Based on current anticipated project scopes
- Based on affordability analysis
- Updated annually for the SSMP

Once a project begins the acquisition process, the approved cost estimate ranges at the CD-0 milestone, *Approve Mission Need*, supersede previous estimates and becomes the basis for resource planning. The project then progresses as described in DOE Order 413.3B (i.e., alternative selection and cost range at CD-1, performance baseline at CD-2, etc.). Per DOE Order 413.3B and DOE/NNSA policy, the project cost estimates are reconciled with independent cost estimates or independent cost reviews performed by either the Office of Cost Estimating and Program Evaluation (pre-CD-0 and -1) or DOE's Office of Project Management (pre-CD-2).

The early-stage planning estimates use technical input based on an assumed scope. However, these assumptions do not predetermine the project's actual acquisition strategy or the outcome of subsequent analysis of alternatives. The assumed scope should be considered estimated until the design matures and the project reaches CD-2, *Performance Baseline*.

The cost estimation professional society, American Association of Cost Engineering International, has published a cost estimate classification system[17] based on the scope definition of the project. DOE/NNSA has mapped the American Association of Cost Engineering International cost estimate classes to the most common uses for capital acquisitions.[18] **Table 8–13** summarizes the cost estimation classification system, including the level of project definition, the expected uncertainty range, and the corresponding DOE/NNSA capital acquisition milestones. Note that the estimate ranges and typical applications represent rough expectations and cannot simply be applied to an estimate to determine uncertainty.

[16] The DOE/NNSA OMB Office of Programing, Analysis, and Evaluation performs the cost estimates on behalf of Defense Programs.
[17] American Association of Cost Engineering International Recommended Practice 18R-97, Cost Estimation Classification System as Applied in Engineering, Procurement and Construction for the Process Industries.
[18] DOE Guide 413.3-21A, Cost Estimating Guide.

Table 8–13. Capital Acquisition Cost Estimate Classification System

Estimate Class	*Primary Characteristic*	*Secondary Characteristic*			
	Maturity Level of Project Definition (percent)	*DOE Capital Acquisition Milestone*	*Typical Types of Estimate*	*Methodology*	*Expected Accuracy Range (percent)*
Class 5	0 to 2	Mission Need (CD-0)	Planning Estimate, Rough Order of Magnitude	Capacity factored, parametric models, judgment, or analogy	Low: -20 to -50 High: +30 to +100
Class 4	1 to 15	Alternative Selection (CD-1)	Analysis of Alternatives, Conceptual Design	Equipment factored or parametric models	Low: -15 to -30 High: +20 to +50
Class 3	10 to 40	Performance Baseline (CD-2) (low-risk projects)	Preliminary Design	Semi-detailed unit costs with assembly level line-items	Low: -10 to -20 High: +10 to +30
Class 2	30 to 75	Start of Construction (CD-3)/ Performance Baseline (CD-2) (high-risk projects)	Final Design	Detailed unit cost with forced detailed take-off	Low: -5 to -15 High: +5 to +20
Class 1	65 to 100			Detailed unit cost with detailed take-off	Low: -3 to -10 High: +3 to +15

CD = Critical Decision

8.9.3.2 Fiscal Year 2024 through Fiscal Year 2048 Estimates

The budget request for capital acquisitions in FY 2024 reflects the latest estimates for existing construction projects. DOE/NNSA continues to execute the schedules of multiple ongoing major capital acquisition projects. A list of major capital acquisition project proposals has been developed through the efforts of a series of working groups and deep dives with representatives from DOE/NNSA sites and responsible Federal offices. Both project- and portfolio-level planning initiatives are in progress to ensure DOE/NNSA is consistently funding the highest-priority infrastructure investments across the enterprise. The schedule for the current 25-year plan of major capital acquisition projects and project proposals is listed in Chapter 6, "Infrastructure and Operations." This planning schedule will be updated annually based on available funding and programmatic priorities.

8.10 Affordability

The FY 2024 President's Budget Request fully supports DOE/NNSA's needs. As described throughout this document, DOE/NNSA is undertaking a risk-informed, complex, and time-constrained modernization and recapitalization effort in coordination with DoD. DOE/NNSA is making concerted investments in its production facilities so that the necessary capabilities and infrastructure will be available to execute modernization programs to meet DoD timelines. Additionally, DOE/NNSA is working to maintain and upgrade its science and technology infrastructure so that it can continue supporting the cutting-edge science that underpins science-based stockpile stewardship and enables continued confidence in the reliability of the nuclear stockpile without the need for underground testing.

Figure 8–22 depicts updated Weapons Activities budget projections beyond the FYNSP, based on the FY 2024 President's Budget Request and a continuation of the program of record. The budget projection incorporates the Stockpile Major Modernization program cost estimates described in Section 8.9.2 and the cost estimates for the planned major programmatic construction projects described in Chapter 6, Section 6.2.1; these estimates are augmented by as-yet-unplanned construction beginning after FY 2040. Significant out-year estimates included in Figure 8–22 are:

- Reestablishing a plutonium pit production capability
- Reestablishing a domestic uranium enrichment capability
- Revitalizing depleted uranium manufacturing capability
- Establishing and modernizing DOE/NNSA's SRT&E capabilities for certifying warheads upon entry into the stockpile

The FY 2024 budget assumes a National Defense topline, including the DOE/NNSA topline, for FY 2029 through FY 2033 that grows at 0.7 percent. However, for illustrative purposes of this affordability analysis and to conform to assumptions in prior versions of the SSMP, DOE/NNSA assumes that funding for FY 2029 through FY 2050 will be escalated at 2.1 percent. This projection does not and cannot include unknown requirements, which may necessitate additional Stockpile Major Modernization programs, enhanced Stockpile Sustainment activities, R&D efforts, or further infrastructure investments. Out-year projections are adjusted annually as part of the programming process to align the total resource needs with available resources. As projected available resources are made clearer for years outside of the FYSNP, current capability and mission needs are examined and prioritized to build a program that maximizes the safety, security and effectiveness of the nuclear deterrent while staying within the available resources. If there are significant changes to future requirements, DOE/NNSA, in conjunction with DoD, would be forced to make difficult decisions with respect to scope and schedule of projects, or defer construction or recapitalization projects. Limiting risk across the nuclear security enterprise is a key consideration.

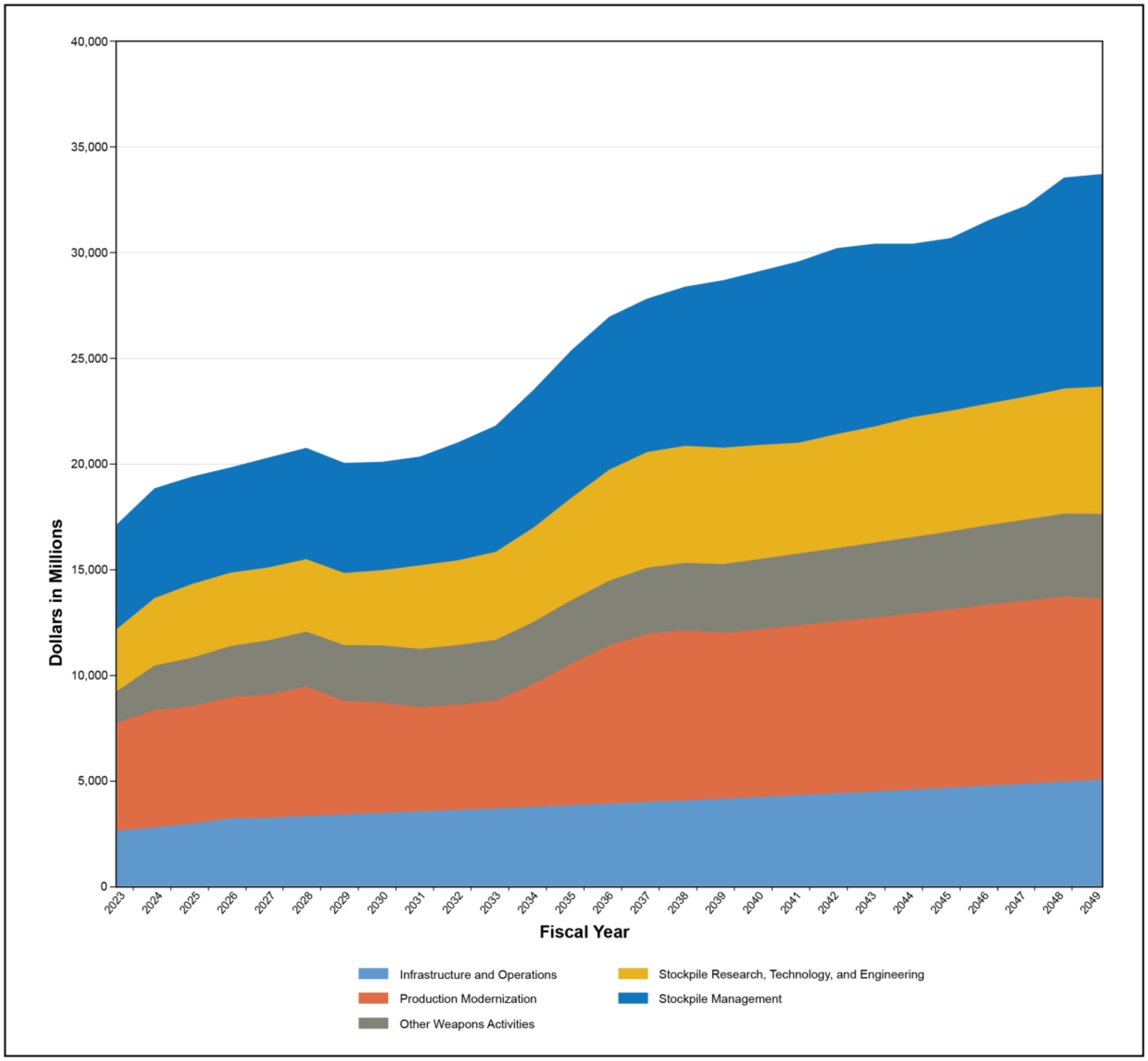

Figure 8–22. Projected out-year budget estimates for DOE/NNSA Weapons Activities in then-year dollars

Chapter 9 Conclusion

This Department of Energy's National Nuclear Security Administration (DOE/NNSA) *Fiscal Year 2024 Stockpile Stewardship and Management Plan* (FY 2024 SSMP), together with its classified annex, is a key planning document for the nuclear security enterprise. This FY 2024 SSMP is the culmination of planning efforts across numerous DOE/NNSA programs and organizations and documents the 25-year plan for ensuring the safety, security, and effectiveness of the U.S. nuclear stockpile. The FY 2024 SSMP also details efforts to maintain the scientific and engineering tools, capabilities, and infrastructure that underpin the current and future nuclear deterrent. The SSMP was prepared by the DOE/NNSA Federal workforce in collaboration with DOE/NNSA's management and operating partners and coordinated with the Department of Defense (DoD) through the Nuclear Weapons Council.

The global threat environment continues to rapidly evolve and grow increasingly dangerous, complex, and uncertain. In response to this changing environment, the United States must develop a modern, resilient, and flexible nuclear security enterprise to provide DoD with the necessary capabilities to continue to execute its critical nuclear deterrent mission. Together with support from Congress, DOE/NNSA will provide the nuclear security enterprise workforce with the resources and responsive, agile infrastructure needed to steward the systems that comprise the deterrent today, while preparing for the cutting-edge research and development that will inform the national security mission solutions of tomorrow.

Appendix A
Requirements Mapping

A.1 National Nuclear Security Administration Response to Statutory Reporting Requirements and Related Requests

The *Fiscal Year 2024 Stockpile Stewardship and Management Plan* (FY 2024 SSMP) consolidates a number of statutory reporting requirements and related congressional requests. This appendix maps the statutory and congressional requirements to the respective chapter and section in the FY 2024 SSMP.

A.2 50 U.S. Code § 2523

50 U.S. Code § 2523	*FY 2023 Response*	*FY 2024 Response*
§ 2523. Nuclear weapons stockpile stewardship, management, and responsiveness plan		
(a) Plan requirement The Administrator, in consultation with the Secretary of Defense and other appropriate officials of the departments and agencies of the Federal Government, shall develop and annually update a plan for sustaining the nuclear weapons stockpile. The plan shall cover, at a minimum, stockpile stewardship, stockpile management, stockpile responsiveness, stockpile surveillance, program direction, infrastructure modernization, human capital, and nuclear test readiness. The plan shall be consistent with the programmatic and technical requirements of the most recent annual Nuclear Weapons Stockpile Memorandum.		*Unclassified* Message from the NNSA Administrator; Message from the Secretary; Chapters 2, 4, 6, 7; Appendix D *Classified Annex*
(b) Submissions to Congress		
(1) In accordance with subsection (c), not later than March 15 of each even-numbered year, the Administrator shall submit to the congressional defense committees a summary of the plan developed under subsection (a).	*Unclassified* Message from the NNSA Administrator; All Chapters	N/A
(2) In accordance with subsection (d), not later than March 15 of each odd-numbered year, the Administrator shall submit to the congressional defense committees a detailed report on the plan developed under subsection (a).	N/A	*Unclassified* All Chapters
(3) The summaries and reports required by this subsection shall be submitted in unclassified form, but may include a classified annex.		
(c) Elements of biennial plan summary Each summary of the plan submitted under subsection (b)(1) shall include, at a minimum, the following:		
(1) A summary of the status of the nuclear weapons stockpile, including the number and age of warheads (including both active and inactive) for each warhead type.	*Unclassified* Chapter 1, Section 1.3, Figure 1-1	N/A

50 U.S. Code § 2523	*FY 2023 Response*	*FY 2024 Response*
(2) A summary of the status, plans, budgets, and schedules for warhead life extension programs and any other programs to modify, update, or replace warhead types.	*Unclassified* Chapter 1, Section 1.4; Chapter 2, Section 2.2, Figure 2-2	N/A
(3) A summary of the methods and information used to determine that the nuclear weapons stockpile is safe and reliable, as well as the relationship of science-based tools to the collection and interpretation of such information.	*Unclassified* Chapter 2, Sections 2.1, 2.2	N/A
(4) A summary of the status of the nuclear security enterprise, including programs and plans for infrastructure modernization and retention of human capital, as well as associated budgets and schedules.	*Unclassified* Chapter 4, Sections 4.2, 4.3; Appendix C, Section C-1	N/A
(5) A summary of the status, plans, and budgets for carrying out the stockpile responsiveness program under section 2538b of this title.	*Unclassified* Chapter 2, Section 2.1; Chapter 5, Section 5.4	N/A
(6) A summary of the plan regarding the research and development, deployment, and lifecycle sustainment of technologies described in subsection (d) (7).	*Unclassified* Chapter 1, Sections 1.4, 1.5, Figure 1-3	N/A
(7) A summary of the assessment under subsection (d)(8) regarding the execution of programs with current and projected budgets and any associated risks.	*Unclassified* Chapter 5, Sections 5.1, 5.5, 5.6, 5.9	N/A
(8) Identification of any modifications or updates to the plan since the previous summary or detailed report was submitted under subsection (b).	*Unclassified* Chapter 5, Section 5.4	N/A
(9) Such other information as the Administrator considers appropriate.		
(d) Elements of biennial detailed report Each detailed report on the plan submitted under subsection (b)(2) shall include, at a minimum, the following:		
(1) With respect to stockpile stewardship, stockpile management, and stockpile responsiveness—		
(A) the status of the nuclear weapons stockpile, including the number and age of warheads (including both active and inactive) for each warhead type;	*N/A*	*Unclassified* Chapter 1, Section 1.3, Table 1-1 *Classified Annex*
(B) for each five-year period occurring during the period beginning on the date of the report and ending on the date that is 20 years after the date of the report— (i) the planned number of nuclear warheads (including active and inactive) for each warhead type in the nuclear weapons stockpile; and (ii) the past and projected future total lifecycle cost of each type of nuclear weapon;	*N/A*	*Unclassified* Chapter 2, Section 2.2, Figure 2-2; Chapter 8, Sections 8.9, 8.9.2.2, 8.9.2.3, Table 8-4 *Classified Annex*

50 U.S. Code § 2523	*FY 2023 Response*	*FY 2024 Response*
(C) the status, plans, budgets, and schedules for warhead life extension programs and any other programs to modify, update, or replace warhead types;	*N/A*	*Unclassified* Chapter 2, Sections 2.2; Chapter 8, Section 8.9.2, Figures 8-16–8-22, Tables 8-5–8-13 *Classified Annex*
(D) a description of the process by which the Administrator assesses the lifetimes, and requirements for life extension or replacement, of the nuclear and non-nuclear components of the warheads (including active and inactive warheads) in the nuclear weapons stockpile;	*N/A*	*Unclassified* Chapter 2, Sections 2.1, 2.2, 2.3; Chapter 4, Sections 4.2.2, 4.3.2 *Classified Annex*
(E) a description of the process used in recertifying the safety, security, and reliability of each warhead type in the nuclear weapons stockpile;	*N/A*	*Unclassified* Chapter 2, Sections 2.1.1, 2.1.1.1–2.1.1.2; Chapter 4, Section 4.2.1, Figure 4-2 *Classified Annex*
(F) any concerns of the Administrator that would affect the ability of the Administrator to recertify the safety, security, or reliability of warheads in the nuclear weapons stockpile (including active and inactive warheads);	*N/A*	*Unclassified* Chapter 1, Overview; Chapter 6, Section 6.1 *Classified Annex*
(G) mechanisms to provide for the manufacture, maintenance, and modernization of each warhead type in the nuclear weapons stockpile, as needed;	*N/A*	*Unclassified* Chapter 3, Sections 3.1–3.4; Chapter 4, Sections 4.2.1, 4.2.4, Figure 4-2
(H) mechanisms to expedite the collection of information necessary for carrying out the stockpile management program required by section 2524 of this title, including information relating to the aging of materials and components, new manufacturing techniques, and the replacement or substitution of materials;	*N/A*	*Unclassified* Chapter 4, Sections 4.2.4, 4.3
(I) mechanisms to ensure the appropriate assignment of roles and missions for each national security laboratory and nuclear weapons production facility, including mechanisms for allocation of workload, mechanisms to ensure the carrying out of appropriate modernization activities, and mechanisms to ensure the retention of skilled personnel;	*N/A*	*Unclassified* Chapter 1, Section 1.2; Chapter 7, Sections 7.3.3, 7.4; Appendix F
(J) mechanisms to ensure that each national security laboratory has full and complete access to all weapons data to enable a rigorous peer-review process to support the annual assessment of the condition of the nuclear weapons stockpile required under section 2525 of this title;	*N/A*	*Unclassified* Chapter 1, Section 1.2.1; *Classified Annex*
(K) mechanisms for allocating funds for activities under the stockpile management program required by section 2524 of this title, including allocations of funds by weapon type and facility; and	*N/A*	*Unclassified* Chapter 8, Sections 8.9.2.2, 8.9.2.3, Table 8-4
(L) for each of the five fiscal years following the fiscal year in which the report is submitted, an identification of the funds needed to carry out the program required under section 2524 of this title;	*N/A*	*Unclassified* Chapter 8, Section 8.3, Table 8-1

50 U.S. Code § 2523	*FY 2023 Response*	*FY 2024 Response*
(M) the status, plans, activities, budgets, and schedules for carrying out the stockpile responsiveness program under section 2538b of this title;	*N/A*	*Unclassified* Appendix D
(N) for each of the five fiscal years following the fiscal year in which the report is submitted, an identification of the funds needed to carry out the program required under section 2538b of this title; and	*N/A*	*Unclassified* Chapter 8, Section 8.3, Table 8-1
(O) as required, when assessing and developing prototype nuclear weapons of foreign countries, a report from the directors of the national security laboratories on the need and plan for such assessment and development that includes separate comments on the plan from the Secretary of Energy and the Director of National Intelligence.	*N/A*	*N/A*
(2) With respect to science-based tools—		
(A) a description of the information needed to determine that the nuclear weapons stockpile is safe and reliable;	*N/A*	*Unclassified* Chapter 2, Sections 2.1.1, 2.1.1.1–2.1.1.2; Chapter 4, Sections 4.2.1, 4.3.1 *Classified Annex*
(B) for each science-based tool used to collect information described in subparagraph (A), the relationship between such tool and such information and the effectiveness of such tool in providing such information based on the criteria developed pursuant to section 2522(a) of this title; and	*N/A*	*Unclassified* Chapter 2, Section 2.2; Chapter 4, Section 4.3
(C) the criteria developed under section 2522(a) of this title (including any updates to such criteria).	*N/A*	*Classified Annex*
(3) An assessment of the stockpile stewardship program under section 2521 (a) of this title by the Administrator, in consultation with the directors of the national security laboratories, which shall set forth—		
(A) an identification and description of— (i) any key technical challenges to the stockpile stewardship program; and (ii) the strategies to address such challenges without the use of nuclear testing;	*N/A*	*Unclassified* Chapter 4, Sections 4.3.1–4.3.4, Tables 4-1–4-4 *Classified Annex*
(B) a strategy for using the science-based tools (including advanced simulation and computing capabilities) of each national security laboratory to ensure that the nuclear weapons stockpile is safe, secure, and reliable without the use of nuclear testing;	*N/A*	*Unclassified* Chapter 4, Sections 4.3.4, Table 4-4
(C) an assessment of the science-based tools (including advanced simulation and computing capabilities) of each national security laboratory that exist at the time of the assessment compared with the science-based tools expected to exist during the period covered by the future-years nuclear security program; and	*N/A*	*Unclassified* Chapter 4, Sections 4.2, 4.3, Table 4-4
(D) an assessment of the core scientific and technical competencies required to achieve the objectives of the stockpile stewardship program and other weapons activities and weapons-related activities of the Administration, including—	*N/A*	*Unclassified* Chapter 4, Section 4.3, 4.3.1–4.3.5, Figure 4-3, Tables 4-1–4-4
(i) the number of scientists, engineers, and technicians, by discipline, required to maintain such competencies; and	*N/A*	*Unclassified* Chapter 7, Section 7.1.2, Figure 7-2

50 U.S. Code § 2523	*FY 2023 Response*	*FY 2024 Response*
(ii) a description of any shortage of such individuals that exists at the time of the assessment compared with any shortage expected to exist during the period covered by the future-years nuclear security program.	*N/A*	*Unclassified* Chapter 7, Section 7.4, Table 7-1
(4) With respect to the nuclear security infrastructure—		
(A) a description of the modernization and refurbishment measures the Administrator determines necessary to meet the requirements prescribed in—	*N/A*	
(i) the national security strategy of the United States as set forth in the most recent national security strategy report of the President under section 3043 of this title if such strategy has been submitted as of the date of the plan;	*N/A*	*Unclassified* Executive Summary; Chapter 6
(ii) the most recent quadrennial defense review if such strategy has not been submitted as of the date of the plan; and	*N/A*	*Unclassified* Executive Summary; Chapter 6
(iii) the most recent Nuclear Posture Review as of the date of the plan;	*N/A*	*Unclassified* Executive Summary; Chapter 6
(B) a schedule for implementing the measures described under subparagraph (A) during the 10-year period following the date of the plan;	*N/A*	*Unclassified* Chapter 6, Section 6.3.1, 6.3.2
(C) the estimated levels of annual funds the Administrator determines necessary to carry out the measures described under subparagraph (A), including a discussion of the criteria, evidence, and strategies on which such estimated levels of annual funds are based; and	*N/A*	*Unclassified* Chapter 8, Sections 8.7, 8.9.3, Figure 8-12, Table 8-13
(D) a description of— (I) the metrics (based on industry best practices) used by the Administrator to determine the infrastructure deferred maintenance and repair needs of the nuclear security enterprise; and (II) the percentage of replacement plant value being spent on maintenance and repair needs of the nuclear security enterprise; and (III) an explanation of whether the annual spending on such needs complies with the recommendation of the National Research Council of the National Academies of Sciences, Engineering, and Medicine that such spending be in an amount equal to four percent of the replacement plant value, and, if not, the reasons for such noncompliance and a plan for how the Administrator will ensure facilities of the nuclear security enterprise are being properly sustained.	*N/A*	*Unclassified* Chapter 8, Section 8.7, Table 8-2
(5) With respect to the nuclear test readiness of the United States—		
(A) an estimate of the period of time that would be necessary for the Administrator to conduct an underground test of a nuclear weapon once directed by the President to conduct such a test;	*N/A*	*Unclassified* Chapter 4, Section 4.4
(B) a description of the level of test readiness that the Administrator, in consultation with the Secretary of Defense, determines to be appropriate;	*N/A*	*Unclassified* Chapter 4, Section 4.4
(C) a list and description of the workforce skills and capabilities that are essential to carrying out an underground nuclear test at the Nevada National Security Site;	*N/A*	*Unclassified* Chapter 4, Section 4.4; Appendix F, Section F.4.1.5

50 U.S. Code § 2523	*FY 2023 Response*	*FY 2024 Response*
(D) a list and description of the infrastructure and physical plants that are essential to carrying out an underground nuclear test at the Nevada National Security Site; and	*N/A*	*Unclassified* Chapter 4, Section 4.4; Appendix F, Section F.4.1.3
(E) an assessment of the readiness status of the skills and capabilities described in subparagraph (C) and the infrastructure and physical plants described in subparagraph (D).	*N/A*	*Unclassified* Chapter 4, Section 4.4; Appendix F, Sections F.4.1.3, F.4.1.5
(6) A strategy for the integrated management of plutonium for stockpile and stockpile stewardship needs over a 20-year period that includes the following:		
(A) An assessment of the baseline science issues necessary to understand plutonium aging under static and dynamic conditions under manufactured and nonmanufactured plutonium geometries.	*N/A*	*Unclassified* Chapter 4, Sections 4.3.1, 4.3.2
(B) An assessment of scientific and testing instrumentation for plutonium at elemental and bulk conditions.	*N/A*	*Unclassified* Chapter 4, Sections 4.3.1, 4.3.2
(C) An assessment of manufacturing and handling technology for plutonium and plutonium components.	*N/A*	*Unclassified* Chapter 4, Sections 4.3.1, 4.3.2
(D) An assessment of computational models of plutonium performance under static and dynamic loading, including manufactured and nonmanufactured conditions.	*N/A*	*Unclassified* Chapter 4, Section 4.3.4
(E) An identification of any capability gaps with respect to the assessments described in subparagraphs (A) through (D).	*N/A*	*Unclassified* Chapter 4, Sections 4.3.1–4.3.4
(F) An estimate of costs relating to the issues, instrumentation, technology, and models described in subparagraphs (A) through (D) over the period covered by the future-years nuclear security program under section 2453 of this title.	*N/A*	*Unclassified* Chapter 8, Section 8.6.1, Figure 8-8
(G) An estimate of the cost of eliminating the capability gaps identified under subparagraph (E) over the period covered by the future-years nuclear security program.	*N/A*	*Unclassified* Chapter 8, Section 8.3, Table 8-1
(H) Such other items as the Administrator considers important for the integrated management of plutonium for stockpile and stockpile stewardship needs.	*N/A*	*Unclassified* Chapter 3, Section 3.1.1
7) A plan for the research and development, deployment, and lifecycle sustainment of the technologies employed within the nuclear security enterprise to address physical and cyber security threats during the five fiscal years following the date of the report, together with—	*N/A*	*Unclassified* Chapter 5, Sections 5.2, 5.3 *Classified Annex*
(A) for each site in the nuclear security enterprise, a description of the technologies deployed to address the physical and cybersecurity threats posed to that site;	*N/A*	*Unclassified* Chapter 5, Section 5.3.2 *Classified Annex*
(B) for each site and for the nuclear security enterprise, the methods used by the Administration to establish priorities among investments in physical and cybersecurity technologies; and	*N/A*	*Unclassified* Chapter 8, Sections 8.8.4, 8.8.5 *Classified Annex*
(C) a detailed description of how the funds identified for each program element specified pursuant to paragraph (1) in the budget for the Administration for each fiscal year during that five-fiscal-year period will help carry out that plan.	*N/A*	*Unclassified* Chapter 8

50 U.S. Code § 2523	*FY 2023 Response*	*FY 2024 Response*
(8) An assessment of whether the programs described by the report can be executed with current and projected budgets and any associated risks.	*N/A*	*Unclassified* Chapter 8, Sections 8.9, 8.10
(9) Identification of any modifications or updates to the plan since the previous summary or detailed report was submitted under subsection (b).	*N/A*	*Unclassified* Chapter 8
(e) Nuclear Weapons Council assessment (1) For each detailed report on the plan submitted under subsection (b)(2), the Nuclear Weapons Council shall conduct an assessment that includes the following: (A) An analysis of the plan, including— (i) whether the plan supports the requirements of the national security strategy of the United States or the most recent quadrennial defense review, as applicable under subsection (d)(4)(A), and the Nuclear Posture Review; (ii) whether the modernization and refurbishment measures described under subparagraph (A) of subsection (d)(4) and the schedule described under subparagraph (B) of such subsection are adequate to support such requirements; and (iii) whether the plan supports the stockpile responsiveness program under section 2538b of this title in a manner that meets the objectives of such program and an identification of any improvements that may be made to the plan to better carry out such program. (B) An analysis of whether the plan adequately addresses the requirements for infrastructure recapitalization of the facilities of the nuclear security enterprise. (C) If the Nuclear Weapons Council determines that the plan does not adequately support modernization and refurbishment requirements under subparagraph (A) or the nuclear security enterprise facilities infrastructure recapitalization requirements under subparagraph (B), a risk assessment with respect to— (i) supporting the annual certification of the nuclear weapons stockpile; and (ii) maintaining the long-term safety, security, and reliability of the nuclear weapons stockpile. (2) Not later than 180 days after the date on which the Administrator submits the plan under subsection (b)(2), the Nuclear Weapons Council shall submit to the congressional defense committees a report detailing the assessment required under paragraph (1).	*N/A*	*N/A*

50 U.S. Code § 2523	*FY 2023 Response*	*FY 2024 Response*
(f) Definitions – In this section: (1) The term "budget", with respect to a fiscal year, means the budget for that fiscal year that is submitted to Congress by the President under section 1105(a) of title 31. (2) The term "future-years nuclear security program" means the program required by section 2453 of this title. (3) The term "nuclear security budget materials", with respect to a fiscal year, means the materials submitted to Congress by the Administrator in support of the budget for that fiscal year. (4) The term "quadrennial defense review" means the review of the defense programs and policies of the United States that is carried out every four years under section 118 of title 10. (5) The term "weapons activities" means each activity within the budget category of weapons activities in the budget of the Administration. (6) The term "weapons-related activities" means each activity under the Department of Energy that involves nuclear weapons, nuclear weapons technology, or fissile or radioactive materials, including activities related to— (A) nuclear nonproliferation; (B) nuclear forensics; (C) nuclear intelligence; (D) nuclear safety; and (E) nuclear incident response.	*Unclassified* Appendix G	*Unclassified* Appendix G

A.3 50 U.S. Code § 2538a

50 U.S. Code § 2538a	*FY 2023 Response*	*FY 2024 Response*
§2538a. Plutonium pit production capacity (a) Requirement Consistent with the requirements of the Secretary of Defense, the Secretary of Energy shall ensure that the nuclear security enterprise- (1) during 2021, begins production of qualification plutonium pits; (2) during 2024, produces not less than 10 war reserve plutonium pits; (3) during 2025, produces not less than 20 war reserve plutonium pits; (4) during 2026, produces not less than 30 war reserve plutonium pits; and (5) during 2030, produces not less than 80 war reserve plutonium pits.	*Unclassified* Executive Summary; Chapter 3, Section 3.4.1; Chapter 4, Section 4.2.1; Chapter 5, Section 5.5.3	*Unclassified* Executive Summary; Chapter 3, Sections 3.3.1, 3.1.1.2, Table 3-1; Chapter 6, Section 6.3.1.4
(b) Annual certification Not later than March 1, 2015, and each year thereafter through 2030, the Secretary of Energy shall certify to the congressional defense committees and the Secretary of Defense that the programs and budget of the Secretary of Energy will enable the nuclear security enterprise to meet the requirements under subsection (a).	*Unclassified* Chapter 3, Section 3.4.1; Chapter 5, Sections 5.5.3, 5.9.2	*N/A*
(c) Plan If the Secretary of Energy does not make a certification under subsection (b) by March 1 of any year in which a certification is required under that subsection, by not later than May 1 of such year, the Chairman of the Nuclear Weapons Council shall submit to the congressional defense committees a plan to enable the nuclear security enterprise to meet the requirements under subsection (a). Such plan shall include identification of the resources of the Department of Energy that the Chairman determines should be redirected to support the plan to meet such requirements.	*N/A*	*N/A*

A.4 H.R. 116-449

H.R. 116-449 – *ENERGY AND WATER DEVELOPMENT AND RELATED AGENCIES APPROPRIATIONS BILL, 2021, July 15, 2020, pp 141-142*	***FY 2023 Response***	***FY 2024 Response***[1]
Stockpile Responsiveness Program The NNSA shall submit to the Committee an annual report with the budget request that includes a detailed accounting and status of each program, project, and activity within the program. The Committee expects to receive timely updates on the status of any new and existing taskings, studies, and assessments.	*Unclassified* Appendix E	*Unclassified* Appendix D

A.5 H.R. 244

H.R.244 – Consolidated Appropriations Act, 2017, P.L. 115-31	***FY 2023 Response***	***FY 2024 Response***
SEC. 4. EXPLANATORY STATEMENT. The explanatory statement regarding this Act, printed in the House section of the Congressional Record on or about May 2, 2017, and submitted by the Chairman of the Committee on Appropriations of the House, shall have the same effect with respect to the allocation of funds and implementation of divisions A through L of this Act as if it were a joint explanatory statement of a committee of conference.		
Congressional Record – House, Vol 163, No 76—Book II, page H3753, May 3, 2017 (Explanatory Statement to Accompany the FY 17 Omnibus Appropriations [P.L. 115-31]]		
Life Extension Reporting. – The NNSA is directed to provide to the Committees on Appropriations of both Houses of Congress a classified summary of each ongoing life extension and major refurbishment program that includes explanatory information on the progress and planning for each program beginning with the award of the phase 6.3 milestone and annually thereafter until completion of the program.	*Classified Annex*	*Classified Annex*

A.6 Related Legislation: 50 U.S. Code § 2521

50 U.S. Code § 2521
§ 2521. Stockpile stewardship program (a) Establishment The Secretary of Energy, acting through the Administrator for Nuclear Security, shall establish a stewardship program to ensure – (1) the preservation of the core intellectual and technical competencies of the United States in nuclear weapons, including weapons design, system integration, manufacturing, security, use control, reliability assessment, and certification; and (2) that the nuclear weapons stockpile is safe, secure, and reliable without the use of underground nuclear weapons testing.

[1] H. Rept. 117-98 accompanying the *Energy and Water Development and Related Agencies Appropriations Bill, 2022* restated this annual Stockpile Responsiveness Program reporting requirement and noted that as the Stockpile Stewardship and Management Plan (SSMP) does not typically accompany the annual budget request, including the report within the SSMP, "therefore does not offer a useful and timely companion to the budget." This direction was reiterated again through Joint Explanatory Statement accompanying the *Energy and Water Development and Related Agencies Appropriations Act, 2022*. In accordance with this direction, Department of Energy's National Nuclear Security Administration (DOE/NNSA) submitted the report as a standalone document to provide as timely updates as possible and resubmitted within the SSMP, as the SSMP is also required to provide information on the Stockpile Responsiveness Program under 50 USC 2523 and 2523(c)(5), as noted.

50 U.S. Code § 2521
(b) Program elements The program shall include the following:
1) An increased level of effort for advanced computational capabilities to enhance the simulation and modeling capabilities of the United States with respect to the performance over time of nuclear weapons.
(2) An increased level of effort for above-ground experimental programs, such as hydrotesting, high-energy lasers, inertial confinement fusion, plasma physics, and materials research.
(3) Support for new facilities construction projects that contribute to the experimental capabilities of the United States, such as an advanced hydrodynamics facility, the National Ignition Facility, and other facilities for above-ground experiments to assess nuclear weapons effects.
(4) Support for the use of, and experiments facilitated by, the advanced experimental facilities of the United States, including - (A) the National Ignition Facility at Lawrence Livermore National Laboratory; (B) the Dual Axis Radiographic Hydrodynamic Testing facility at Los Alamos National Laboratory; (C) the Z Machine at Sandia National Laboratories; and (D) the experimental facilities at the Nevada National Security Site.
(5) Support for the sustainment and modernization of facilities with production and manufacturing capabilities that are necessary to ensure the safety, security, and reliability of the nuclear weapons stockpile, including - (A) the nuclear weapons production facilities; and (B) production and manufacturing capabilities resident in the national security laboratories.
(1) With respect to exascale computing—
(a) PLAN REQUIRED.—The Administrator for Nuclear Security shall develop and carry out a plan to develop exascale computing and incorporate such computing into the stockpile stewardship program under section 4201 of the Atomic Energy Defense Act (50 U.S.C. 2521) during the 10-year period beginning on the date of the enactment of this Act [Dec. 26, 2013]
(b) MILESTONES.—The plan required by subsection (a) shall include major programmatic milestones in— (1) the development of a prototype exascale computer for the stockpile stewardship program; and (2) mitigating disruptions resulting from the transition to exascale computing.
(c) COORDINATION WITH OTHER AGENCIES.—In developing the plan required by subsection (a), the Administrator shall coordinate, as appropriate, with the Under Secretary of Energy for Science, the Secretary of Defense, and elements of the intelligence community (as defined in section 3(4) of the National Security Act of 1947 (50 U.S.C. 3003[4]).
(d) INCLUSION OF COSTS IN FUTURE-YEARS NUCLEAR SECURITY PROGRAM.—The Administrator shall— (1) address, in the estimated expenditures and proposed appropriations reflected in each future-years nuclear security program submitted under section 3253 of the National Nuclear Security Administration Act (50 U.S.C. 2453) during the 10-year period beginning on the date of the enactment of this Act, the costs of— (A) developing exascale computing and incorporating such computing into the stockpile stewardship program; and (B) mitigating potential disruptions resulting from the transition to exascale computing; and (2) include in each such future-years nuclear security program a description of the costs of efforts to develop exascale computing borne by the National Nuclear Security Administration, the Office of Science of the Department of Energy, other Federal agencies, and private industry.
(e) SUBMISSION TO CONGRESS.—The Administrator shall submit the plan required by subsection (a) to the congressional defense committees [Committees on Armed Services and Appropriations of Senate and the House of Representative] with each summary of the plan required by subsection (a) of section 4203 of the Atomic Energy Defense Act (50 U.S.C. 2523) submitted under subsection (b)(1) of that section during the 10-year period beginning on the date of the enactment of this Act.
(f) EXASCALE COMPUTING DEFINED.—In this section, the term ''exascale computing'' means computing through the use of a computing machine that performs near or above 10 to the 18^{th} power floating point operations per second.

A.7 Related Legislation: 50 U.S. Code § 2522

50 U.S. Code § 2522
§ 2522. Stockpile stewardship criteria
(a) Requirement for criteria The Secretary of Energy shall develop clear and specific criteria for judging whether the science-based tools being used by the Department of Energy for determining the safety and reliability of the nuclear weapons stockpile are performing in a manner that will provide an adequate degree of certainty that the stockpile is safe and reliable.
(b) Coordination with Secretary of Defense The Secretary of Energy, in developing the criteria required by subsection (a), shall coordinate with the Secretary of Defense.

A.8 Related Legislation: 50 U.S. Code § 2524

50 U.S. Code § 2524
§ 2524. Stockpile management program
(a) Program required The Secretary of Energy, acting through the Administrator for Nuclear Security and in consultation with the Secretary of Defense, shall carry out a program, in support of the stockpile stewardship program, to provide for the effective management of the weapons in the nuclear weapons stockpile, including the extension of the effective life of such weapons. The program shall have the following objectives:
(1) To increase the reliability, safety, and security of the nuclear weapons stockpile of the United States.
(2) To further reduce the likelihood of the resumption of underground nuclear weapons testing.
(3) To achieve reductions in the future size of the nuclear weapons stockpile.
(4) To reduce the risk of an accidental detonation of an element of the stockpile.
(5) To reduce the risk of an element of the stockpile being used by a person or entity hostile to the United States, its vital interests, or its allies.
(b) Program limitations In carrying out the stockpile management program under subsection (a), the Secretary of Energy shall ensure that—
(1) any changes made to the stockpile shall be made to achieve the objectives identified in subsection (a); and
(2) any such changes made to the stockpile shall— (A) remain consistent with basic design parameters by including, to the maximum extent feasible, components that are well understood or are certifiable without the need to resume underground nuclear weapons testing; and (B) use the design, certification, and production expertise resident in the nuclear security enterprise to fulfill current mission requirements of the existing stockpile.
(c) Program budget In accordance with the requirements under section 2529 of this title, for each budget submitted by the President to Congress under section 1105 of title 31, the amounts requested for the program under this section shall be clearly identified in the budget justification materials submitted to Congress in support of that budget.

A.9 Related Legislation: 50 U.S. Code § 2538b

50 U.S. Code § 2538b
§ 2538b. Stockpile responsiveness program (a) Statement of policy It is the policy of the United States to identify, sustain, enhance, integrate, and continually exercise all capabilities required to conceptualize, study, design, develop, engineer, certify, produce, and deploy nuclear weapons to ensure the nuclear deterrent of the United States remains safe, secure, reliable, credible, and responsive.
(b) Program required The Secretary of Energy, acting through the Administrator and in consultation with the Secretary of Defense, shall carry out a stockpile responsiveness program, along with the stockpile stewardship program under section 2521 of this title and the stockpile management program under section 2524 of this title, to identify, sustain, enhance, integrate, and continually exercise all capabilities required to conceptualize, study, design, develop, engineer, certify, produce, and deploy nuclear weapons.
(c) Objectives The program under subsection (b) shall have the following objectives: (1) Identify, sustain, enhance, integrate, and continually exercise all of the capabilities, infrastructure, tools, and technologies across the science, engineering, design, certification, and manufacturing cycle required to carry out all phases of the joint nuclear weapons life cycle process, with respect to both the nuclear security enterprise and relevant elements of the Department of Defense. (2) Identify, enhance, and transfer knowledge, skills, and direct experience with respect to all phases of the joint nuclear weapons life cycle process from one generation of nuclear weapon designers and engineers to the following generation. (3) Periodically demonstrate stockpile responsiveness throughout the range of capabilities required, including prototypes, flight testing, and development of plans for certification without the need for nuclear explosive testing. (4) Shorten design, certification, and manufacturing cycles and timelines to minimize the amount of time and costs leading to an engineering prototype and production. (5) Continually exercise processes for the integration and coordination of all relevant elements and processes of the Administration and the Department of Defense required to ensure stockpile responsiveness. (6) The retention of the ability, in consultation with the Director of National Intelligence, to assess and develop prototype nuclear weapons of foreign countries and, if necessary, to conduct no-yield testing of those prototypes.
(d) Joint nuclear weapons life cycle process defined In this section, the term “joint nuclear weapons life cycle process” means the process developed and maintained by the Secretary of Defense and the Secretary of Energy for the development, production, maintenance, and retirement of nuclear weapons.

A.10 Related Legislation: S. 4049 NDAA for Fiscal Year 2021

S. 4049 NDAA for FY 2021
§ 3153. MONITORING OF INDUSTRIAL BASE FOR NUCLEAR WEAPONS COMPONENTS, SUBSYSTEMS, AND MATERIALS. (a) DESIGNATION OF OFFICIAL.—Not later than March 1, 2021, the Administrator for Nuclear Security shall designate a senior official within the National Nuclear Security Administration to be responsible for monitoring the industrial base that supports the nuclear weapons components, subsystems, and materials of the Administration, including— (1) the consistent monitoring of the current status of the industrial base; (2) tracking of industrial base issues over time; and (3) proactively identifying gaps or risks in specific areas relating to the industrial base.
(b) PROVISION OF RESOURCES.—The Administrator shall ensure that the official designated under subsection (a) is provided with resources sufficient to conduct the monitoring required by that subsection.
(c) CONSULTATIONS.—The Administrator, acting through the official designated under subsection (a), shall, to the extent practicable and beneficial, in conducting the monitoring required by that subsection, consult with— (1) officials of the Department of Defense who are members of the Nuclear Weapons Council established under section 179 of title 10, United States Code; (2) officials of the Department of Defense responsible for the defense industrial base; and (3) other components of the Department of Energy that rely on similar components, subsystems, or materials.

S. 4049 NDAA for FY 2021
(d) BRIEFINGS.— (1) INITIAL BRIEFING.—Not later than April 1, 2021, the Administrator shall provide to the Committees on Armed Services of the Senate and the House of Representatives a briefing on the designation of the official required by subsection (a), including on— (A) the responsibilities assigned to that official; and (B) the plan for providing that official with resources sufficient to conduct the monitoring required by subsection (a). (2) SUBSEQUENT BRIEFINGS.—Not later than April 1, 2022, and annually thereafter through 2024, the Administrator shall provide to the Committees on Armed Services of the Senate and the House of Representatives a briefing on activities carried out under this section that includes an assessment of the progress made by the official designated under subsection (a) in conducting the monitoring required by that subsection. The committee notes that the NNSA industrial base shares many of the same challenges faced by that of the Department of Defense (DOD): parts and materials are procured in small quantities, at irregular intervals, and with exacting performance specifications. Unlike the DOD, however, the NNSA does not comprehensively monitor the health of its industrial base and instead has left this responsibility to individual programs or contractors. As a result, efforts are fragmented and duplicative, as identified by the Department of Energy Inspector General in a July 2018 report titled ''Supplier Quality Management at National Nuclear Security Administration Sites'' (DOE–IG–18–41). The committee believes that this provision would help the NNSA reduce cost, schedule, and performance risk in future programs.

A.11 Related Legislation: S. 1605A NDAA for Fiscal Year 2022

S. 1605A for FY 2022 NDAA	***FY 2023 Response***	***FY 2024 Response***
§ 3135. Reports on risks to and gaps in industrial base for nuclear weapons components, subsystems, and materials Section 3113 of the William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021 (Public Law 116– 283; 50 U.S.C. 2512 note) is amended by adding at the end the following new subsection: ''(e) REPORTS.—The Administrator, acting through the official designated under subsection (a), shall submit to the Committees on Armed Services of the Senate and the House of Representatives, contemporaneously with each briefing required by subsection (d)(2), a report— ''(1) identifying actual or potential risks to or specific gaps in any element of the industrial base that supports the nuclear weapons components, subsystems, or materials of the National Nuclear Security Administration; ''(2) describing the actions the Administration is taking to further assess, characterize, and prioritize such risks and gaps; ''(3) describing mitigating actions, if any, the Administration has underway or planned to mitigate any such risks or gaps; ''(4) setting forth the anticipated timelines and resources needed for such mitigating actions; and ''(5) describing the nature of any coordination with or burden sharing by other departments or agencies of the Federal	*N/A*	*Unclassified* Appendix E

Appendix B
Weapons Activities Capabilities

This appendix describes the breadth of capabilities maintained by Weapons Activities programs in the Department of Energy's National Nuclear Security Administration (DOE/NNSA) nuclear security enterprise to execute the stockpile mission. These capabilities should not be viewed in isolation or as mutually exclusive, as many overlap and are complementary. They represent the underlying disciplines, activities, and specialized skills required to meet DOE/NNSA missions. In this document, the capabilities are grouped into seven interdependent areas, each of which constitutes a major facet of Weapons Activities work. In part, this appendix supports the legislative requirements listed in Appendix A.

As part of its portfolio management approach for Weapons Activities, DOE/NNSA continuously evaluates the health of the Weapons Activities capabilities, which are comprised of four elements:

- Human capital (experience, skill, people)
- Physical assets (facilities, infrastructure, equipment)
- Resources (resources, materials)
- Enabling processes (knowledge, technology, processes)

All four elements must be sustained and modernized to meet current and future missions. If any of these elements are missing, the capabilities cannot function as a system.

B.1 Weapon Science and Engineering

The Weapon Science and Engineering area includes the suite of physical sciences and engineering disciplines that comprise the theoretical and experimental capabilities necessary to assess the current nuclear stockpile and certify warheads for the future stockpile.

Capability	***Definition***
Atomic Physics, Nuclear Physics, Nuclear Engineering, and Radiochemistry	Atomic physics is the study of atomic systems, such as a collection of atoms and electrons, and their interaction with X-rays. The extremely high temperatures of functioning nuclear weapons generate X-rays. Nuclear physics is the study of atomic nuclei and their constituents and nuclear engineering is the translation of nuclear physics principles to the practical application of nuclear interactions, especially fission and fusion. The need to understand the design and function of the nuclear explosive package drives the requirement to improve understanding of both fission and fusion, which requires new experimental data from the Los Alamos Neutron Science Center (LANSCE). Radiochemistry is the study of radioactive materials and their interactions. It is critical to evaluating data from legacy underground testing, as well as modeling problems in nuclear forensics and attribution. Thermonuclear fusion experiments at the National Ignition Facility (NIF), Omega Laser Facility (Omega), and Z pulsed power facility (Z) can use radiochemical tracers in their diagnostic suites.

Capability	***Definition***
Materials Science, High Explosives and Energetics Science, Chemistry, and Actinide Science	Materials science, in this context of stockpile stewardship, is the study of how materials in a nuclear weapon are produced, age, and are replaced. Chemistry studies the elemental composition, structure, bonding, and properties of matter. The stability of material properties, and the nature of reactions, and interactions are critical components of system aging studies. How materials and properties change with time must be understood to ensure reliability and safety of the stockpile. Strength, aging, compatibility, viability, and damage mechanics are among the materials characteristics to be evaluated. Materials science and chemistry play a key role in resolving stockpile and production issues, validating computational models, and developing new materials (e.g., materials produced through additive manufacturing). Actinide science is the study of physics and chemistry of elements from actinium to lawrencium; it is useful to understand production, purification, compatibility, targets, and behavior of actinide materials relevant to the stockpile. This section also includes high explosives and energetics science and engineering, which are the study of detonation and deflagration physics, shock wave propagation, and reaction initiation. It includes the design, synthesis, manufacture, inspection, testing and evaluation of high explosives and other energetic materials and components for specific applications. Knowledge of these materials is necessary for understanding nuclear weapon performance. Data required to advance and underpin this knowledge is obtained from LANSCE and national light source facilities.
High Energy Density Science and Plasma Physics	High energy density science is the study of matter and radiation under extreme conditions such as those in a functioning nuclear weapon and reproduced in high-temperature experiments. Plasma physics is the study of systems containing separate ions and electrons that exhibit a collective behavior. The extremely high temperatures of functioning nuclear weapons generate plasma. Facilities such as NIF, Omega, and Z generate high energy density states producing data exploring the physical processes that occur in plasma states to validate computational models.
Technologies for Creating Extreme Conditions (lasers, accelerators, pulsed power)	This capability area includes laser, pulsed power, and accelerator technologies that are focused on creating extreme conditions, under which to study weapons-relevant matter and radiation behavior. Lasers are coherent light sources delivering intense beams of energy to localized regions to generate and probe high energy density conditions similar to those produced during nuclear weapon operation. A laser's rapid energy delivery enables studies of fundamental properties of matter, radiation transport, hydrodynamics and turbulence, thermonuclear ignition and burn, as well as outputs and effects. Pulsed power devices accumulate energy over long periods of time and release it rapidly to generate extreme pressures, temperatures, and radiation conditions. Accelerators use electromagnetic fields to accelerate charged particles to the velocities needed to generate high-energy X-rays, protons, or neutrons. The resulting emissions are sources for advanced imaging, investigating nuclear physics phenomena, or simulating weapons outputs and hostile environments. Advancements in these areas produce data critical to understanding physical phenomena, qualifying nuclear weapon components, and improving performance assessments. Facilities include NIF, Omega, LANSCE, and Z.

Capability	***Definition***
Advanced Experimental Diagnostics and Sensors	Advanced diagnostics and sensors provide detailed measurements of materials, objects, and dynamic processes that are critical to weapon operation and other national security operations. Standard diagnostics provide lower-resolution data suitable for basic inquiries, but not for detailed part, process, or physics qualification; continued diagnostic and sensor development is important to addressing these limitations. An example of an advanced diagnostic is static or multi-frame dynamic radiography at high resolution. Radiography is an imaging technique that uses X-rays or subatomic particles (e.g., protons, neutrons) to view the internal structure of an object that is opaque to visible light. Static radiography of a stationary object is used during the post-fabrication inspection process to ensure components are defect-free and meet exacting quality requirements. Dynamic radiography takes multiple images of a dynamic process to examine physical behavior in progress.
Hydrodynamic and Subcritical Experiments	Hydrodynamic experiments explore implosion physics and provide data on the behavior of full-scale dynamic systems. Subcritical experiments are driven by high explosives and contain special nuclear material (SNM) that never achieves a critical configuration and does not create nuclear yield. Both types of experiments provide data that are essential to validating models within multi-physics design codes and predicting nuclear weapon performance.

B.2 Weapon Simulation and Computing

The Weapon Simulation and Computing area includes high-performance computers, weapons codes, models, and data analytics used to assess the behavior of nuclear weapons and components. It must support calculations of sufficient resolution and complexity to simulate and assess the behavior of weapon systems, components, and fundamental science processes that are critical to nuclear weapon performance.

Capability	***Definition***
High-performance Computing	High-performance computing (HPC) encompasses software, hardware, and facilities of sufficient power to achieve the dimensionality, resolution, and complexity in simulation codes to accurately model the performance of weapon systems and components and the fundamental physical processes that are critical to nuclear operation. This capability includes research and development (R&D) in computer, information, and mathematical sciences to support developing and operating HPC.
Simulation Capabilities for Weapon Science, Engineering, and Physics	Advanced computer codes, models, and data analytics are used to simulate and assess the behavior of nuclear weapons and their components. Codes range in application from design of systems to fundamental science processes. DOE/NNSA codes operate on computers ranging from desktop machines to the world's largest high-performance supercomputers.

B.3 Weapon Design and Integration

The Weapon Design and Integration area encompasses the capabilities needed to design, test, analyze, qualify, and integrate components and subsystems into weapon systems that will meet all military requirements and endure all predicted environments to validate and verify that they will always work as expected and never work when not intended.

Capability	Definition
Weapons Physics Design and Analysis	Design and analysis of the nuclear explosive package is required to maintain existing U.S. nuclear weapons; modernize the stockpile; evaluate possible proliferant nuclear weapons; and respond to emerging threats, unanticipated events, and technological innovation. Elements of design capability include concept exploration, conceptual design, requirements satisfaction, detailed design and development, production, process development, certification, and qualification. Weapons physics analysis includes evaluation of weapons effects.
Weapons Engineering Design, Analysis, and Integration	Elements of weapons engineering include the following lifecycle phases: concept exploration, requirements satisfaction, conceptual design, detailed design and development, production, certification, and qualification. This capability also encompasses systems integration, which includes understanding and developing the interfaces among the non-nuclear subsystems, between the non-nuclear components and the nuclear explosives package, and between DOE/NNSA and Department of Defense (DoD) systems.
Environmental Effects Analysis, Testing, and Engineering Sciences	Environmental effects analysis, testing, and engineering sciences use an array of test equipment, tools, and techniques to create stockpile-to-target sequence conditions and measure the ensuing response of materials, components, and systems. Examples of environmental testing (normal, hostile, and abnormal) include shock, vibration, radiation, acceleration, temperature, electrostatics, and pressure conditions. The engineering sciences that support this analysis include thermal and fluid sciences, structural mechanics, dynamics, aerodynamics, and electromagnetics.
Weapons Surety Design, Testing, Analysis, and Manufacturing	Weapons surety design, analysis, integration, and manufacturing employ a variety of safety and use control systems to prevent accidental nuclear detonation and unauthorized use of nuclear weapons to ensure a safe and secure stockpile. This knowledge, infrastructure, and equipment requires strict classification control and secure facilities.
Radiation-Hardened Microelectronics Design and Manufacturing	Research, design, production, and testing of radiation-hardened microelectronics is required for nuclear weapons to function properly in hostile environments. This capability requires a secure, trusted supply chain, including quality control of the materials used in the process and products.

B.4 Weapon Material Processing and Manufacturing

The Weapon Material Processing and Manufacturing area covers the packaging, processing, handling, and/or manufacture of plutonium, uranium, tritium, energetic and hazardous materials, lithium, and other metal and organic materials needed for nuclear weapons.

Capability	Definition
Plutonium Management	Components that contain plutonium require special conduct of operations, physical security protection, facilities, and equipment to handle, package, process, manufacture, and inspect these components.
Uranium Management	Components that contain enriched and depleted uranium require special conduct of operations, physical security protection, facilities, and equipment to handle, package, process, manufacture, and inspect these components.

Capability	*Definition*
Tritium Management	Tritium has a 12-year half-life and must be periodically replenished in gas transfer systems (GTS). Tritium is produced by irradiating tritium-producing burnable absorber rods (TPBARs) in Tennessee Valley Authority's Watts Bar nuclear reactors. Handling and processing of tritium includes transporting TPBARs to the Savannah River Site and extracting tritium from the TPBARS, as well as purifying, storing, and loading the tritium into GTS reservoirs and inspecting reservoirs. Tritium is also recovered from returned GTSs.
High Explosives and Energetics Management	Development and production of energetics, including the associated manufacturing processes and infrastructure modernization to meet legacy and modernization stockpile applications. Energetics are materials that provide instantaneous energy through an exothermic chemical reaction. Energetics include specific end products, such as high explosives (conventional and insensitive) low explosives (pyrotechnics and propellants), their respective energetic ingredients, and various inert ingredients required for manufacturing (e.g., polymers, reactants, catalysts, plasticizers, oxidizers, fuels, ballistic modifiers, stabilizers, surfactants, and bonding agents).
Lithium Management	Components that contain lithium materials require special conduct of operations, physical security protection, facilities, and equipment to handle, package, process, manufacture, and inspect these components.
Additional Material Needs	Specialized components and materials that are not commercially available must be produced within the nuclear security enterprise. This production may require synthesis of organic materials and processing, manufacturing, and inspection of metallic and organic products, based on knowledge of material behavior, compatibility, and aging, which would include, but is not limited to, polymer material and part manufacturing.

B.5 Weapon Component Production

The Weapon Component Production area includes the core capabilities for producing all of the components and systems required to arm, fuze, fire, and deliver nuclear weapons to their target. The Weapon Component Production area includes the capabilities for producing all of the non-nuclear components and systems for weaponization of the nuclear explosive package. These functions enable the weapons to arm, fuze, and fire for the designed function when needed. This capability includes both internal and external manufacturing and a broad supply base, as well as identification and verification of trusted suppliers to provide materials and parts within the weapon product realization process.

Capability	*Definition*
Non-Nuclear Component Modernization and Production	Non-nuclear weapon components and assembly processes require special manufacturing, assembly, and inspection protocols. The components include, but are not limited to, cable assemblies; electronic assemblies; microelectronics packaging; GTSs; arming, fuzing, and firing assemblies; lightning arrestor connectors; environmental sensing devices; radars; neutron generators; and power sources.
Weapon Component and Material Process Development	Process development of weapon components involves small-lot production, precise controls, and a deep understanding of the hazards of working with SNM and other exotic materials. Component process development is needed whenever process changes are made to reduce costs or production time.

Capability	*Definition*
Weapon Component and System Prototyping	Development, qualification, and manufacture of high-fidelity, full-scale prototype weapon components and systems reduce costs and lifecycle time to develop and qualify new designs and technologies. This capability includes the ability to design, manufacture, and employ mockups with sensors to support laboratory and flight tests that provide evidence that components can function with DoD delivery systems in realistic environments.
Advanced Manufacturing	Advanced manufacturing uses innovative techniques from industry, academia, or internal R&D to reduce costs, reduce component development and production time, improve safety and performance, and control waste streams. Examples include additive manufacturing, use of microreactors, microwave casting, and electrorefining.

B.6 Weapon Assembly, Storage, Testing, and Disposition

After weapon components are produced, each requires assembly into complete warheads and temporary storage before delivery to DoD. Some of these warheads are removed from the stockpile on an annual basis for surveillance to provide data to evaluate the health of the stockpile. These surveillance activities (such as inspections, laboratory and flight tests, nondestructive tests, and component and material evaluations) provide data over time to predict, detect, assess, and resolve aging trends and any observed anomalies. This process requires disassembly and sometimes reassembly. At their end of life, or for other reasons, nuclear weapons undergo disposition. The Weapon Assembly, Storage, Testing, and Disposition area covers all these capabilities.

Capability	*Definition*
Weapon Assembly, Storage, and Disposition	This capability includes assembly and disassembly of all warheads, including components and subsystems contained within a device, and encompasses the breadth of national security enterprise capabilities requiring special conduct of operations, equipment, facilities, and quality control. Disassembly, inspection, and disposition of the warhead, components, and subsystems requires similar special conduct of operations, equipment, and facilities. Storage of weapons and subsystems requires special safety and security processes and protocols.
Testing Equipment Design and Fabrication	Design and fabrication of special test equipment to simulate environmental and functional conditions ensure that products meet specifications. Data from test equipment provide evidence for qualification, certification, reliability, surety, and surveillance.
Weapon Component and System Surveillance and Assessment	Surveillance enhances integration across test regimes to demonstrate performance requirements for stockpile systems by inspections, laboratory and flight tests, nondestructive tests, and component and material evaluations. Comparing data over time provides the ability to predict, detect, assess, and resolve aging trends and anomalous changes in the stockpile and address or mitigate issues or concerns. Assessment is the analysis, largely through modeling and simulation, of data gathered during surveillance to evaluate the safety, performance, and reliability of weapon systems and the effect of aging on performance, uncertainties, and margins.

B.7 Transportation and Security

The Transportation and Security area involves DOE/NNSA's capabilities for protecting the people, places, information, and other items and processes critical to the function of the nuclear security enterprise.

Capability	***Definition***
Secure Transportation	Protection and movement of nuclear weapons, weapon components, and SNM between facilities includes design and fabrication or modification of vehicles, design and fabrication of special communication systems, and training of Federal agents.
Physical Security	Physical security protects the Nation's nuclear materials, infrastructure assets, and workforce at DOE/NNSA sites involved in Weapons Activities. It protects assets from theft, diversion, sabotage, espionage, unauthorized access, compromise, and other hostile or noncompliant acts that may adversely affect national security, program continuity, and employee security.
Information Technology and Cybersecurity	Information technology and cybersecurity provides infrastructure and protection for computing networks, secure communications, applications, systems, and logical environments. It ensures electronic information and information assets are operating nominally and are protected from unauthorized access and malicious acts that would adversely affect national and economic security.

Appendix C
Exascale

The United States must retain state-of-the-art capabilities in high-performance computing (HPC) to maintain competitive advantage and perform the annual stockpile assessment. HPC will support U.S. national security, economic prosperity, technological strength, and scientific and energy research leadership. Failure to apply HPC to national security, science, and growing big data needs will open the door for other nations with a demonstrated commitment to HPC investment to take the lead in several critical areas. Risk to U.S. leadership in high-end computing would increase, and could also eventually increase in science, national defense, energy innovation, and the commercial computing market (see **Figure C–1**).

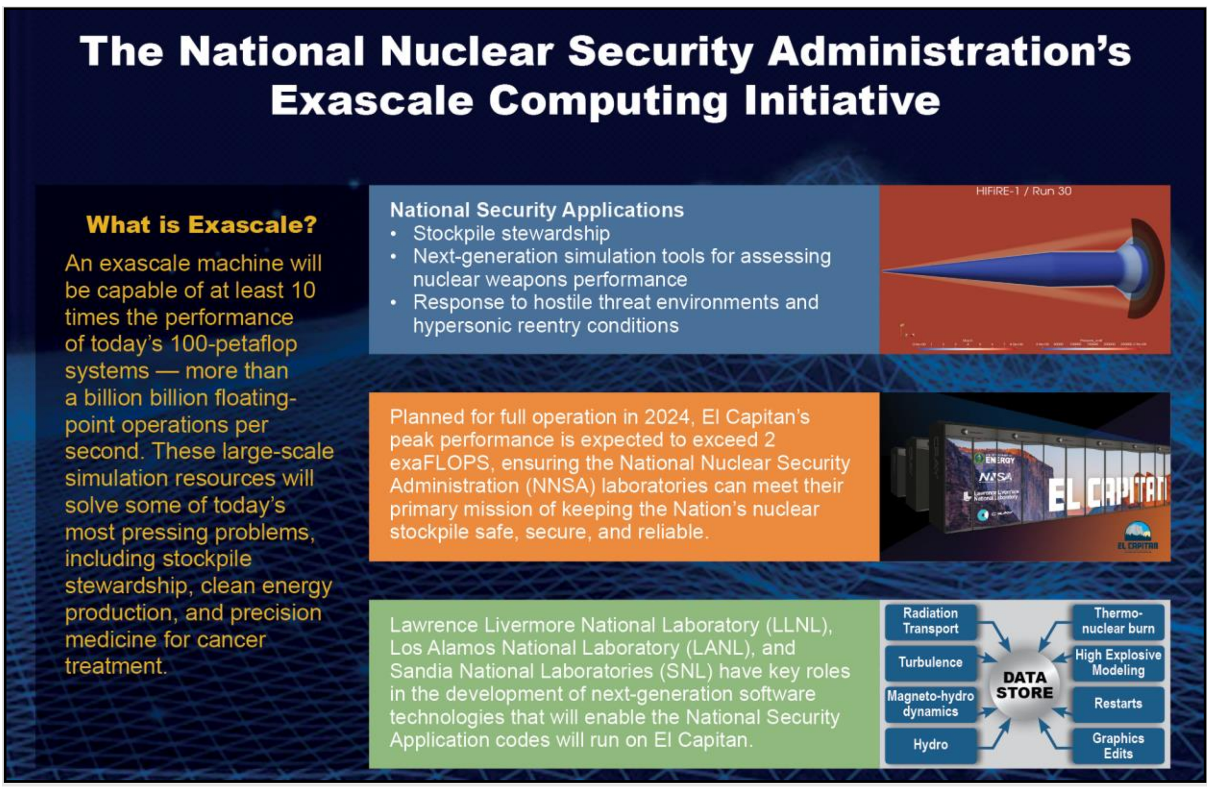

Figure C–1. Overview of the DOE/NNSA Exascale Computing Initiative

The National Strategic Computing Initiative was established as a Federal interagency campaign in 2015 and updated in 2019 to maximize the benefits of HPC for U.S. economic competitiveness, scientific discovery, and national security. Other agencies with major responsibilities for the Initiative include the National Science Foundation, the intelligence community, and the Departments of Commerce, Defense, Justice, and Homeland Security. The National Strategic Computing Initiative's major focus areas are the exploration and development of quantum computing, bio computing, and exascale computing. Within this initiative, the Department of Energy (DOE), represented by a partnership between the DOE Office of

Science and DOE's National Nuclear Security Administration (DOE/NNSA), has the lead responsibility for focusing and implementing the joint Exascale Computing Initiative (ECI). This initiative focuses on advanced simulation that continues exploiting MOSFET[1] technology to emphasize sustained HPC to advance DOE/NNSA missions. The objectives and the associated scientific challenges define a mission need for a computing capability of 2 to 10 exaFLOPS[2] in the early to mid-2020s.

C.1 Challenges

To deliver the exascale computing capability for the nuclear security mission within the next decade while maintaining and modifying the integrated design codes (IDCs), DOE/NNSA will need to focus on six challenges:

- Developing HPC technologies and systems, in close partnership with computer vendors, that will provide at least an eight-fold increase in sustained application code performance over the currently largest NNSA supercomputer (a 125-petaFLOPS[3] system).
- Addressing code performance on the current advanced architecture and next-generation systems, which employ heterogeneous architectures that are very different from the homogeneous computing environment DOE/NNSA has experienced in the past two decades.
- Advancing the Advanced Simulation and Computing (ASC) program-funded laboratory and open-source software stack to run efficiently on the new advanced architectures and to support emerging workflows.
- Developing prototype systems to assess the viability of alternate HPC architecture paths for ASC.
- Improving remote computing infrastructure to facilitate access across the DOE/NNSA complex to exascale and other leading-edge platforms wherever each may be sited.
- Modernizing DOE/NNSA computing facilities to prepare them for siting future petascale and exascale platforms through increasing structural integrity, power, and cooling capabilities.

C.2 Approaches and Strategies

The U.S. Government has been interacting with industry in HPC technology development to achieve DOE/NNSA's exascale goals. Past partnerships between the U.S. Government and industry have led to development of innovative technologies that met Federal and private sector objectives. DOE/NNSA is continuing its partnership with the DOE Office of Science on the ECI, including investments in research and development of hardware and systems technologies, software tools, and applications with computer vendors, the national laboratories, and universities. In addition, the two organizations collaborated on the joint April 2018 CORAL-2 procurement, which delivered one exascale-class system to DOE's Office of Science in fiscal year (FY) 2021–2022 and will deliver another to DOE/NNSA in FY 2023. This joint procurement greatly supports the two organizations as they leverage each other's critical non-recurring engineering development costs and jointly manage the technical progress of the two exascale system projects.

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[1] MOSFET stands for metal-oxide semiconductor, field-effect transistor. This technology, which has been the incumbent technology associated with Moore's law in microelectronics since the 1960s, theoretically begins failing significantly at speeds faster than exascale speeds.

[2] 1 exaFLOPS = 10^{18} floating-point operations per second.

[3] 1 petaFLOPS = 10^{15} floating-point operations per second.

The FY 2024 spend plan for ECI elements is delineated in **Table C–1**. In FY 2024, the DOE/NNSA portion of the ECI spans across four ASC program elements: Integrated Codes; Physics and Engineering Models; Verification and Validation, which fund the next-generation simulation technologies for the weapons mission (or the Defense Applications and Modeling portfolio); and Computational Systems and Software Environment subprogram, which deploys the next-generation system software stack and procures the El Capitan system.

Table C–1. NNSA Exascale Computing Initiative funding schedule for FY 2024

Exascale Computing Initiative Elements	*FY 2024 Request (dollars in millions)*	*FY 2016-2024 Totals (dollars in millions)*
Defense Applications and Modeling	18	82
Computational Systems and Software Environment	15	79
El Capitan Procurement	130	542
Advanced Technology Development and Mitigation	0	630
Facility Operations and User Support	0	20
Exascale Computing Facility Modernization	0	105
Total, NNSA Exascale Initiative	**163**	**1,458**

Defense Application and Modeling – Next-Generation Application Development

In FY 2021, DOE/NNSA began transitioning the validated next-generation code and associated capabilities into its Integrated Codes, Physics and Engineering Modeling, and Verification and Validation subprograms to support the annual assessment activities.

Computational Systems and Software Environment – Next-Generation Computing Technologies

In FY 2024, DOE/NNSA will transition the next-generation computing technology activities to Computational Systems and Software Environment subprogram. DOE/NNSA will continue evaluating its next-generation IDC performance portability on advanced architecture prototype systems. Funding will be for development, maintenance, and user support for the DOE/NNSA tri-laboratory software stack that will be required for the next-generation codes to run efficiently on these advanced technology systems. In addition, DOE/NNSA will continue investing in the application of advanced machine learning techniques, which are well-suited to the imminent advanced architectures, to address stockpile stewardship challenges.

Computational Systems and Software Environment – El Capitan Procurement

DOE/NNSA has been embarking on a multi-year collaboration with the selected system vendor and its subcontractors to work on non-recurring engineering and system integration to deliver El Capitan. The collaboration focuses on system engineering efforts and software technologies to assure the 2024 exascale system will be a capable and productive computing resource for the Stockpile Stewardship Program.

C.3 Collaborative Management

As the Exascale Computing Project (ECP) spans across DOE/NNSA, its management equally involves both organizations' Federal and laboratory personnel. The ECP overall management structure includes the Integrated Project Team in **Figure C–2**. The Integrated Project Team provides planning, execution, coordination, and communication for the ECP to ensure the project's objectives are achieved on schedule and within budget and are consistent with quality, environment, safety, and health standards.

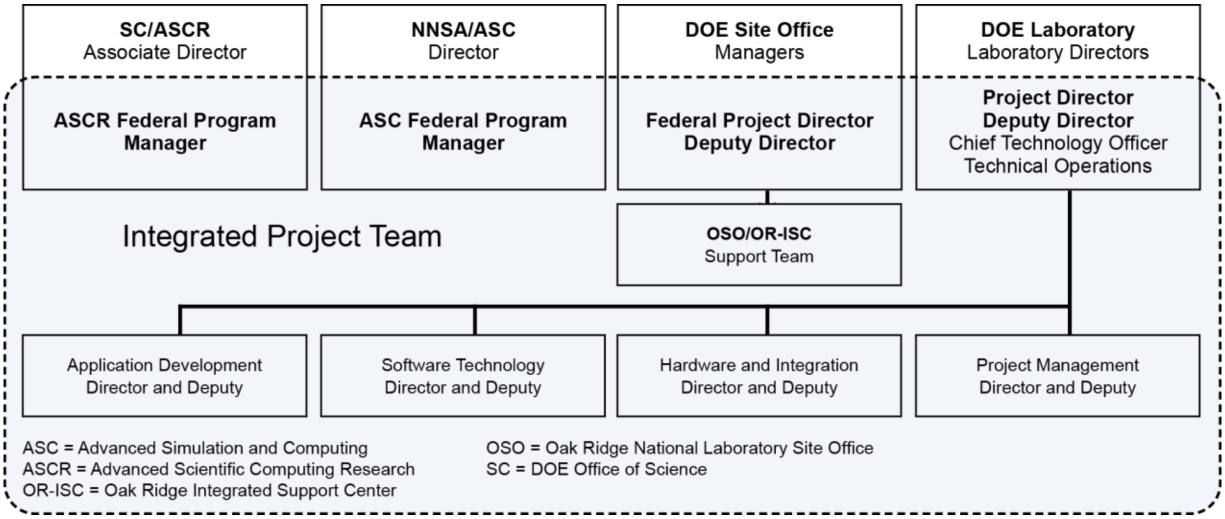


Figure C–2. Exascale Computing Project integrated project team

C.4 Milestones

DOE/NNSA has five milestones for FY 2024:

- Collaborate with DOE Office of Science on the close-out of the 7-year ECP
- Transition ASC's next-generation computing software technologies to its Computational Systems and Software Environment portfolio
- Continue porting additional IDCs to RZVernal, which is the classified El Capitan early access system-3 nodes, to analyze potential performance issues that may occur on El Capitan
- Collaborate with the El Capitan platform vendor on the full system's deployment and acceptance at Lawrence Livermore National Laboratory
- Transition El Capitan to classified computing environment

C.5 Conclusion

DOE/NNSA, through the ASC exascale computing effort, is investing in products and approaches that will respond directly to anticipated disruptive changes in the HPC ecosystem. Activities include creating research and development partnerships with multiple HPC vendors, developing next-generation weapons codes with new simulation capabilities, advancing the tri-laboratory software stack, procuring an exascale system, deploying prototype systems to assess the viability of new computing technologies, and upgrading facilities to house future exascale and petascale systems. Collaboration projects with computer vendors have also led to significant advances in HPC software and hardware technologies. These activities have provided valuable lessons learned and delivered numerous software development tools and libraries that many ASC applications and the broader U.S. HPC community now rely heavily on. Research, development, and engineering efforts will continue in 2024 and beyond for DOE/NNSA to optimally utilize the exascale computing capability, integrated with AI/ML and data analytics technologies, to address Defense Programs' mission needs.

Appendix D
Stockpile Responsiveness Program

This appendix is provided pursuant to 50 United States (U.S.) Code § 2523, which requires inclusion of plans for the Stockpile Responsiveness Program (SRP) in the Stockpile Stewardship and Management Plan (SSMP).

Section 3112 of the *National Defense Authorization Act for Fiscal Year 2016* established that "[i]t is the policy of the United States to identify, sustain, enhance, integrate, and continually exercise all capabilities required to conceptualize, study, design, develop, engineer, certify, produce, and deploy nuclear weapons to ensure the nuclear deterrent of the United States remains safe, secure, reliable, credible, and responsive." Section 3112 created the SRP to achieve this policy in coordination with already existing Stockpile Stewardship and Stockpile Management Programs.

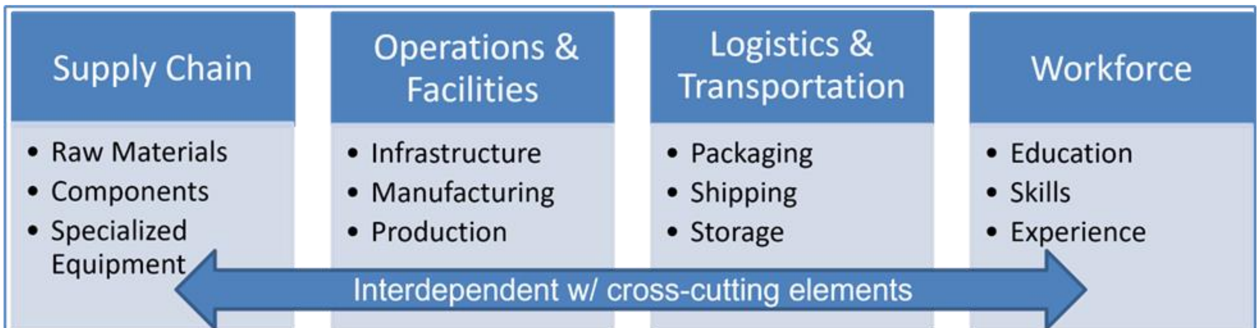
SRP is intended to exercise and enhance capabilities through the entire nuclear weapons lifecycle to improve the responsiveness of the United States to future threats, technology trends, and international developments not addressed by existing life extension programs. Technology development teams also provide leadership opportunities for early-career staff members while SRP activities fully exercise the abilities of the workforce and allow the enterprise to identify efficiencies for current and future programs. SRP is organized according to major technical efforts and heavily focuses on improving production responsiveness along with joint activities with the Office of the Under Secretary of Defense for Research and Engineering. The SRP report provides information regarding the program's purpose, planned budget, governance, and priorities.

H. Rept. 117-98 accompanying the *Energy and Water Development and Related Agencies Appropriations Bill, 2022*, restated an annual SRP reporting requirement and noted that since the SSMP does not typically accompany the annual budget request, including the report within the SSMP, it "therefore does not offer a useful and timely companion to the budget." This direction was reiterated through the Joint Explanatory Statement accompanying the *Energy and Water Development and Related Agencies Appropriations Act, 2022*. Therefore, in accordance with this direction, the Department of Energy's National Nuclear Security Administration submitted the report most recently as a standalone document in July 2023 to provide as timely updates as possible. (See Status of and Plans for Projects and Activities within the Stockpile Responsiveness Program, 2023 Annual Report.)

Appendix E
Industrial Base

E.1 Framework

The nuclear security enterprise industrial base (NIB) is the global industrial capacity and capability that enables research and development, design, production, shipping, sustainment, and modernization of nuclear weapons components, subsystems, and materials to support the U.S. nuclear deterrent. The Department of Energy's National Nuclear Security Administration (DOE/NNSA) monitors the NIB through a framework consisting of four pillars: supply chain, operations and facilities, logistics and transportation, and workforce. DOE/NNSA uses these pillars to identify the full scope of industrial base challenges to maintaining the nuclear stockpile, including those that are internal to the nuclear security enterprise, such as material production and workforce management, and external, such as vendor resiliency. DOE/NNSA stands apart from many other U.S. Departments and Agencies in that through its laboratories, plants, and sites, it is a producer and consumer of manufactured goods. The activities listed under the pillars in **Figure E–1** indicate the types of activities that are considered when examining the NIB.



- **Supply Chain** includes the procurement of raw materials, special design and commercial off-the-shelf components, and specialized equipment; includes the acquisition process
- **Operations** includes the infrastructure required to process materials, manufacture and test sub-components and components then assemble those components into a final weapon, and the ability to disassemble and reuse weapon components upon retirement
- **Logistics** includes the ability to handle and transport a range of materials, the delivery of warheads to/from customers and the storage of strategic materials
- **Workforce** includes the specialized education, skills, training and experience required within the nuclear security enterprise; recruitment and retention of cleared personnel; and processes to ensure critical knowledge is maintained and transferred across the enterprise

Figure E–1. The nuclear security enterprise industrial base framework

E.2 Risk Management

Risk management is an area of increased attention across the nuclear security enterprise. Programs and sites within the enterprise employ varying risk management methods to identify, characterize, monitor, and manage risks, including tracking and monitoring global events to identify emerging risks to the enterprise. These efforts include program-specific risk matrices, supply chain-focused risk matrices (which track risks from raw material procurements through product acceptance), and implementation of supplier transparency software for a more proactive approach to supply chain risk management. There are also significant efforts underway to standardize the methods used for risk management, such as the Supply Chain Risk Management Team, which is working to standardize the methods used to identify, monitor, and respond to supply chain risks across the nuclear security enterprise. The Supply Chain Risk Management Team supports larger DOE/NNSA initiatives that address all the pillars of the NIB to create an overarching process to make risk management practices more rigorous. There are many risk factors that can affect the DOE/NNSA's ability to provide continued viability of the nuclear weapons stockpile. Consequently, these factors are not unique to the nuclear security enterprise, as they affect all industry sectors (i.e., government and commercial). Examples of these are listed in **Table E–1**.

Table E–1. The nuclear security industrial base risk factors

Human Capital Gaps	Industry is unable to hire or retain U.S. workers with the necessary skill sets
Sole Source Vendors	Only one supplier is qualified to provide the required capability and/ or product
Constrained Market	Capacity is unavailable in required quantities or time due to competing market demands
Product Security	Lack of cyber and physical protection results in eroding integrity and confidence
Sunset Technologies	Product or material obsolescence resulting from decline in relevant suppliers
Foreign Dependency	Domestic industry does not produce the product, or does not produce in sufficient quantities
Eroding Infrastructure	Loss of specialized capital equipment needed to integrate, manufacture, or maintain capability
Regulatory Changes	Labor, environmental, transportation, etc., laws outpace industry's ability to develop alternative processes
Inflation	Changes to the global market causing uncertainty in suppliers pricing models thereby increase costs in material, labor, and freight over a short period of time
Global Events	Both manmade and natural events such as the war in Ukraine and the COVID-19 pandemic that negatively impact the supplies of critical goods and services

COVID-19 = Coronavirus Disease 2019

E.2.1 Monitoring

The NIB is complex and multi-faceted. Many diverse groups within the enterprise monitor and act on industrial base issues that are specific to their own programs or activities, which does not always allow for a broad view of the industrial base. Therefore, DOE/NNSA leverages its Integrated Planning Group to increase data sharing across various program offices, and monitors more than 80 active working groups both internal and external to the nuclear security enterprise to improve coordination and collaboration. In addition, information sharing occurs across the enterprise with specific emphasis in areas such as risk management and issues related to supply chain assurance.

E.2.2 Mitigation

Within the Stockpile Stewardship and Management Plan, each of the four NIB pillars are addressed in additional detail in their relevant sections along with actual or potential challenges (risks) and mitigation strategies. While not a complete index of references, some examples are:

- Supply Chain challenges are discussed throughout but primarily in Chapter 3, "Production Modernization." Specific examples of supply chain challenges discussed include managing glovebox fabrication and deliveries, developing sufficient capacity for energetic materials, maintaining a reliable tritium supply chain, and supply chain disruptions affecting a range of microelectronic materials.
- Operations and Facilities challenges are discussed primarily in Chapter 3, "Production Modernization"; Chapter 4, "Stockpile Research, Technology, and Engineering"; and Chapter 6, "Infrastructure and Operations." Specific examples of operations and facilities challenges include issues stemming from outdated and aging infrastructure, the need to invest in both modern infrastructure and emerging technology, and lack of capacity to meet emerging mission requirements.
- Logistics and Transportation challenges are primarily discussed in Chapter 2, "Stockpile Management," Chapter 5, "Security," and Appendix B, Section B.7, "Transportation and Security." Specific examples of logistics and transportation challenges include sustaining the Safeguards Transporter fleet, manufacturability, and sourcing limitations of future secure transportation programs. These could increase cost and scheduling risks.
- Workforce challenges are primarily discussed in Chapter 7, "Workforce." Specific examples of challenges to the workforce include DOE/NNSA'S need to hire, train, qualify, and retain additional pit production personnel to meet growing requirements, as well as commercial competition and increased turnover among key talent in mission critical areas.

E.3 Interagency Coordination

DOE/NNSA participates in numerous Interagency forums to include the Joint Industrial Base Working Group, which acts as the advisory committee to the Department of Defense (DoD)-led Industrial Base Council. The Council functions as the principal advisory forum on prioritized industrial base matters for DoD to ensure industrial base readiness and resiliency. DOE/NNSA provides a representative to the Joint Industrial Base Working Group and participates in multiple cross-cutting sector working groups related to nuclear weapons.

DOE is a statutory member of the Committee on Foreign Investment in the United States (CFIUS), an interagency committee that reviews certain transactions involving foreign investment in the United States to determine the effect of such transactions on the national security of the United States. For each transaction subject to CFIUS jurisdiction, the Department of Treasury, as CFIUS Chair, assigns a lead agency to review the transaction; DOE is a lead on approximately 25 percent of transaction reviews annually, mostly in the energy sector, but with numerous cases impacting the nuclear weapons complex. In 2022, the NNSA CFIUS team analyzed 71 foreign acquisitions of U.S. companies with potential ties to the NIB or tangentially relevant industries. Of these cases, the NNSA CFIUS team identified and mitigated six major foreign acquisitions that threatened the safety and security of the NIB supply chains and operations.

Appendix F
Workforce and Site-Specific Information

As detailed in Chapter 1, the Department of Energy's National Nuclear Security Administration (DOE/NNSA) has eight nuclear security enterprise sites, spread across the Nation, that possess the expert workforce and advanced capabilities to maintain the Nation's nuclear deterrent. These eight sites include three national security laboratories (Lawrence Livermore National Laboratory [LLNL], Los Alamos National Laboratory [LANL], and Sandia National Laboratories [SNL]), four nuclear weapons production facilities (Kansas City National Security Complex [KCNSC], Pantex Plant [Pantex], Savannah River Site [SRS], and Y-12 National Security Complex [Y-12]), and the Nevada National Security Site (NNSS), as shown in **Figure F–1**. Specific information is included in this appendix to elaborate on each site's mission, weapon activities capabilities, the fiscal year (FY) 2024 budget request, recent accomplishments, and workforce data. This information is also included for the DOE/NNSA Federal workforce.

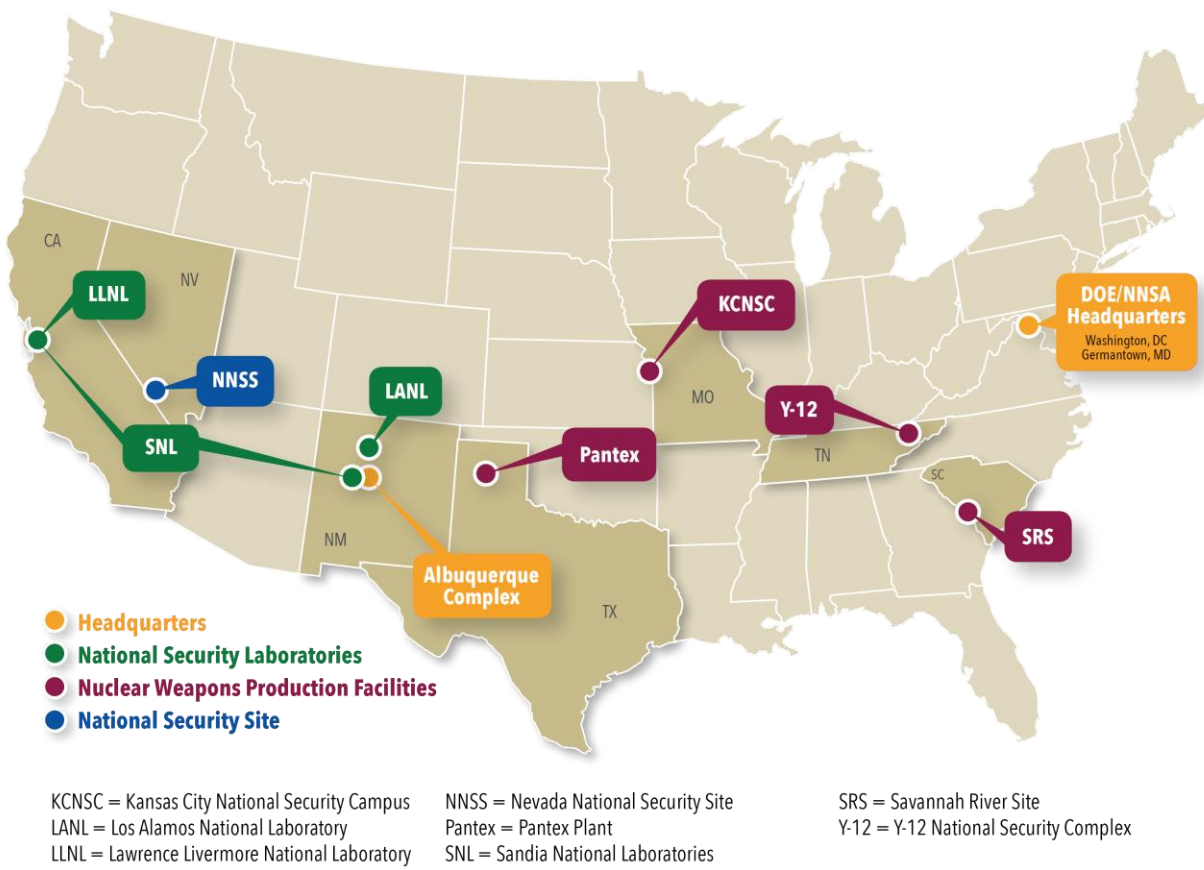


Figure F–1. The DOE/NNSA nuclear security enterprise

Critical Importance of Investing in Advanced Capabilities, Infrastructure, and the Workforce

Planning and investing in advanced capabilities, infrastructure, and most importantly the workforce are at the heart of achieving U.S. nuclear security objectives. These aspects are also interrelated.

- DOE/NNSA provides decision-makers with capabilities that are modern, robust, flexible, resilient, ready, and appropriately tailored to deter 21st century threats, and it continues to modernize and improve the capabilities it offers. Advanced capabilities help meet evolving deterrence needs.
- Modern stockpile stewardship requires specialized technologies and processes, as demonstrated by the capabilities that DOE/NNSA requires for mission success (see Appendix B, "Weapons Activities Capabilities"). These technologies and processes include, but are not limited to, areas such as advanced manufacturing, producing and handling hazardous materials, materials science, and computer science.
- These capabilities, technologies, and processes require purpose-built facilities that can successfully contain the necessary work, such as processing lithium compounds or conducting experiments on plutonium. These facilities must ensure that the work can be done safely and on schedule.
- To successfully accomplish the mission, DOE/NNSA and its laboratories, plants, and sites must attract, train, and retain a skilled and experienced workforce. The workforce provides the knowledge, skills, and abilities to successfully continue Science-Based Stockpile Stewardship and to deliver modernized or new nuclear weapons to the Department of Defense (DoD). In pursuit of these missions, the workforce across the enterprise must operate state-of the-art supercomputers, design and manufacture components, understand how materials will interact, and safely operate with hazardous or explosive materials, among many other areas of knowledge and skills.

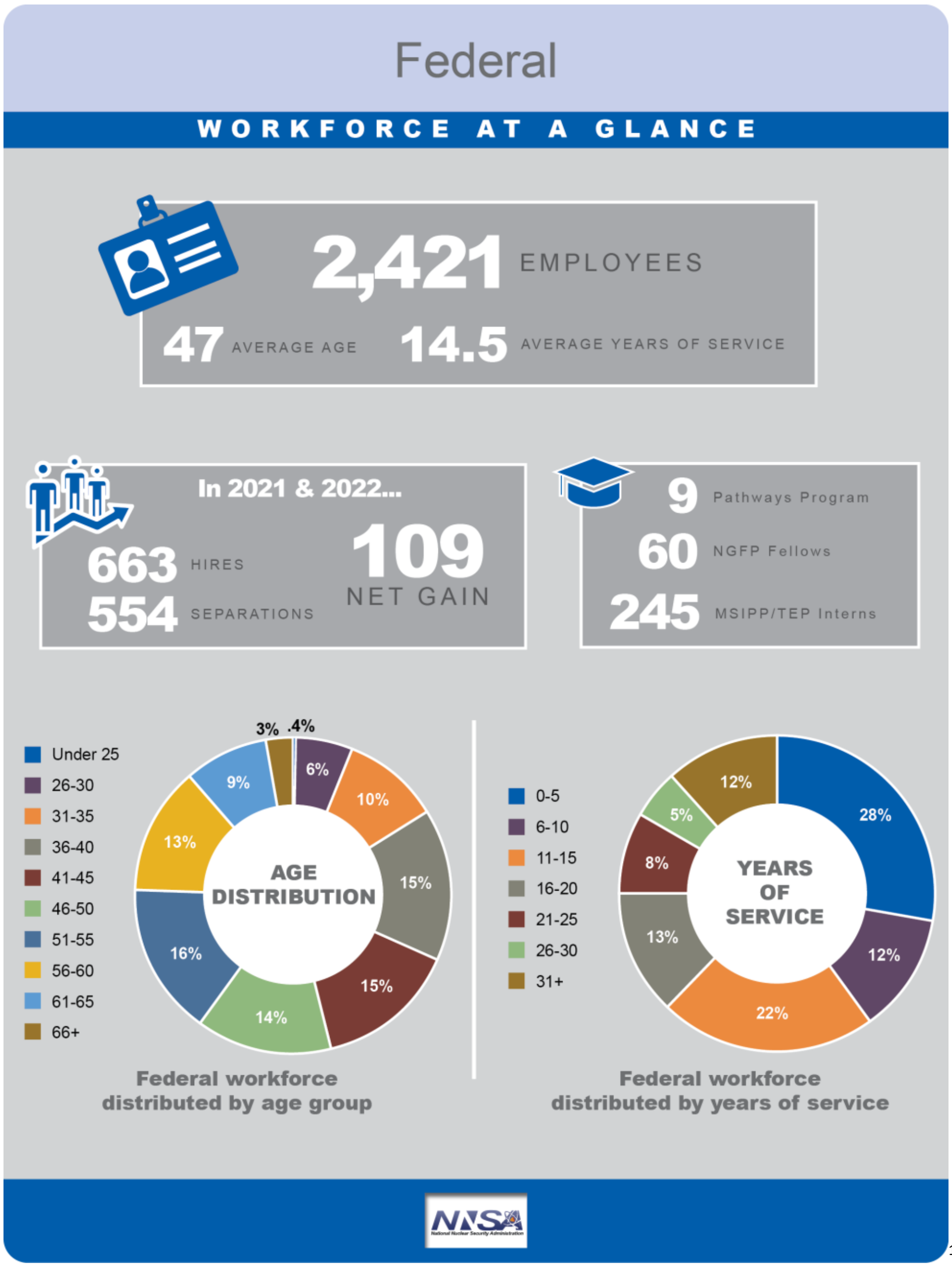
All data shown in this appendix is for FY 2022, unless otherwise noted, using data that was current as of September 30, 2022. Employees are counted by headcount.

F.1 National Nuclear Security Administration

F.1.1 Federal Workforce

The Federal workforce plans, manages, and oversees the nuclear security enterprise and is accountable to the President, Congress, and the public. NNSA's Federal workforce handles program and project management for DOE/NNSA's major missions of maintaining the nuclear weapons stockpile, naval nuclear propulsion, and nuclear threat reduction through global material security and nonproliferation. In addition to these functions, Federal employees also perform important missions in areas such as physical security, cyber security, management and human resources, procurement, infrastructure planning and budgeting, strategic communications, and public affairs. The Federal workforce operates out of Headquarters facilities in Washington, DC; Germantown, Maryland; and Albuquerque, New Mexico. Federal staff are also dispersed throughout field offices located at each of the sites; these field offices employ subject matter experts in a wide variety of disciplines to provide oversight for each site's diverse national security missions. NNSA's Federal workforce, like its contracted management and operating (M&O) partners and other non-M&O contractors, is composed of dedicated professionals working to promote the nuclear security mission.

NNSA's Federal workforce has a fairly even age distribution, with the smallest populations being those who recently completed college or graduate school and those who are retirement-eligible, shown below. Despite this relatively flat age distribution, the workforce is skewed to fewer years of service, with the majority having 0–15 years of service at NNSA. These data reflect aggressive hiring efforts in recent years to meet NNSA's growing mission.



[1]

[1] The number of Federal employees does not include DOE-funded Federal personnel within the Office of Naval Reactors, but does contain Federal staff within the Office of Secure Transportation.

NNSA's recruitment and outreach strategies include a variety of approaches. NNSA continues to expand its relationships with colleges and universities, professional organizations, vocational rehabilitation programs, and with organizations representing women, veterans, people with disabilities, and other groups. NNSA participates in career fairs sponsored by colleges and universities, professional organizations, and other organizations. NNSA also hosts career fairs in which hiring managers interact with candidates, conduct job interviews, and make selections. Additionally, NNSA and its M&O partners continue to conduct "Nuclear Security Enterprise Days" at colleges and universities, giving students an information session followed by the opportunity to directly speak with managers and human resources personnel across the enterprise regarding career opportunities. NNSA continues to leverage the National Graduate Fellowship Program and Presidential Management Fellows Program to train and develop for careers within the nuclear security enterprise. During these programs, Fellows receive training and gain hands-on experience, and NNSA extends offers to a majority of the Fellows upon completion of their programs. In addition to these fellowship programs, NNSA exposes college students to its unique mission through intern programs such as the University of Maryland Program and the Minority-Serving Institution Partnership Program. NNSA continues to use professional job boards as well as social media to highlight career opportunities and hire top talent.

NNSA has experienced a slight increase in separations over the last few years, as shown by **Figure F–2**, which are evenly split between voluntary separations and retirements. As shown in **Figure F–3**, most voluntary separations occur between 0–5 years of service, while most retirements occur after 26 years of service. To retain the top talent it has recruited and hired, NNSA continues to offer a variety of developmental programs for employees to include coaching, mentoring, rotations, and the academic degree program, as well as sponsoring numerous leadership development programs. To the most feasible extent possible, NNSA continues to leverage workforce flexibilities—to include telework, remote work, and flexible work schedules—to retain employees. Additionally, NNSA continues to recognize its workforce through its pay for performance system and employee recognition programs. NNSA also leverages the student loan repayment program to help with retention of its employees.

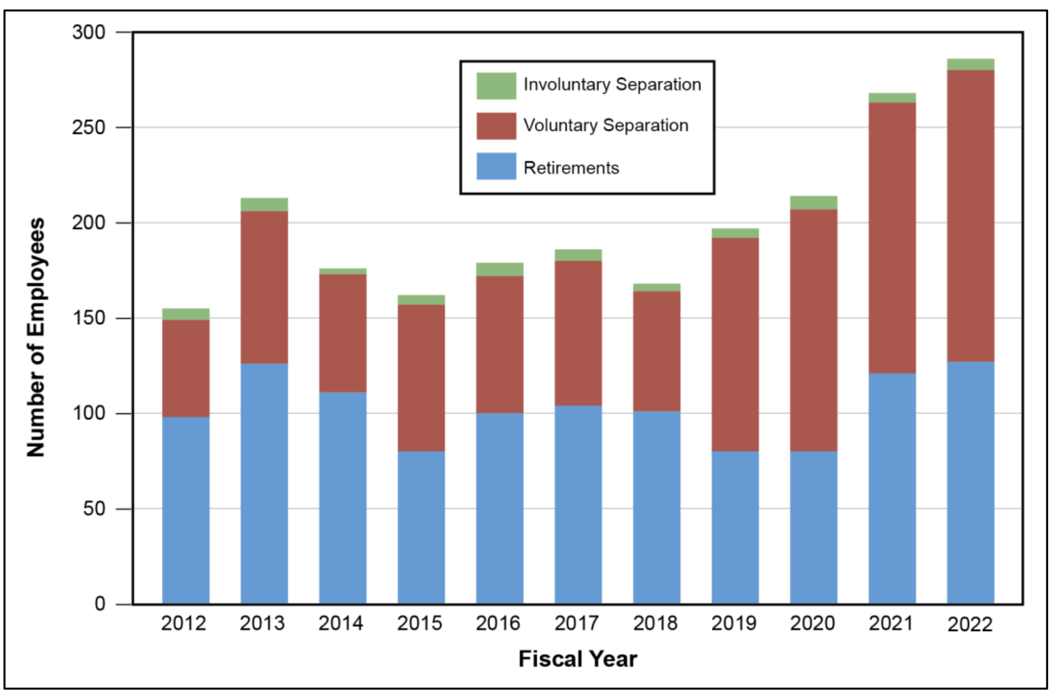


Figure F–2. Federal workforce employee separation trends

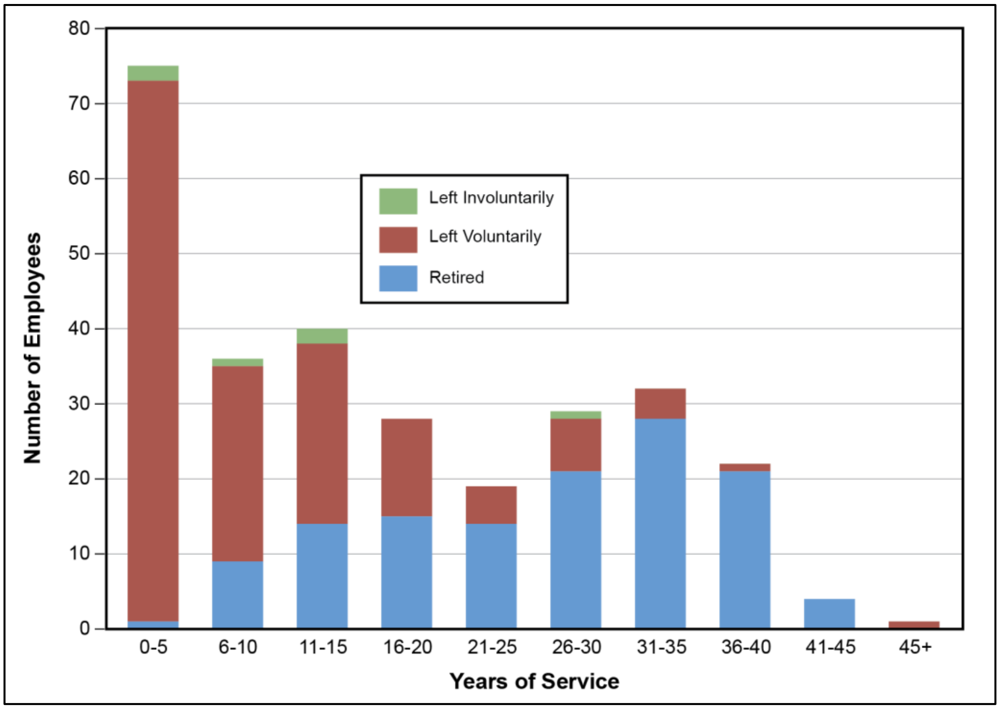


Figure F–3. Federal workforce separations by years of service

Figure F–4 demonstrates that the Federal workforce is successfully retaining mid- and advanced-career employees, though the percentage of advanced career employees has decreased over the last 4 years, primarily due to workforce growth. Despite this growth, the number of early career personnel is staying relatively constant at about 15 percent. The percent of the workforce eligible for retirement is similarly 15 percent. NNSA recognizes the opportunity for knowledge preservation and transfer from advanced career employees to early and mid-career employees, and has been leveraging those programs.

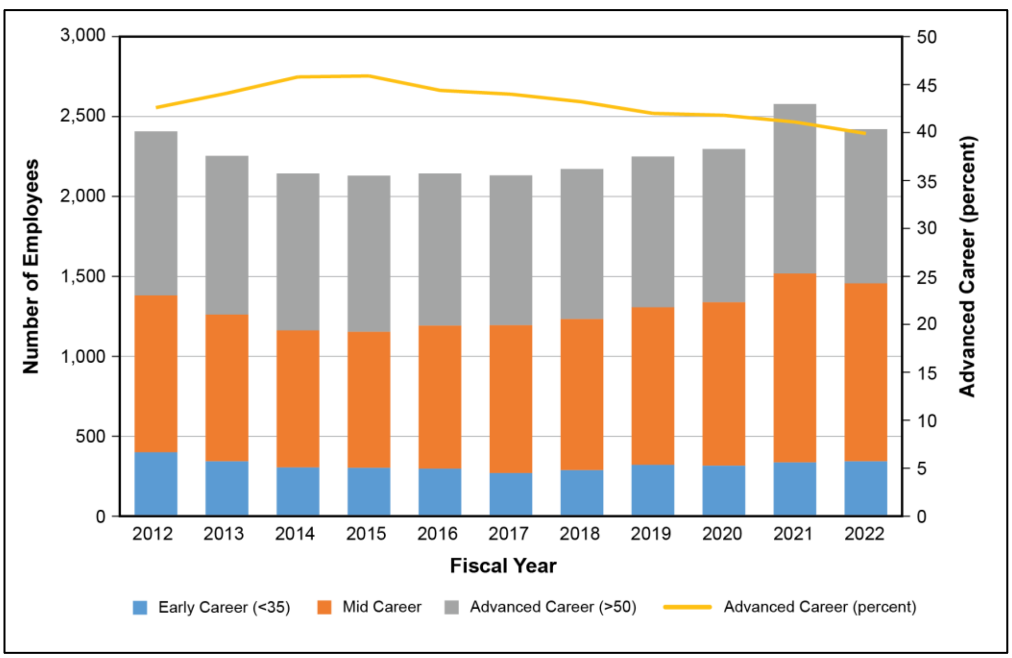


Figure F–4. Federal workforce trend over time by stage of career

F.2 National Security Laboratories

F.2.1 Lawrence Livermore National Laboratory

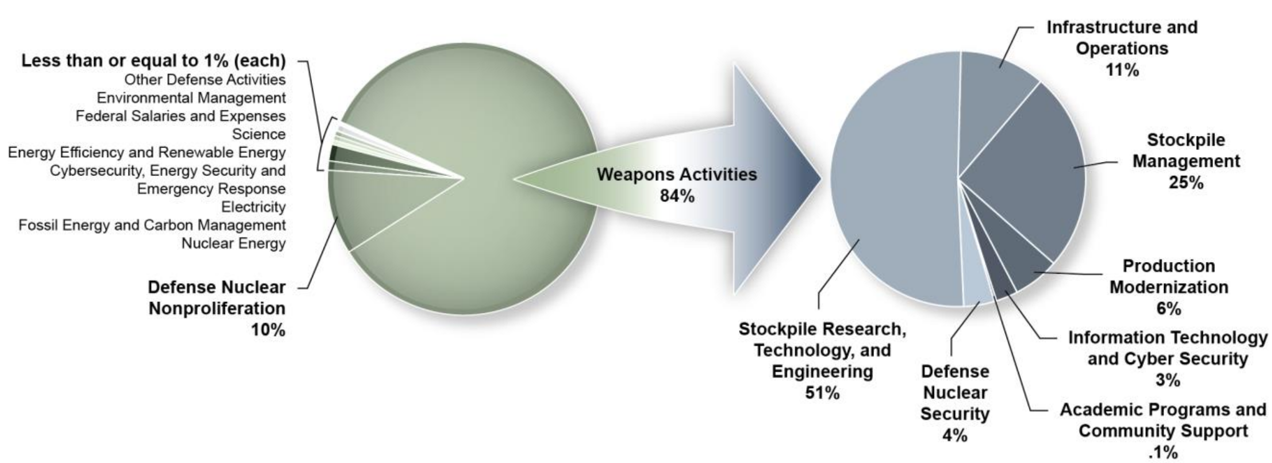
F.2.1.1 Mission Overview

DOE/NNSA sponsors the Lawrence Livermore National Laboratory (LLNL) Federally Funded Research and Development Center. LLNL is uniquely positioned to guide challenging research and development (R&D) and deliver results to support DOE/NNSA mission needs. LLNL provides research, development, test, and evaluation (RDT&E) capabilities for the stockpile, as well as a broad range of national security needs integral to the mission and operation of DOE and other Federal agencies. LLNL is managed by Lawrence Livermore National Security, LLC.

F.2.1.2 Funding

FY 2024 DOE request – site funding by source *(total LLNL FY 2024 request = $2,359 million)*

LLNL split for the FY 2024 Weapons Activities President's Budget Request *($1,988 million)*



F.2.1.3 Site Capabilities

LLNL is a DOE/NNSA Center of Excellence for Nuclear Design and Engineering, with core competencies in high explosives (HE), high energy density (HED) physics, high-performance computing (HPC), nuclear physics, materials science and engineering, and additive manufacturing. LLNL is the lead design agency for the W80-4 (the Air Force's cruise missile warhead) life extension program (LEP) and the W87-1 Modification (Mod) Program. LLNL has primary assessment responsibility for the W80-1, W87-0, B83, and W84, as well as review responsibility for other systems.

LLNL operates DOE/NNSA flagship stockpile stewardship facilities including the National Ignition Facility (NIF), Livermore High Performance Computing Center, Sierra, and the new exascale class El Capitan (both of which are advanced technology computing systems), High Explosives Applications Facility, Contained Firing Facility/Flash X-Ray, National Atmospheric Release Advisory Center, Nuclear Forensics Center, Center for Accelerator Mass Spectrometry, materials engineering at Applied Materials and Engineering Campus, HE testing and development at S300 Energetic Materials Development Enclave Campus, advanced manufacturing in the Livermore Valley Open Campus, and Plutonium Superblock. LLNL also sustains and advances the physical infrastructure and capabilities supporting R&D, science, and technology missions in weapons engineering, design, performance physics, advanced materials, HPC, and HED physics.

LLNL capabilities related to design, development, and sustainment of stockpile systems with their associated challenges and strategies are described in **Table F–1**.

Table F–1. Lawrence Livermore National Laboratory capabilities

<table>
<tr><th colspan="3">Weapons Physics Design and Analysis</th></tr>
<tr><td colspan="3">LLNL scientists, engineers, and technical staff design, assess, and certify the performance of the nuclear explosive package without the need for nuclear testing. This effort is accomplished through implementing advanced computational and experimental capabilities that integrate the best available tools and knowledge. LLNL characterizes primary and secondary performance, safety, HE, and material properties and develops advanced diagnostics and sensors; laser, pulsed power, and accelerator technologies; and hydrodynamic and subcritical experimental platforms.</td></tr>
<tr><th>Challenges</th><th colspan="2">Strategies</th></tr>
<tr><td rowspan="2">Improvements in key capabilities are required for active and future modernization programs, including support for increased demand and operational tempo at experimental facilities; adequately trained workforce with consistent knowledge transfer across teams; and development of advanced diagnostic capabilities, such as dynamic radiography, in support of nuclear explosive package performance certification.</td><th>Current Strategy Being Implemented</th><th>Future Strategies Needed</th></tr>
<tr><td>DOE/NNSA is investing in infrastructure support and recapitalization to modernize Site 300 capabilities, including the Flash X-Ray and Contained Firing Facility, and in plutonium infrastructure and advanced diagnostics development to support weapons certification.

Production enclave investment ensures RDT&E for new materials that support the stockpile.</td><td>Expand material and component test and fabrication capabilities to support weapons design and certification.

Continue infrastructure investments to improve efficiency of facility use.

Partner with other DOE sites to expand access and increase flexibility for focused-science experiments addressing stockpile interests.</td></tr>
<tr><th colspan="3">Weapons Engineering Design, Analysis, and Integration</th></tr>
<tr><td colspan="3">LLNL is responsible for weaponizing the physics package to ensure effectiveness across the weapon stockpile-to-target sequence and safety throughout its complete lifecycle. Engineering design and analysis are core elements of the certification and production of weapon modernization programs. Weapons engineering is also critical for the sustainment of fielded weapons, including integration with DOE/NNSA, DoD, and production sites; support for surveillance evaluations and ongoing production; targeted laboratory experiments; and annual assessments of weapon safety and effectiveness. The same weapons engineering expertise is used to support design and production of high-fidelity test assemblies used for hydrodynamic and subcritical experiments, as well as other high-precision assemblies used to support weapon physics analyses.</td></tr>
</table>

Challenges	Strategies	
	Current Strategy Being Implemented	**Future Strategies Needed**
LLNL will require continuous modernization of warhead test and evaluation capabilities and investment in upgrading and replacing aging facilities, as well as training a new generation of staff.	DOE/NNSA is making multi-year, sustainment investments in weapons engineering capabilities, including fabrication and inspection, nondestructive evaluation, environmental testing, plutonium science, and radioactive material processing.	Continue multi-year investments, including major upgrades to the environmental testing complex.
High Explosives Science and Engineering		
LLNL's HE RDT&E capabilities support stockpile stewardship, nuclear nonproliferation, and nuclear counterterrorism efforts via a multidisciplinary approach to synthesis, formulation, characterization, processing, and testing of energetic materials, components, and warhead subassemblies. LLNL characterizes HE performance and safety at device and laboratory scales. Modernization activities support LEP and warhead assessments in facilities and equipment for HE large charge pressing, plot-scale synthesis, and formulation systems. LLNL has demonstrated the first-known capability to additively manufacture three-dimensional HE structures and has demonstrated their ability to detonate. LLNL holds three Records of Invention in HE additive manufacturing technology.		
Challenges	***Strategies***	
	Current Strategy Being Implemented	**Future Strategies Needed**
LLNL is responsible for qualifying insensitive HE for assigned U.S. stockpile systems. HE processing capabilities require modernization for LLNL to meet programmatic demands for additional prototyping of warhead HE systems and support RDT&E capacities and throughputs. Infrastructure supporting HE pressing and machining capabilities needs continued condition assessment and recapitalization.	DOE/NNSA is investing in the High Explosives Applications Facility and Site 300 infrastructure through a 5-year program that addresses short- and long-term facility recapitalization for mission objectives. LLNL is developing the Energetic Materials Development Enclave Campus, a production enclave that will focus on joint material development and handling with production agencies to deliver increased lot acceptance and improved first principles modeling with the goal of enhancing performance and safety predictions with less experimental verification.	Continue investing in HE RDT&E capabilities and upgrading and revitalizing aging facilities.
High Performance Computing		
LLNL's high performance computing capabilities comprise of a world-class set of computing platforms running highly scalable and advanced modeling and simulation software designed and tuned to give accurate and fast solutions in support of stockpile stewardship and nuclear deterrence. LLNL is fielding El Capitan in FY 2024, the first exascale system in support of national security, marking the culmination of a 15-year effort in DOE and DOE/NNSA to realize exascale computing. This deployment is backed by a nearly decade-long effort to develop and update codes and software for the exascale era and has been performed in collaboration with vendor partners, other DOE/NNSA labs, and the broader community. LLNL HPC expertise includes application development, system software, and a rich supporting software stack of libraries and tools.		
Challenges	***Strategies***	
	Current Strategy Being Implemented	**Future Strategies Needed**
LLNL must anticipate and adapt to the rapid pace of change taking place in the broader computing industry as hardware becomes increasingly specialized, and workloads increasingly move to the cloud. LLNL software applications must continue to support design and certification, while also continuously adapting to new hardware, software, and development practices.	LLNL is building on its exascale strategy to deploy accelerated architectures and develop future-proof applications based on modularity and abstractions that hide hardware complexity from the developer. As Artificial Intelligence and Machine Learning takes root in the computing ecosystem, LLNL is committed to exploring how to apply these techniques in a scientifically rigorous manner to allow even higher productivity, faster turnaround, and deeper insight into our mission-critical applications.	Leverage investments being made by industry in cloud computing to bring better technologies for managing LLNL IT environments. Benefits will include, but are not limited to, higher productivity for developers and users, the ability to more easily burst into public clouds on demand, and increased security in a multi-tenancy environment.

<table>
<tr><th colspan="3">High Energy Density Physics</th></tr>
<tr><td colspan="3">LLNL designs and executes experiments to advance fundamental understanding of HED regimes, the state of matter a weapon is in when the majority of yield is produced. These experiments provide data that improves our fundamental understanding of how to advance and validate computational tools that underwrite the design and certification of the stockpile. HED experiments at the NIF produce data on high-Z material properties, burn physics, radiation transport, radiation hydrodynamics, and a variety of other topics.</td></tr>
<tr><th rowspan="2">Challenges</th><th colspan="2">Strategies</th></tr>
<tr><th>Current Strategy Being Implemented</th><th>Future Strategies Needed</th></tr>
<tr><td>Experimental infrastructure is aging and is subject to increased usage and increased operational tempo. Although the United States has pioneered HED physics, nations around the world are advancing their own experimental capabilities that may soon be competitive with the previously unique capabilities of the United States.</td><td>LLNL has developed a long-term investment plan to sustain and improve infrastructure while supporting more than 400 shots per year at the NIF. Infrastructure recapitalization and modernization are essential to realizing this plan.</td><td>Develop an enduring infrastructure capability base in target fabrication and be prepared to manage increased facility usage.</td></tr>
<tr><th colspan="3">Additive Manufacturing</th></tr>
<tr><td colspan="3">To develop and mature responsive and resilient material and manufacturing options for system components, LLNL is driving advancements in manufacturing and component design optimization to rapidly create and qualify novel materials, structures, and advanced manufacturing methods through fundamental understanding of the underlying science and engineering, leading to improvement of these processes as well as invention and development of new processes. Additionally, providing rapid turnaround manufacturing capability for fast iteration with LLNL engineering and physics designers is critical to component development for emerging needs. These efforts extend, build on, and integrate foundational capabilities at LLNL for validated predictive simulations, tailored materials synthesis, characterization and testing, design optimization, precision engineering and metrology, machine learning and data science, and additive manufacturing. Success also requires integrating with performance testing capabilities – including exascale computing, hydrodynamic and explosive testing, high energy density testing platforms, and environmental testing facilities.</td></tr>
<tr><th rowspan="2">Challenges</th><th colspan="2">Strategies</th></tr>
<tr><th>Current Strategy Being Implemented</th><th>Future Strategies Needed</th></tr>
<tr><td>LLNL manufacturing facilities and infrastructure are dispersed and aging. Maturation of additive and advanced manufacturing technologies requires collaboration between the design, engineering, materials, and manufacturing communities.

Success also requires effective integration of capabilities in feedstocks, design, characterization and testing, environmental and dynamic materials testing, precision engineering and metrology, machine learning and data science, and predictive simulations and performance modeling.</td><td>Exploit industry/academic/laboratory collaborations at the Advanced Manufacturing Laboratory. Engage and partner with NNSA production agencies to accelerate mutual understanding of needs, tech transfer, and adoption through the manufacturing enclave model/concept.

Execute existing infrastructure investment plans, including exploiting capabilities in the Applied Materials Engineering facilities and the Polymer production enclave; completing renovations to the LLNL Manufacturing complex, Non-Destructive Evaluation facilities, and Mechanics of Materials facilities; completing the new Non-Destructive Evaluation and manufacturing high bay facilities; and supporting completion and use of HE and energetic materials capabilities housed in the Energetic Materials Development Enclave.</td><td>Realize infrastructure investments to build on existing capabilities, including facilities that integrate new feedstocks and manufacturing processes with automated processes, in-situ characterization, and advanced data analytics approaches. Planned infrastructure includes the Stockpile Materials Development facilities and Product Realization Infrastructure for Stockpile Modernization facility.

Deepen the collaborative innovation approaches demonstrated in the Polymer Enclave by successfully launching additional collaborative collaboration Enclaves as they are identified and prioritized.</td></tr>
</table>

HE = high explosives
HED = high energy density
HPC = high performance computing
IT = information technology
LEP = life extension program
NIF = National Ignition Facility
RDT&E = research, development, test, and evaluation

F.2.1.4 Accomplishments

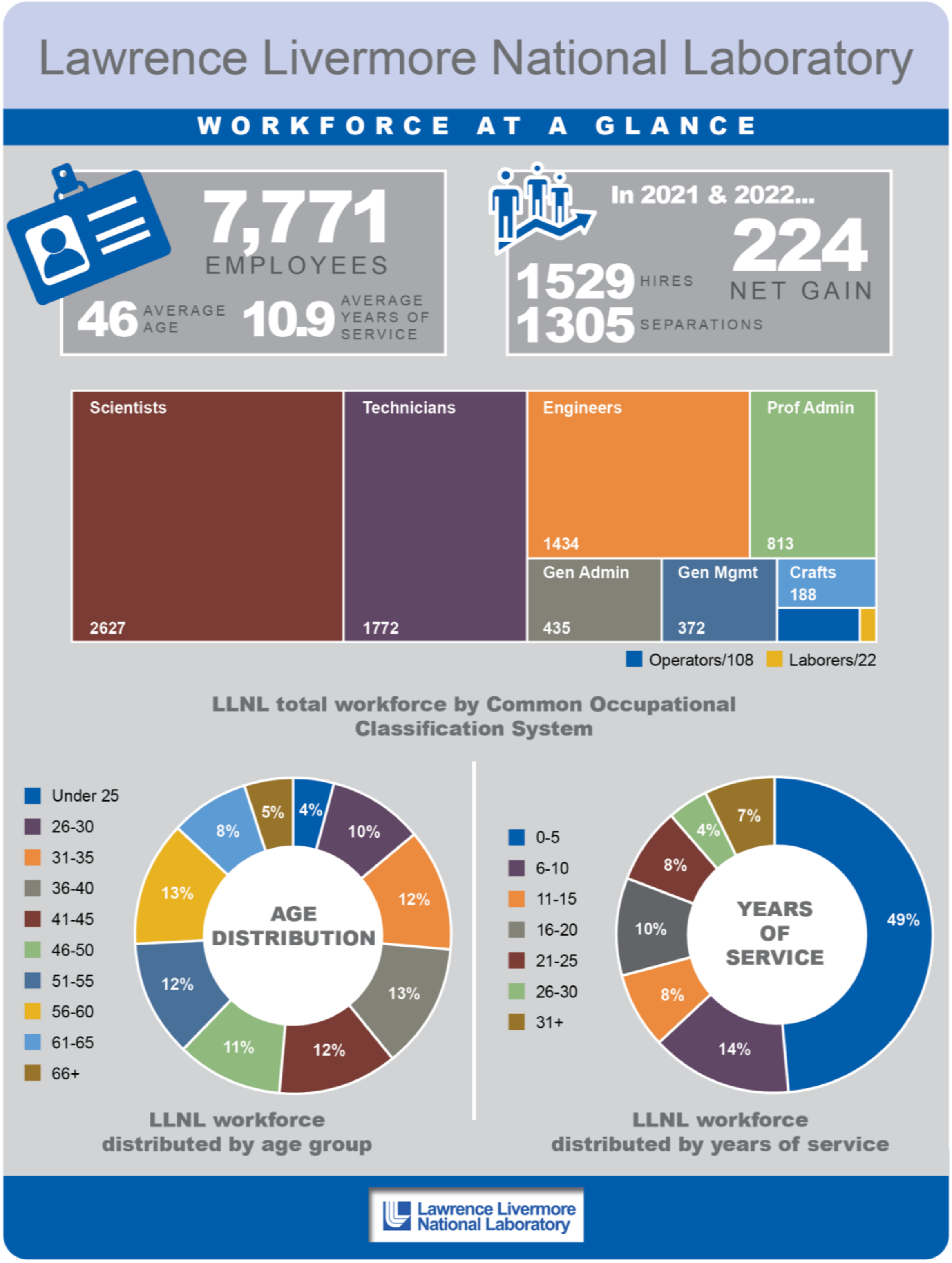
- On December 5, 2022, an experiment at the NIF achieved fusion ignition and energy gain. In the historic experiment, 2.05 megajoules (MJ) of laser energy produced 3.15 MJ of fusion energy.
- LLNL completed all deliverables for Cycle 27 of the Annual Assessment Review, including extensive peer review, as part of the Independent Nuclear Weapon Assessment Process. The Laboratory also met the requirements for sustaining the W80, B83, W84, and W87 systems.
- The W80-4 LEP is preparing to move into Phase 6.4. Programmatic activities in FY 2022 included execution of baseline design reviews, completion of multiple high-fidelity engineering tests, activities to improve producibility, and support of Air Force flight tests.
- In October 2021, the W87-1 Mod Program moved into Phase 6.2A; the Weapon Design and Cost Report was completed, preparing for entry into Phase 6.3; and activities focused on maturing weapon design options and modern manufacturing methods.
- The $100 million Exascale Computing Facility Modernization project was completed on schedule and under budget, preparing LLNL for delivery of NNSA's first exascale supercomputer, El Capitan, in 2023.
- An LLNL research team developed a prototype chemistry-on-a-chip platform for field-deployable nuclear forensics after a nuclear incident. The tool requires only a microsample, yielding easy, safe analyses by scientists.
- In work for the DoD's Defense Threat Reduction Agency, LLNL scientists and research partners made headway developing a multi-pathogen vaccine for protection of warfighters.
- LLNL scientists participated in NASA's successful Double Asteroid Redirection Team experiment conducted on September 26, 2022—providing pre- and post-experiment high-performance simulations of the spacecraft's collision with smaller of the two asteroids.
- LLNL scientists are pioneering CogSim—the use of artificial intelligence to expedite scientific discovery by merging simulations and experimental results, including CogSim's award-winning application in support of NIF experiments.

F.2.1.5 Lawrence Livermore National Laboratory Workforce

LLNL continues to comprise of primarily scientists, technicians, and engineers, who represent over 75 percent of the FY 2022 workforce. LLNL new hires have increased representation of the early-career workforce in the laboratory population. LLNL continues to use campus career fairs and strategic evening with industry functions, national and local diversity recruiting, and discipline-specific national and local events, independently and as part of the National Security Enterprise Workforce Recruitment Strategy, to attract candidates. Partnerships with federally serving programs such as Science Undergraduate Laboratory Internships, Minority Serving Institutions, and several military collaborations have increased hiring for military students and vets, resulting in a 51 percent increase in veteran employees since FY 2019. In FY 2022, 49 percent of the LLNL workforce had 0–5 years of service. Additionally, LLNL leverages early enagement with potential employees through its student and internship programs.

Early Engagement in FY 2022

- *Students: 668*
- *Interns: 65*
- *Post-doctorates: 432*


Lawrence Livermore National Laboratory
WORKFORCE AT A GLANCE
7,771 EMPLOYEES
46 AVERAGE AGE
10.9 AVERAGE YEARS OF SERVICE
In 2021 & 2022...
1529 HIRES
1305 SEPARATIONS
224 NET GAIN
Scientists 2627
Technicians 1772
Engineers 1434
Prof Admin 813
Gen Admin 435
Gen Mgmt 372
Crafts 188
Operators/108
Laborers/22
LLNL total workforce by Common Occupational Classification System
Under 25
26-30
31-35
36-40
41-45
46-50
51-55
56-60
61-65
66+
AGE DISTRIBUTION
4%
10%
12%
13%
12%
11%
12%
13%
8%
5%
LLNL workforce distributed by age group
0-5
6-10
11-15
16-20
21-25
26-30
31+
YEARS OF SERVICE
49%
14%
8%
10%
8%
4%
7%
LLNL workforce distributed by years of service
Lawrence Livermore National Laboratory

LLNL is challenged by increasing attrition among employees with 0–5 years of service (**Figure F–5**). Retention programs, such as career development courses, education assistance programs, the Laboratory Directed R&D program, Federal details, and work-life balance programs continue to be used to improve retention.

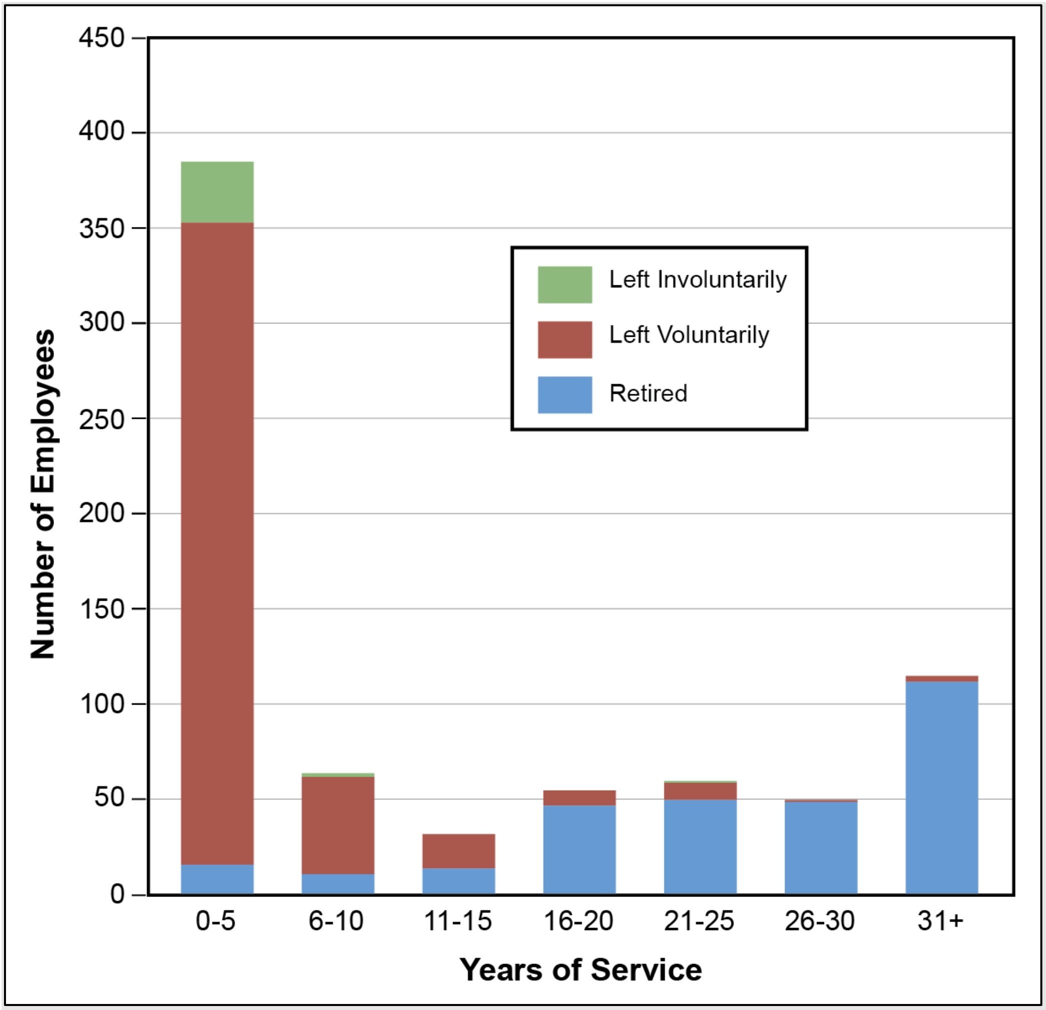


Figure F–5. LLNL separations by years of service

The advanced career population has maintained consistency, with 28 percent of employees being retirement-eligible, while the mid-career population has slightly increased, as **Figure F–6** shows. Recent hiring combined with consistent numbers of retirements have led to increasing proportions of early-career participation (less than 35 years old) and mid-participation (35–40 years old) employees among the laboratory population. Separations continue to be a concern, however, as LLNL experienced its highest attrition year since FY 2013 (**Figure F–7**).

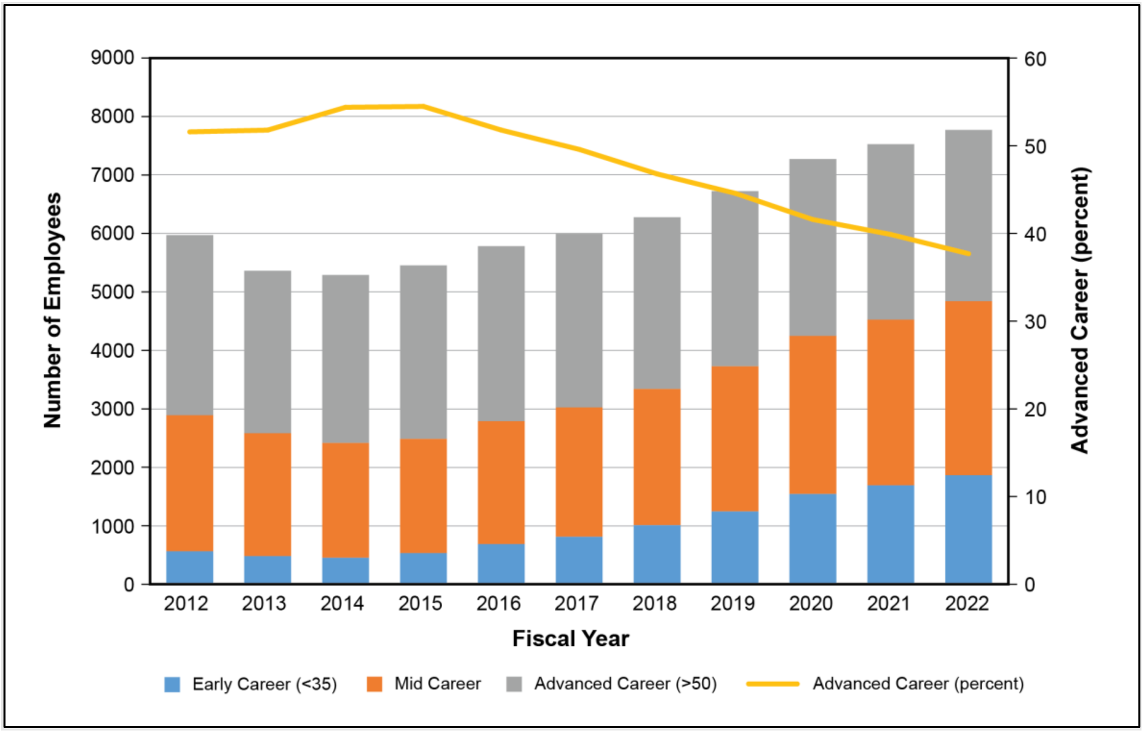


Figure F–6. LLNL workforce participation trends by age category and percent advanced career

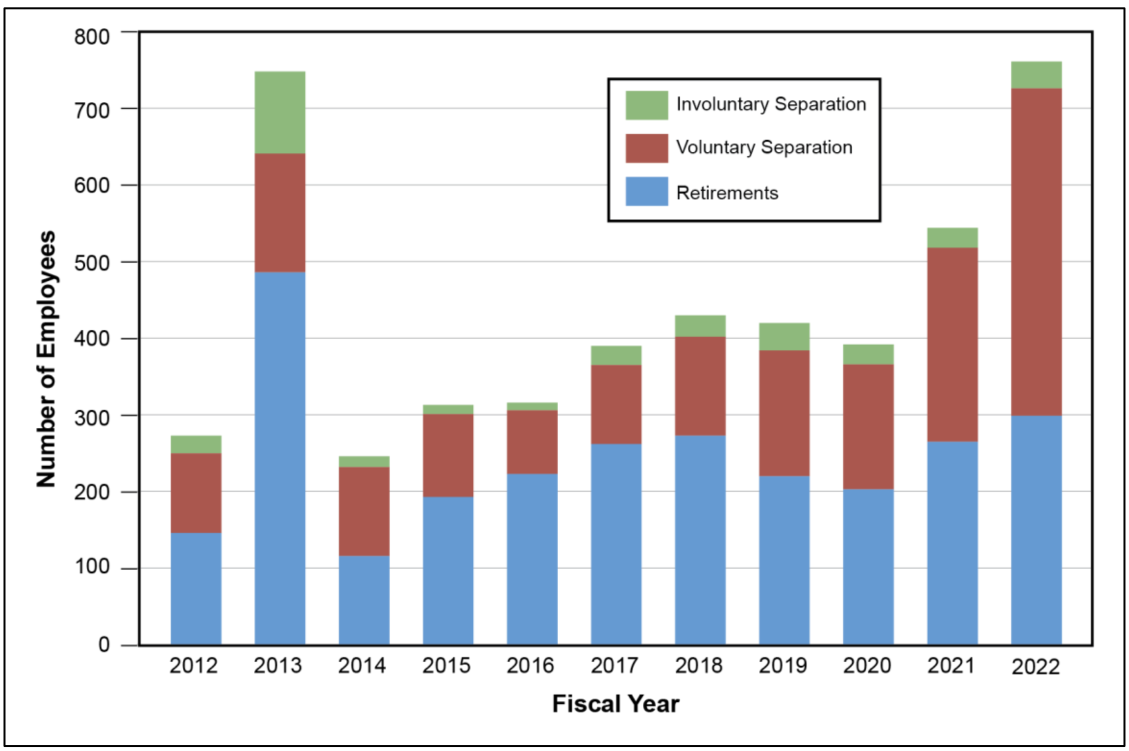


Figure F–7. LLNL employee separation trends[1]

[1] The peak in FY 2013 represents a laboratory budget reduction that resulted in a significant number of early retirements and some layoffs, which are defined as involuntary separations in the chart. Voluntary separations have increased every year since FY 2016, particularly in FY 2022. FY 2022 retention is discussed more broadly in Chapter 7.

LLNL anticipates continued growth over the initial part of the Future Years Nuclear Security Program (FYNSP) period, especially as the work scope increases for W80-4 LEP and W87-1 Mod Program activities (**Figure F–8**).

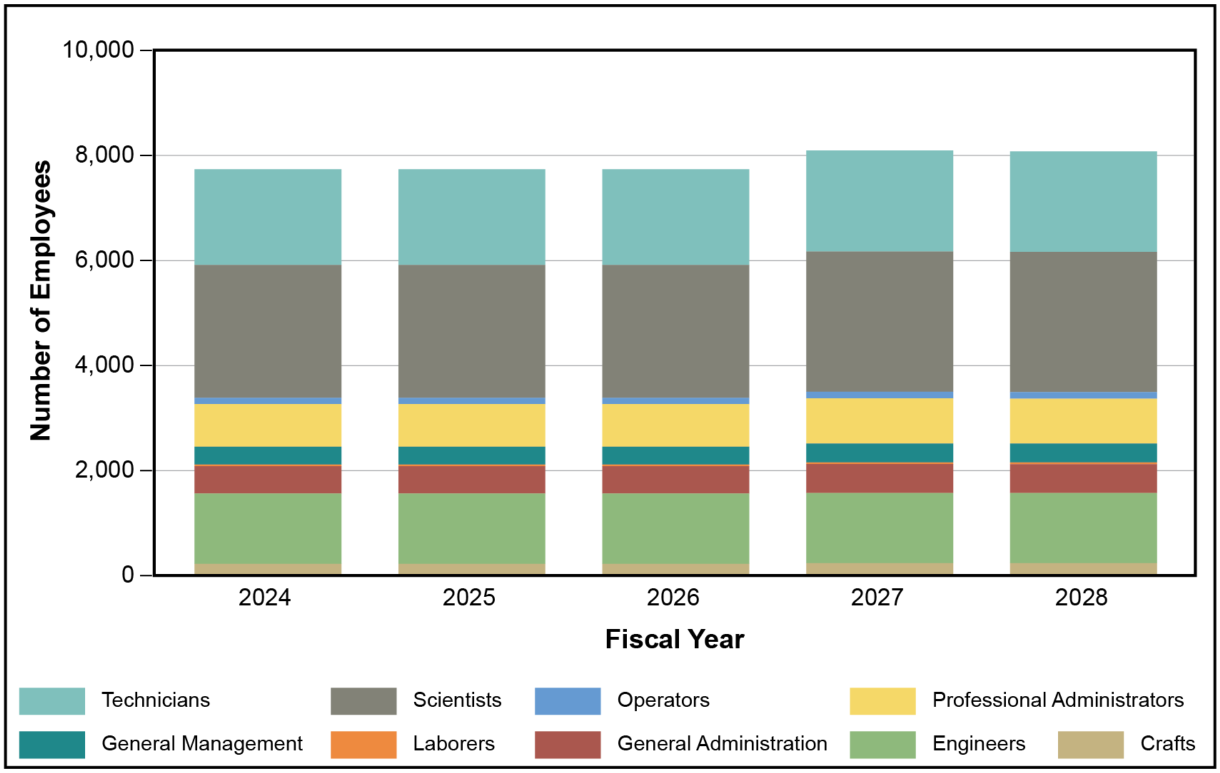


Figure F–8. LLNL workforce projection needs by Common Occupational Classification System

F.2.2 Los Alamos National Laboratory

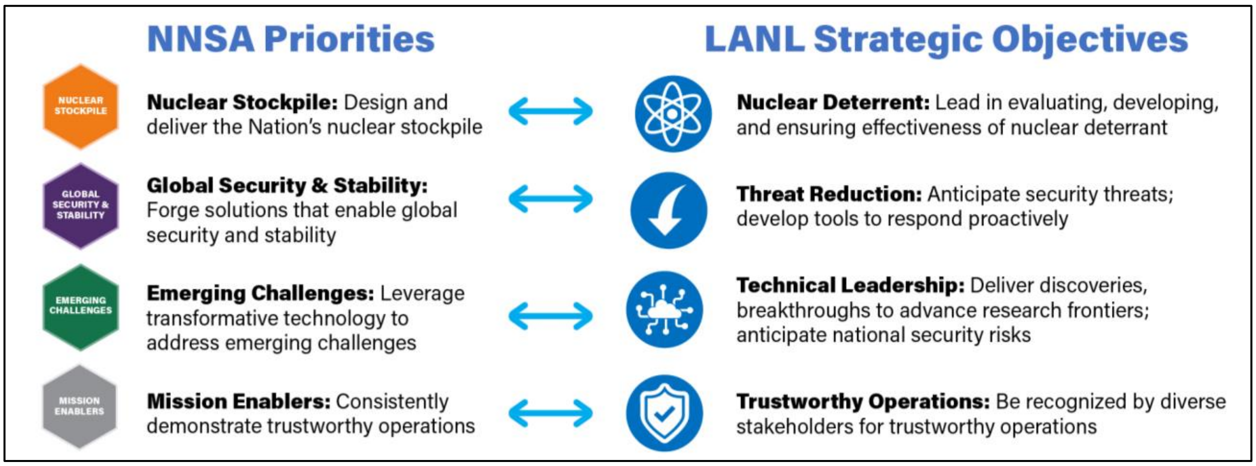
F.2.2.1 Mission Overview

Los Alamos National Laboratory (LANL), initially known as Project Y, was organized in April 1943 during World War II for the design of nuclear weapons as part of the Manhattan Project. After nearly 80 years, LANL continues its service to the Nation through applications of scientific and engineering solutions to solve national and global security challenges. The laboratory relies on its skilled workforce, a complex portfolio of facilities (nuclear, HE, hazardous, multifunctional, and general purpose), specialized equipment, and disciplined business practices to meet its missions and deliver solutions.

LANL's Weapons Activities represent foundational elements of the DOE/NNSA Stockpile Stewardship and Management Plan (SSMP). LANL designed five of the seven types of nuclear warheads in the deployed stockpile and is currently responsible for the continued safety, security, and effectiveness of the B61 gravity bomb, the W76 and W88 submarine-launched intercontinental ballistic missile warheads, and the W78 intercontinental ballistic missile warhead. LANL leads the B61-12 LEP and the W88 Alteration (Alt) 370 Program and is also a production agency with responsibilities including the manufacturing of pits, detonators, detonator cables and radioisotope thermoelectric generators (RTGs). LANL weapons programs provide design expertise, production expertise, and tools including advanced experimental capabilities, modeling and simulation, processing, prototyping, production, surveillance, and testing of weapons materials, and components and warheads assemblies (without nuclear materials).

LANL's national security mission requires a multidisciplinary approach to solve some of the Nation's toughest science and engineering challenges. In addition to direct stockpile stewardship activities, the laboratory addresses overcoming national security and economic challenges, including nuclear nonproliferation and counterterrorism, medicine and health sciences, energy, and advanced computation. LANL is also involved in strategic partnership and collaborations with other agencies. Science, technology, and engineering capabilities consist of a diverse portfolio and execute laboratory missions through six scientific pillars.

LANL's leadership assembles a broad spectrum of operational expertise, resources, and processes to enable the readiness and excellence of the stockpile stewardship and science, technology, and engineering missions. These operational functions address LANL's broad capabilities in integrated planning and execution, safety, security, efficiency, accountability, waste, business practices, workforce management/development, and community relations and service. LANL has defined strategic objectives that align with national policy and DOE/NNSA strategies: (1) Nuclear Deterrent, (2) Threat Reduction, (3) Technical Leadership, and (4) Trustworthy Operations. The major cross-cutting challenge in meeting these objectives and critical outcomes is understanding and improving our operational capacity, including meeting human capital needs with hiring, diversity, knowledge retention, and competitive compensation; revitalizing our infrastructure; and improving disciplined operations. Accomplishments for each pillar are highlighted below.



LANL's Strategic Objectives align with NNSA Mission Priorities

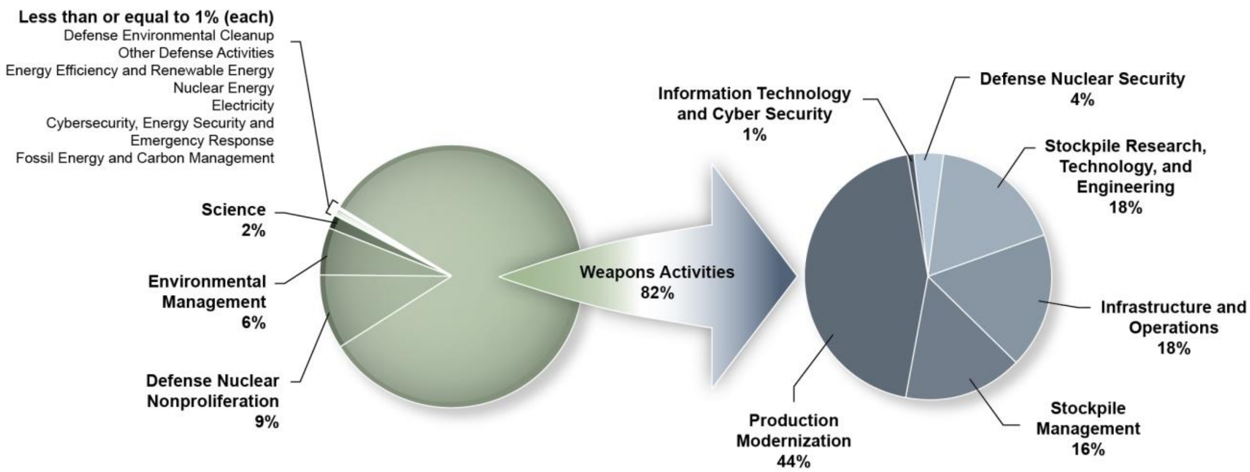
LANL's leadership assembles a broad spectrum of operational expertise, resources, and processes to enable the readiness and excellence of the stockpile stewardship and science, technology, and engineering missions. These operational functions address LANL's broad capabilities in integration planning and execution, safety, security, efficiency, accountability, waste, business practices, workforce management/development, and community relations and service.

LANL operates a complex portfolio of nuclear, HE, and specialized facilities and physical infrastructure. Additional descriptions of laboratory assets and capabilities, and their current state are presented below.

F.2.2.2 Funding

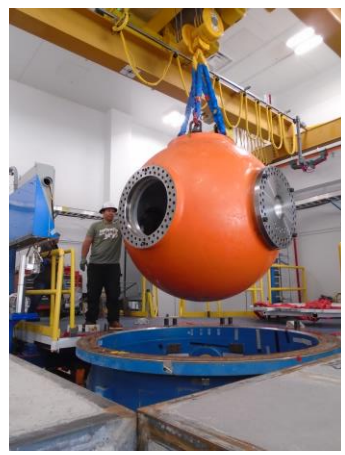
FY 2024 DOE request – site funding by source ***(total LANL FY 2024 request = $4,922 million)***

LANL split for the FY 2024 Weapons Activities President's Budget Request ***($4,053 million)***



F.2.2.3 Site Capabilities

LANL is the lead design agency for the B61, W76, W78, and W88 systems and is also the production agency for pits, detonators, detonator cables, and RTGs. LANL contributes to nuclear design and physics capabilities in the nuclear security enterprise and is the Nation's Plutonium Center of Excellence for Research and Development. Core competencies at LANL include weapons physics design and analysis; weapons engineering and energetics, design, analysis, testing, and integration; stockpile component production and surveillance for pits, detonators, and RTGs; HED physics; materials science and engineering; and HPC.



A hydrodynamic experiment confinement vessel being inserted within the DARHT Weather Enclosure

LANL operates a complex set of nuclear, high explosives, and other specialized scientific facilities. Several weapons mission critical facilities include the Plutonium Facility (PF-4), the Dual-Axis Radiographic Hydrodynamic Test Facility (DARHT), the Uranium R&D facility (Sigma), the Metropolis Center's Strategic Computing Complex, Waste Handling Facilities, as well as several other facilities within the National Energetic and Engineering Weapons Campus. LANL operates several flagship user facilities, including the DOE/NNSA Los Alamos Neutron Science Center (LANSCE), the DOE/Office of Science Center for Integrated Nanotechnologies (with SNL), and one of the sites of the National Science Foundation's National High Magnetic Field Laboratory.

LANL's core capabilities and their associated challenges and strategies are described in **Table F–2**. Additional information on the plutonium capability, and LANL's 30 pits per year (ppy) plan is presented.

Table F–2. Los Alamos National Laboratory capabilities

<table>
<tr><th colspan="3">Weapon Component Production</th></tr>
<tr><td colspan="3">LANL is responsible for producing and surveilling pits, RTGs, and detonators designed by LLNL, LANL, and SNL for use in the nuclear weapons stockpile. As the Nation’s Plutonium Center of Excellence, LANL also performs fundamental research and produces plutonium components and materials to support other NNSA and DOE missions.</td></tr>
<tr><th rowspan="2">Challenges</th><th colspan="2">Strategies</th></tr>
<tr><th>Current Strategy Being Implemented</th><th>Future Strategies Needed</th></tr>
<tr><td>Increase pit production to a steady state rate of at least 30 ppy.</td><td>• Infrastructure investments: Through four major line-item projects and numerous smaller capital projects, install pit production process equipment and construct facilities for access, office space, parking, cafeterias, and training.
• Workforce: Recruit, hire, and train the workforce required to produce pits, operate and maintain facilities, and provide security.</td><td>• Continue to increase integration of construction and production activities that occur concurrently in an active plutonium facility.
• Improve hiring and retention efforts.
• Improve knowledge transfer from experienced subject matter experts to new workforce.</td></tr>
<tr><th colspan="3">Weapons Physics Design and Analysis</th></tr>
<tr><td colspan="3">LANL performs integrated experiments and simulations to enable design and assessment of the nuclear explosives package for both enduring and future weapons systems. Design and assessment capabilities encompass hydrodynamic and subcritical experiments; proton radiography, materials, and nuclear science experiments; HPC; HE RDT&E; weapons engineering, surety, radiography, and assembly; and accelerator technology.</td></tr>
<tr><th rowspan="2">Challenges</th><th colspan="2">Strategies</th></tr>
<tr><th>Current Strategy Being Implemented</th><th>Future Strategies Needed</th></tr>
<tr><td>Aging in weapons materials and components; an aging workforce with specialized weapons knowledge and experiments capabilities, lack of programmatic needs to transition to the next generation of designers and engineers; and degrading design and certification infrastructure.</td><td>Current warhead modernization activities provide a near-term opportunity to reinvest in current capabilities and exercise the workforce. LANL is coordinating with DOE/NNSA to address aging enduring physical infrastructure and modernize specialized capabilities such as DARHT, LANSCE, Sigma, HPC, HE, and weapons engineering facilities.</td><td>• Continue coordination with DOE/NNSA. Several mission-critical facilities will need substantial reinvestment and/or replacement, with planning required in advance.
• See Chapter 7 for enterprise workforce strategies.</td></tr>
<tr><th colspan="3">High Performance Computing</th></tr>
<tr><td colspan="3">The HPC core capability provides the supercomputers, facilities, and computer science that enable simulations of weapons performance for all aspects of stockpile stewardship. HPC enables scientists to routinely use multi-dimensional simulations to increase understanding of complex physics, as well as improve confidence in the predictive capability for stockpile stewardship for LEPs and significant finding investigations (SFIs). The ASC Program leverages the ATS and Commodity Technology System for this work.</td></tr>
<tr><th rowspan="2">Challenges</th><th colspan="2">Strategies</th></tr>
<tr><th>Current Strategy Being Implemented</th><th>Future Strategies Needed</th></tr>
<tr><td>Near-term challenges, by approximately 2026, include physical infrastructure modernization to accommodate the next-generation supercomputer (ATS-5) at LANL.</td><td>Planning is ongoing for the near- and long-term HPC infrastructure. Trinity (ATS-1) will be replaced by Crossroads. The EPCU line item is a key enabling infrastructure investment to meet power demand for the next-generation supercomputer.</td><td>Modernization of HPC with ATS-5 system.</td></tr>
<tr><th colspan="3">Weapons Engineering and Energetics</th></tr>
<tr><td colspan="3">Weapons engineering and HE capabilities provide the materials, components, and assemblies for legacy and new life extension program work. The scope also covers modeling weapon performance, safety, engineering, and aging responses throughout their operating conditions and life cycle. This capability includes the experimental testing required to assess the current state of the stockpile; surveil the current stockpile and address SFIs; assess and qualify existing energetic materials; and develop novel energetics for future designs.</td></tr>
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<table>
<tr><th>Challenges</th><th colspan="2">Strategies</th></tr>
<tr><td rowspan="2">The primary challenge is aging physical infrastructure. Many of the facilities were built in the 1950s and were optimized for the fabrication and engineering testing capabilities and processes of that time.</td><th>Current Strategy Being Implemented</th><th>Future Strategies Needed</th></tr>
<tr><td>• The current strategy includes a combination of line-item investments and minor construction to consolidate, replace, or extend the life of existing facilities.
• Once LANL has available construction capacity, construct the Energetic Materials Characterization line-item.</td><td>Strategies are being developed to address modernization needs for several mission critical facilities. This effort includes continued coordination within LANL and with DOE/NNSA.</td></tr>
<tr><th colspan="3">Hydrodynamic and Subcritical Experiments</th></tr>
<tr><td colspan="3">Hydrodynamic and subcritical experimental capabilities supply data to weapon physicists and engineers to inform the annual assessment process and certification decisions, advance nuclear weapon science, refine weapon computational models, develop emergency response tools, assess foreign and terrorist designs, gauge technological surprise, and develop the skills and experience of weapon designers and engineers.</td></tr>
<tr><th>Challenges</th><th colspan="2">Strategies</th></tr>
<tr><td rowspan="2">The hydrodynamic facilities and infrastructure (DARHT complex) are aging, and new diagnostics/experimental techniques are needed. There are demands for additional facilities for DARHT-related maintenance, repair, and storage space for mission critical spares.</td><th>Current Strategy Being Implemented</th><th>Future Strategies Needed</th></tr>
<tr><td>The ECSE program will deliver advanced diagnostics at the Nevada National Security Site in 2030.</td><td>Execute plans for the DARHT Capability eXpansion Strategy.</td></tr>
<tr><th colspan="3">Neutron Science – Los Alamos Neutron Science Center (LANSCE)</th></tr>
<tr><td colspan="3">The protons and neutrons produced by the LANSCE accelerator deliver essential material science, nuclear physics, and dynamic radiography data needed for assessment of the current stockpile, qualification of advanced manufacturing techniques, certification of the future stockpile, and threat reduction. LANSCE data are used for materials characterization; support of LEP, Alt, and Mod certification; qualification of new materials; and the development of advanced material models predictive capabilities.</td></tr>
<tr><th>Challenges</th><th colspan="2">Strategies</th></tr>
<tr><td rowspan="2">The LANSCE accelerator was commissioned in 1972, and some components are starting to experience end-of-life failures. Deferred maintenance has reduced the reliability of other components.</td><th>Current Strategy Being Implemented</th><th>Future Strategies Needed</th></tr>
<tr><td>A modernization initiative, including the LAMP line-item, is being pursued. LAMP would replace obsolete elements at the front of the LANSCE accelerator and address performance limitations. Recapitalization investments are addressing aging facility condition issues. A new spallation target and the return of explosively driven plutonium experiments are targeted.</td><td>Next generation facilities, infrastructure, and equipment will eventually be required.</td></tr>
<tr><th colspan="3">Uranium, Beryllium, Organics, and Inorganics</th></tr>
<tr><td colspan="3">The Sigma Capability includes the expertise, facilities, and equipment for work with uranium, beryllium, and most organic and inorganic materials in the stockpile. Sigma maintains a small-lot production capability for all nuclear weapons package components and relevant materials (except HE, HEU, and plutonium). The work provides low- to mid-TRL manufacturing process development, pathfinding for new materials and emerging technologies, and understanding of the materials' properties inclusive of performance and ageing behaviors. Additional capabilities include surveillance activity for legacy weapons systems, as well as manufacturing science and production support at Y-12 and KCNSC.</td></tr>
</table>

Challenges	Strategies	
	Current Strategy Being Implemented	***Future Strategies Needed***
Built in the late 1950s, Sigma Complex facilities are increasingly expensive to operate and necessary investments in infrastructure offer diminishing return. The aging infrastructure, including mission critical equipment, face frequent downtime that introduce operational risk and negatively impacts Sigma's ability to meet milestones, especially as demand increases.	Several revitalization efforts have been completed (such as the modernization of the Electrochemistry Lab and completion of the Machining Annex). Other significant upgrades to processing equipment are proposed within the next 5–10 years. Sigma will transition to Weapons Program operations in the near-term.	The Sigma Replacement project is aligned with enduring mission activities and emerging demands.

Alt = alteration
ASC = Advanced Simulation and Computing
ATS = Advanced Technology System
DARHT = Dual-Axis Radiographic Hydrodynamic Test
EPCU = Electrical Power Capacity Upgrade
GPP = General Plant Projects
HE = high explosives
HEU = highly enriched uranium
HPC = high performance computing
LAMP = LANSCE Modernization Project
LANSCE = Los Alamos Neutron Science Center
LEP = life extension program
Mod = modification
RDT&E = research, development, test, and evaluation
RTG = radioisotope thermoelectric generators
TRL = technology readiness level

Plutonium Capability and 30 ppy Plan – LANL is designated by NNSA as the Nation's Plutonium Center of Excellence. The LANL plutonium enterprise includes an experienced and skilled workforce, high-hazard nuclear facilities with associated infrastructure, and unique plutonium processing, fabrication, and experimental capabilities. This enterprise enables the safe, secure, and compliant work with plutonium and other materials and components. The Nation relies on the LANL plutonium enterprise to perform the following plutonium missions:

- Produce plutonium pits for the nuclear weapons stockpile
- Produce RTGs for the nuclear weapons stockpile
- Produce plutonium-238 heat sources for use in space exploration
- Evaluate pits returned from the nuclear weapons stockpile to support annual stockpile assessments
- Produce plutonium components for assembly into devices for use in subcritical experiments
- Conduct fundamental science on the material properties and aging of plutonium
- Process plutonium into forms suitable for disposition to support nuclear nonproliferation goals
- Evaluate containers for safe storage of plutonium materials throughout the DOE/NNSA complex
- Recover americium for the DOE Office of Science

In May 2018, NNSA directed LANL to increase pit production to deliver a minimum of 30 War Reserve pits per year starting in 2026. In June 2018, NNSA selected Triad National Security, LLC to manage LANL starting in November 2018. Recognizing the urgency to understand the actions and resources required to expand the pit production mission, LANL completed a thorough sitewide assessment of resources, such as facilities, workforce, capabilities, and business systems. The results of this assessment were published in 2019 by LANL (with feedback from NNSA) in a series of plans related to pit production. In 2020 and 2021, these plans were updated and expanded to include requirements and planning

LANL employees working in a downdraft room in the plutonium facility. The airflow in a downdraft room creates a safe environment required to perform certain types of work in pit production.

for all plutonium missions. As a result of these planning efforts, NNSA recognized the need to increase the annual budget for the pit production mission at LANL, and Congress increased funding for pit production and the facilities, security, and services required to support the LANL plutonium enterprise.

In response to the surge in activity to expand pit production, LANL began routine 24/7 operations in the Plutonium Facility in FY 2022. Expanded operational hours enables LANL to deconflict schedules for programmatic, construction, and maintenance activities.

F.2.2.4 Accomplishments

LANL successfully met mission delivery in the following laboratory strategic areas: nuclear deterrence, threat reduction, technical leadership, and trustworthy operations.

- LANL completed 150 of 153 Defense Program milestones, achieving a 98 percent completion rate (including a Level 1 aging and lifetimes milestone).
- LANL completed seven plutonium pit builds compared with five planned builds.
- LANL completed deliverables for the annual assessment reporting process.
- DARHT executed four hydrodynamic shots and three static series.
- LANL executed 80 experiments in support of the evolving stockpile and more than 400 dynamic materials and nuclear physics experiments.
- LANL continued leadership role for the W93-0 and achieved written authorization for Phase 2.
- LANL modernized technology for the radiation case, including remarkable progress on direct casting of binary components.
- LANL developed new HE formulations as alternatives for potential insertion into emerging weapons programs.
- LANL shipped more than 6,900 cubic meters of waste and prevented a backlog of generated waste.
- LANL delivered the first phase of the Crossroads supercomputer in FY 2023, and Crossroads deployment is being finalized in FY 2024. LANL completed an electrical system upgrade and 98 percent of water-cooling loops for CTS-2 and Crossroads.
- LANL refurbished over 1 million square feet of office space, replaced 4.8 acres of roof, and laid over 9.5 acres of pavement. LANL occupied a second Santa Fe lease to provide a centrally located workspace.
- LANL invested in a new and expanded employee benefits program (effective as of January 2023), which includes paid time off, enhanced maternity and parental leave, compassionate care, and accelerated employer match for 401(k), among other changes.
- LANL's personnel security has accelerated clearance processing through several improvements.

F.2.2.5 Los Alamos National Laboratory Workforce

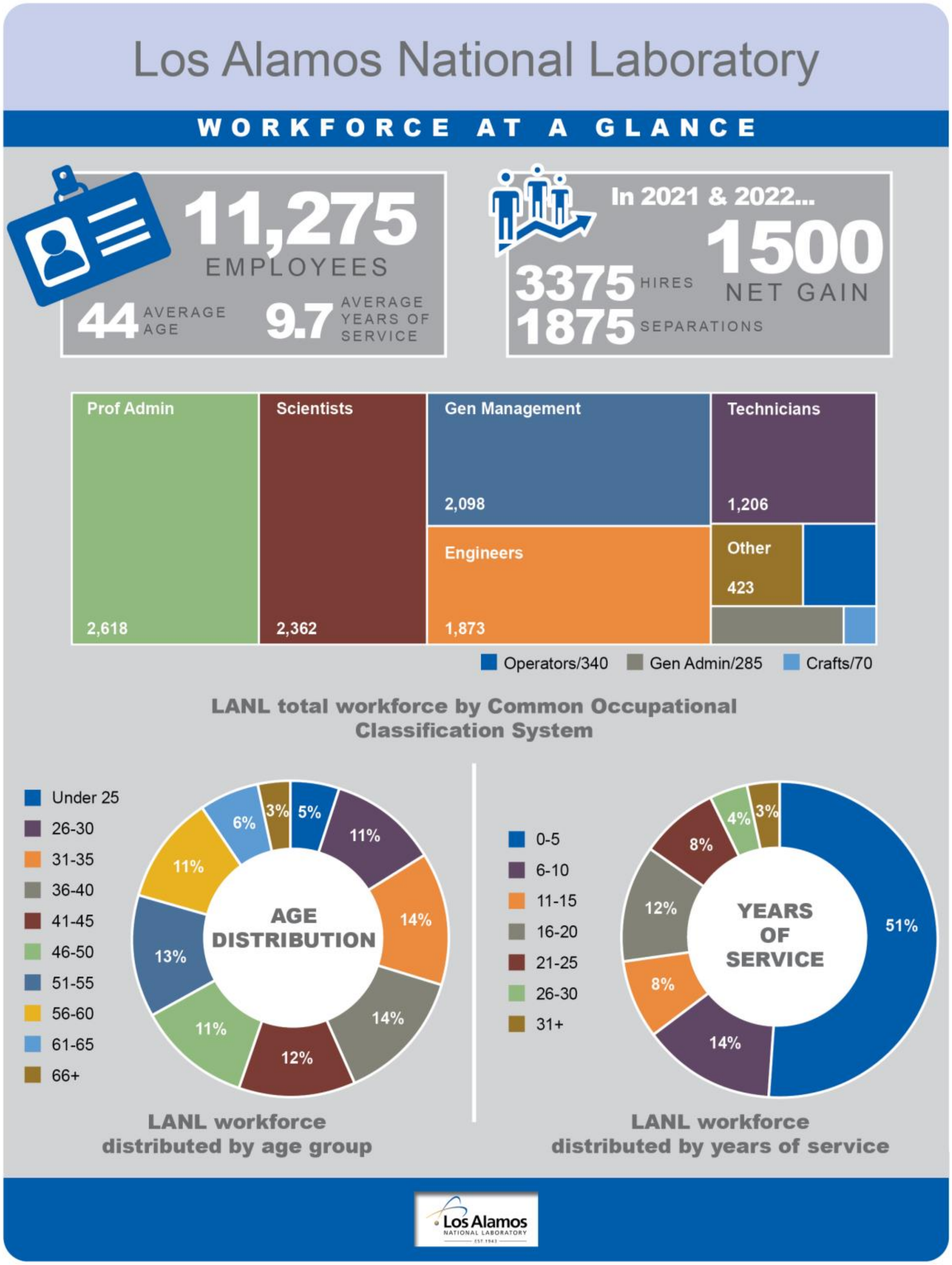
Early Engagement in FY 2022

- *Students: 2,091*
- *Post-doctorates: 647*

In FY 2022, LANL's diverse workforce was comprised of 11,275 regular, limited term, and protective force employees with expertise across various disciplines working to solve national security challenges. This population of employees had an average age of 44 years and an average of 9.7 years of service. Approximately 36 percent of LANL's employees were eligible to retire.[1] Staffing plans indicate that hiring is expected to accommodate the workforce

[1] Retirement Eligible is age 50+.

growth needed to meet future mission demands (e.g., pit production) and anticipated attrition over the next 5 years. Additionally, LANL offered internships and other student engagement opportunities to nearly 2,100 students during FY 2022 and hosted an additional 647 post-doctoral research fellows.



LANL's FY 2022 employee headcount increased 8.2 percent from FY 2021. Growth was seen in most categories, with the largest increases observed for general management (+18.5 percent), engineers (+11.8 percent), and professional administration (+8.0 percent).[2] The general management increase was attributed to the recategorization of technical managers in pit mission areas (establishing a lower ratio of manager to employee) to improve safety and efficiency. The workforce will continue to increase by approximately 1,000 additional full-time equivalent over the next few years, as growth will be targeted to support plutonium programs and dependent infrastructure investments.

There is an even distribution of employees across the specified 5-year age groups, as shown in **Figure F–9**. The median age dropped from 45.1 (FY 2021) to 43.6 (FY 2022), reflecting the increasing population of younger new hires. The retirement eligible population has also decreased from previous years.

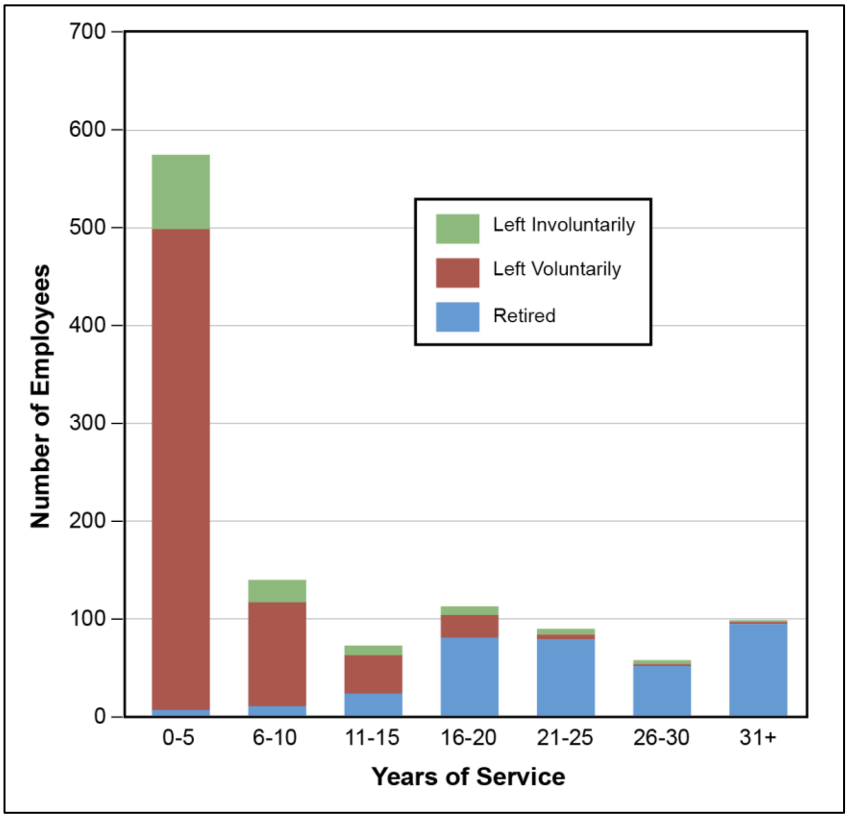


Figure F–9. LANL separations by years of service

The increase in early career hires and retirements has impacted headcount by years of service, shown in **Figure F–10**. The group of employees with 5 or less years of service or less has increased from 43 percent (FY 2020) to 51 percent in FY 2022. This trend is expected to continue, with ~9,000 employees (regular appointment type) expected to have 5 or less years of service or less by FY 2028. The average years of service was 9.7 in FY 2022, down from 10.9 (FY 2021) and 11.4 (FY 2020).

[2] In FY 2022, LANL began including Limited Term (242) and Protective Force (423) employees in the employee site count. Protective Force employees are counted under the COCS code of "Other." Protective Force employees are contractors, thus LANL has limited age and years of service information; therefore, they are not included in the other demographic charts. LANL also does not classify any employee under the COCS code of "Laborers."

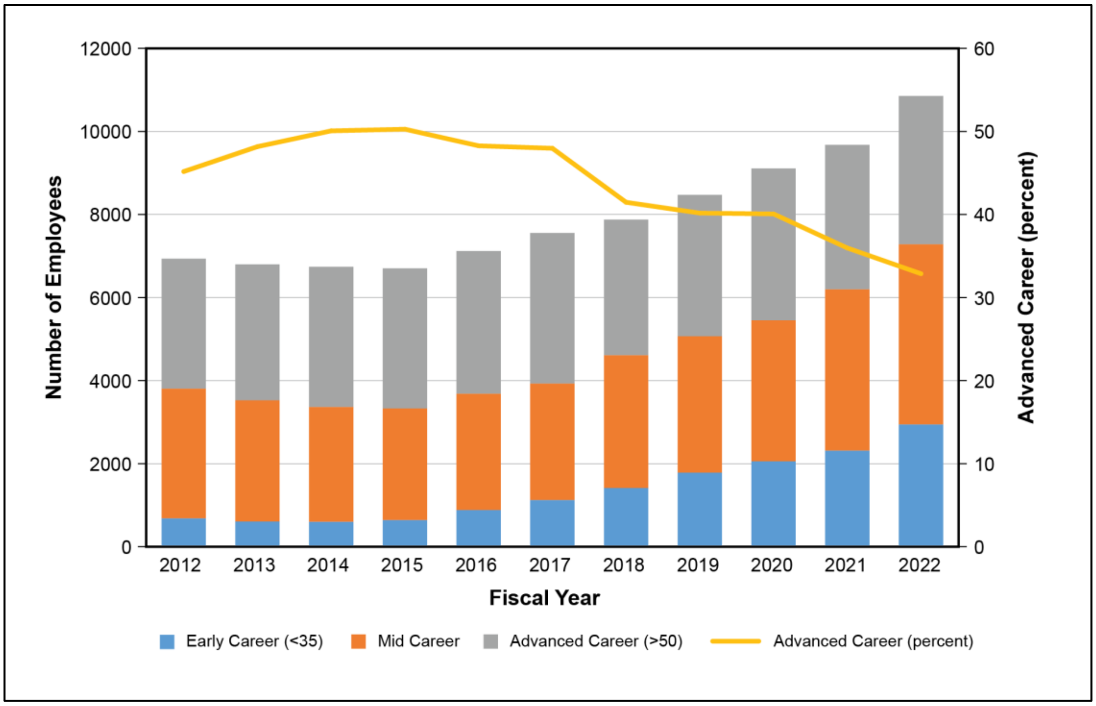


Figure F–10. LANL workforce trends by career category and percent advanced career

Retirements and voluntary separations have increased in FY 2022; the most separations were seen in employees with 10 years of service or less (74 percent of all voluntary attrition), shown in **Figure F–11**. In addition to retention challenges, such as the competitive job market and limited housing and supporting services (e.g., daycare, schooling, medical care, etc.), the separation increase may have been compounded by employees delaying planned separation from FY 2020 into FY 2022.

LANL has been hiring in all career categories, but the largest portion of hiring is among early career employees (51.3 percent in FY 2022). The population of early career employees continues to grow in FY 2022 (up 27.2 percent); it has more than quadrupled over the past decade (shown in Figure F–10). This increase is due to early career employees making up most of the new hires. Mid-career employees experienced an increase of 11.3 percent, which is due to onboarding of mid-career new hires and the transition of previous new hires from the early career stage into mid-career. Inversely, the population of advanced career employees has decreased over the past few years.

Figure F–12 shows that total separations (1,147 in FY 2022) from the laboratory are again higher than the previous fiscal year (757 in FY 2021), reinforcing the retention challenge. Both retirements (+18 percent) and voluntary separations (+75 percent) increased. As noted above, retention challenges due to the competitive job market and limited housing and supportive services could have contributed to the separation increases observed. LANL is addressing these challenges via recruitment, hiring, total compensation and benefit changes, diversity, equity, inclusion, and accessibility approaches, training, and knowledge retention approaches.

The LANL workforce is projected to grow over the FYNSP period, as shown in Figure F–12, to meet the pit production rate capacity requirements, scope increases in weapons work, infrastructure modernization plans, and enduring scientific and national security missions. The need for retention efforts is expected to remain high due to competitive job markets in engineering, technology, and craft areas. The laboratory is making significant investments in programmatic and enabling physical infrastructure and in processes to meet increasing demands for office space, parking, training, housing, and other support services.

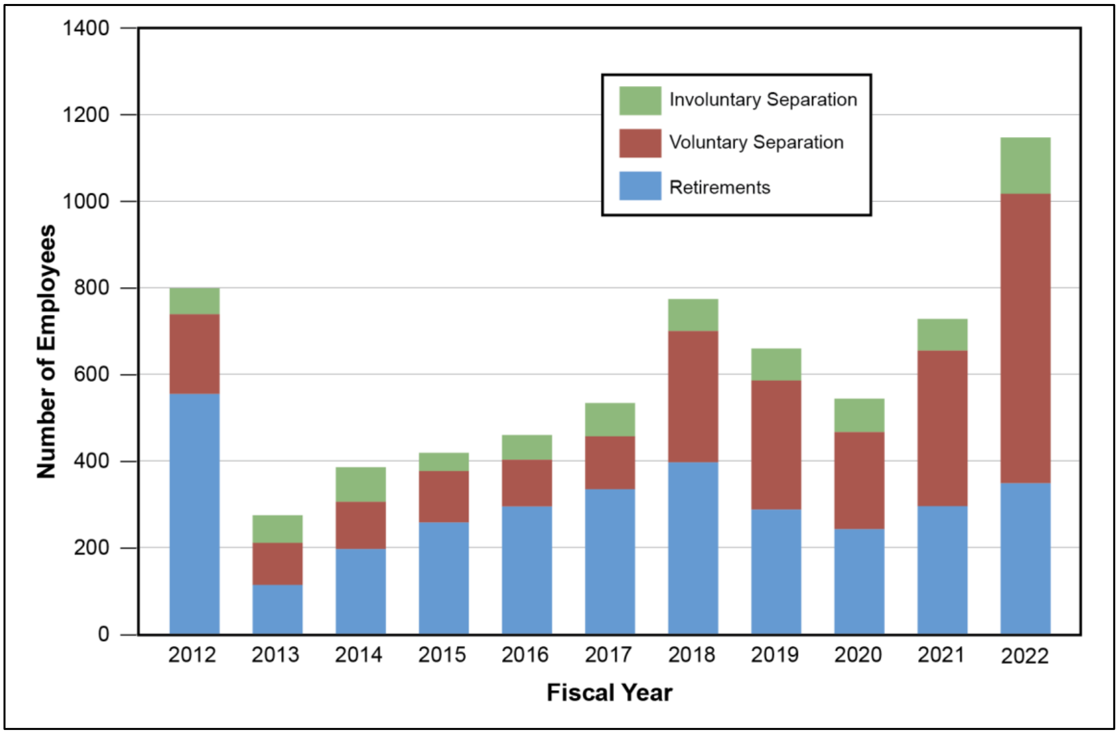


Figure F–11. LANL employee separation trends

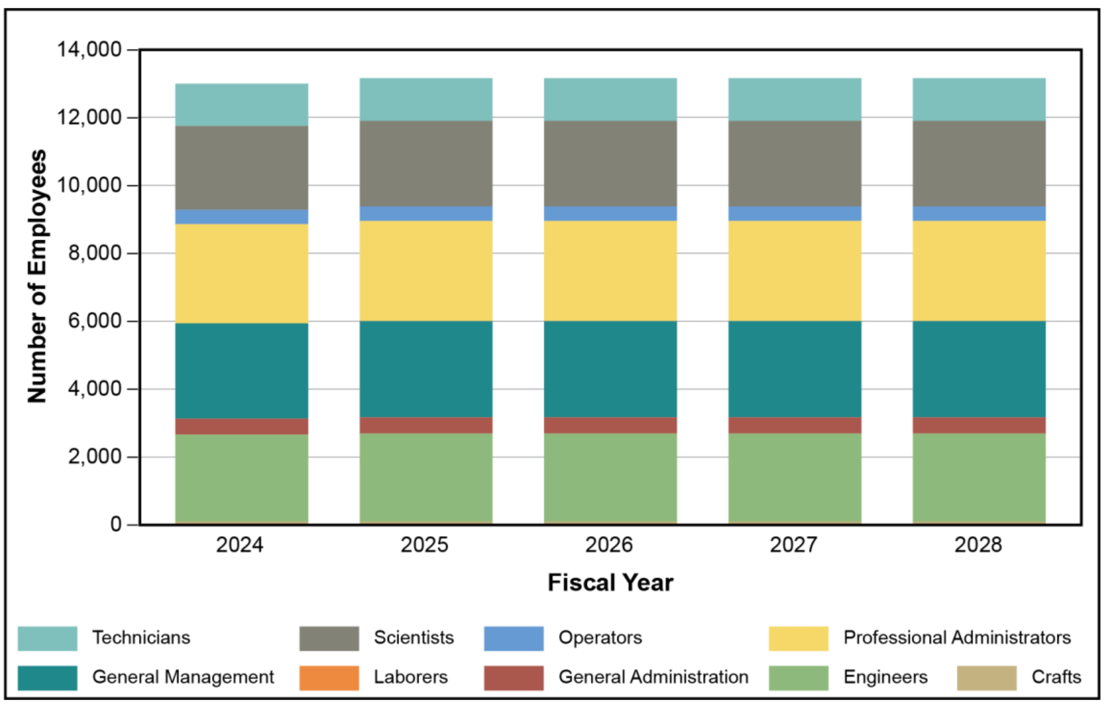


Figure F–12. LANL workforce projection needs by Common Occupational Classification System[3]

[3] The increase in headcount projections is attributable to the LANL pit production mission. Technician and Professional Administration categories are expected to be required and, thus, grow in the next years.

F.2.3 Sandia National Laboratories

Sandia National Laboratories

Albuquerque, NM
Livermore, CA

Multi-mission national security laboratory

www.sandia.gov

Operated By: National Technology and Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International, Inc.

Sandia Field Office

- Warhead system engineering and integration
- Design, development, and qualification of non-nuclear components
- Production of non-nuclear components (power sources, neutron generators, and trusted, strategic radiation hardened microelectronics)
- Development and application of science and technology to solve other national security challenges

Sandia National Laboratories

F.2.3.1 Mission Overview

Sandia National Laboratories (SNL) is a DOE/NNSA multi-mission Federally Funded Research and Development Center (FFRDC). Since 2017, SNL has been managed and operated by National Technology and Engineering Solutions of Sandia LLC, a wholly owned subsidiary of Honeywell International Inc., with primary locations in Albuquerque, New Mexico, and Livermore, California. As an FFRDC, SNL operates in the public interest with objectivity and independence, free from organizational conflicts of interest, by maintaining core science, technology, and engineering capabilities to address missions of national significance.

For over 70 years, SNL has delivered essential and innovative engineering, science, and technology to resolve the Nation's most challenging security issues. SNL began in 1945 as Z Division, the ordnance design, testing, and assembly arm of Project Y, which after World War II became Los Alamos Scientific Laboratory. Z Division was renamed Sandia Laboratory in 1948 and, in 1949, Sandia Corporation was established as an AT&T, Inc. subsidiary to manage the laboratory through a no-fee contract. In 1956, a second site was opened in California's Livermore Valley. In 1979, Congress designated Sandia Laboratory as a DOE national laboratory. SNL has other sites, including Tonopah Test Range, Nevada; Kauai Test Facility, Hawaii; Washington, DC; Weapon Evaluation Test Laboratory, Texas; and Minnesota Site, Minnesota.

The nuclear deterrence mission exists at SNL within a framework of five interdependent portfolios that represent multiple missions. Most of these have a direct and symbiotic relationship with nuclear weapons work, and all strengthen SNL's capability-based science and engineering foundation.

SNL's activities for other Federal agencies and for non-Federal entities leverage, sustain, and strengthen the unique capabilities, facilities, and essential skills that support the Office of Defense Programs mission and broader national security needs. SNL's national security work includes the following programs' portfolios:

- Nuclear Deterrence
- Global Security

- National Security Programs
- Energy and Homeland Security
- Advanced Science and Technology

SNL's five program portfolios set strategic direction for their respective mission spaces and have identified multi-year program priorities that align to and support NNSA mission priorities. Functional areas including facilities, human resources, information technology (IT), finance and others develop and execute on strategic plans that ensure SNL has the resources and infrastructure to deliver on priority objectives.

SNL's nuclear deterrence mission includes nuclear weapons R&D, design, qualification, testing, certification, and systems integration of all components, subsystems, and systems, to arm, fuze, and fire a weapon to military specifications and ensure safety and security. The integration role is evident in three key areas:

- Integration of all non-nuclear components, systems, and subsystems
- Integration between a weapon's non-nuclear portion and its nuclear explosives package
- Integration of a weapon with its military delivery platform

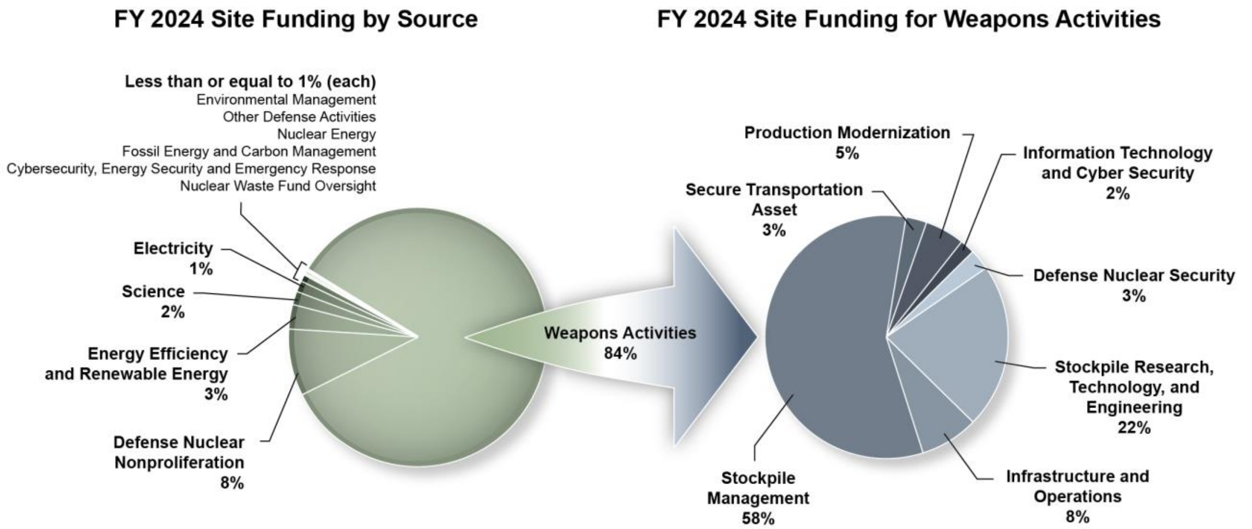
The current warhead modernization activities constitute SNL's largest, most complex design, development, and qualification work scope in the last 30 years. SNL is involved in all stockpile modernization programs currently underway (the B61-12 LEP, W88 Alteration [Alt] 370 Program, W80-4 LEP, W87-1 Mod Program, W93, and Mk21 Fuze), and is responsible for designing the life extension of the Safeguards Transporter and its replacement design (the Mobile Guardian Transporter [MGT]) to securely transport nuclear weapon materials and components to DOE/NNSA partner sites and DoD customer sites. SNL also has production agency responsibilities for weapon non-nuclear components (e.g., power sources, neutron generators, and trusted, strategic radiation-hardened microelectronics).

As reinforced by the 2022 *Nuclear Posture Review* and recent global events, SNL's nuclear deterrence mission is now more urgent than at any time since the end of the Cold War. The United States must maintain the range of flexible, responsive, and tailored nuclear capabilities to protect ourselves and our allies against nuclear and non-nuclear aggression. This capability versatility translates to a need to sustain SNL's capability-based science and engineering foundation to prepare for uncertain and evolving future threats. As an FFRDC, part of this service to the Nation is to scan the horizon for emerging national security issues and articulate the challenges anticipated for the country.

F.2.3.2 Funding

FY 2024 DOE request – site funding by source
(total SNL FY 2024 request = $3,188 million)

SNL split for the FY 2024 Weapons Activities President's Budget Request *($2,681 million)*



F.2.3.3 Site Capabilities

Table F–3. Sandia National Laboratories capabilities

Weapon Engineering Design, Analysis, and Integration/ Weapon Component and System Surveillance and Assessment/Agile Component and Systems Design		
Systems integration, engineering, and surveillance are the core capabilities of SNL's nuclear deterrence mission. SNL designs, develops, qualifies, and assesses arming, fuzing, and firing systems, neutron generators, gas transfer systems, power sources, energetic components, and weapon surety and nuclear safety and security systems for Alts, Mods, and LEPs. This capability also includes production responsibility for several non-nuclear components and robust prototyping that is enabled by model-based design and advanced manufacturing technologies. SNL performs surveillance evaluations and stockpile maintenance to assess nuclear weapon systems and detect or anticipate potential problems.		
Challenges	***Strategies***	
	Current Strategy Being Implemented	***Future Strategies Needed***
SNL depends on viable infrastructure to execute its core mission now and in the future, and to ensure that its premier workforce has the tools needed to execute the mission. SNL must maintain R&D, production, and surveillance capabilities.	• Proactively engage with NNSA to ensure an integrated approach to resolve facility challenges (co-locates related capability assets to improve efficiency and effectiveness, recapitalizes aging and inadequate facilities, and maintains facilities fit for mission use). • Execute the Power Sources Capability line item which entered the CD-1 phase in January 2023. • Use SNL's LIIST process to capture infrastructure needs and define priorities.	• Continue to pursue line-item funding for key mission needs. • Recapitalization or replacement of equipment and facilities will be needed to sustain long-term health.
Given rapid geopolitical change, SNL must respond quickly to new threats while improving efficiencies as responsible stewards of national investments. Traditional weapon product lifecycles (design, development, and production) are too long, impeding the ability to respond in a timely manner to emerging threats.	• Accelerate product realization through continued implementation of digital engineering tools and processes, updated peer review processes, modular architectures, and expanded partnerships across the nuclear security enterprise. • Continue the use of Technology Maturation Roadmaps to realize the benefits of new capability investments. • Leverage rapid hardware procurement and prototyping to close knowledge gaps early.	Continue coordination with DOE/NNSA to define longer-term strategies and investments.

Increasing supply chain risk to meet stringent non-nuclear component production requirements.	Seek opportunities to maintain current and develop new trusted supplier partnerships. Improve our sourcing methods to engage suppliers more strategically.	Continue current efforts and assess opportunities for new technologies.
Retention and recruitment of staff. Competition is high for the critically skilled workforce required to maintain these capabilities, particularly electrical engineers, and computer scientists.	• Utilize university partnerships engagement strategies to work with academic partners to build collaborative research opportunities and fill SNL's talent pipeline. • Leverage the existing recruiting programs and initiate innovative on-campus research partnership, internships, and other creative mechanisms to develop a pipeline of future-generation warhead engineers. • Use targeted recruiting programs that have been initiated to fill critical skills disciplines. • NNSA and SNL are co-leading the NNSA Strategic Outlook Initiative study focused on the "Future of Work" to help combat workforce challenges. • SNL added recruiters dedicated to its nuclear deterrence mission and is working with NNSA to enhance compensation and benefits.	Continue to proactively engage with NNSA to ensure an integrated approach is used for competitive compensation and benefits.
Major life extension activities have focused laboratory attention and resources on near-term deliveries, making maturation of new technologies and components difficult.	Seek opportunities to advance technology development in a broad range of program venues, including the NNSA's Technology Maturation efforts, Strategic Partnership Projects, Laboratory-Directed Research and Development, and other NNSA programs such as the Stockpile Responsiveness Program.	Continue coordination with DOE/NNSA to define longer-term strategies and investments.
Radiation-Hardened Microelectronics Design and Manufacturing		
Trusted, strategic, radiation-hardened advanced microsystems (i.e., nanoscale and microscale system security testing and evaluation).		
Challenges	***Strategies***	
	Current Strategy Being Implemented	***Future Strategies Needed***
Trusted microsystems fabrication facilities are aging, past their design lives, and are required to support this capability.	Continue to work with NNSA to extend the life of current infrastructure needed to maintain the R&D capability and the production capability. Ensure an uninterrupted ability to produce trusted, strategic radiation-hardened microsystems.	Work with NNSA to secure line-item and other infrastructure funding for facilities and equipment needed to maintain this capability.
Materials Science and Engineering / Advanced Manufacturing		
Virtually all classes of non-nuclear materials, including metals, polymers, glasses, ceramics, and electronic and optical materials and their interfaces and interactions with their environments, are critical to the safety, security, and effectiveness of the U.S. nuclear weapon stockpile. This capability at SNL includes (1) evaluation of materials for aging, compatibility, and model validation to resolve stockpile and production issues rapidly and (2) innovation to replace legacy materials and evaluate new materials for insertion into the stockpile.		
Challenges	***Strategies***	
	Current Strategy Being Implemented	***Future Strategies Needed***
SNL must support evaluating materials aging, compatibility, and model development/validation and sustain the innovation necessary to replace legacy materials and evaluate new materials for insertion into the stockpile. SNL must advance material science R&D for response to evolving threats and future needs.	SNL is creating new measurement and analytical capabilities to conduct R&D to enhance our understanding of the structure and processing of materials to evaluate their behavior, capturing the phenomenology driving this behavior, defining and predicting performance in current and future stockpiles, and enabling applications in additive manufacturing with a science basis for qualification.	Expand/continue engagement with DOE/NNSA.

The material science and engineering facility at SNL/California does not meet modern seismic and other building code standards. The existing building (C916) was built in 1958. SNL/New Mexico material science and engineering facilities need revitalization since they are at the end of their design life and need extension of systems and new capabilities.	• Proactively engage with DOE/NNSA to ensure an integrated approach to resolving facility challenges. • Use SNL's LIIST process to capture infrastructure needs and define priorities. Commission studies to establish conditions and alternatives to best mitigate risk to the mission.	Continue coordination with DOE/NNSA. Continue to pursue Weapons Engineering Science and Technology Laboratory at SNL/California to ensure that modern and world-class materials science capabilities lead to breakthrough solutions in response to enduring and emerging national security challenges.
The current generation of materials scientists is approaching the end of their careers. The number of students seeking advanced degrees in material disciplines who choose to enter and work within the nuclear security enterprise may not be sufficient to meet future workforce needs. Competition is high for scientists and engineers who are qualified in these disciplines.	Leverage existing recruiting programs and initiate innovative on-campus research partnerships, internships, and other creative mechanisms to develop a pipeline of a future generation of materials science specialists for SNL's unique needs.	Reference Chapter 7 for enterprise recruitment and hiring challenges and strategies.
Environmental Effects Analysis, Testing, and Engineering Sciences/High Energy Density Physics/Advanced Experimental Diagnostics and Sensors		
These capabilities include evaluation of the effects of operational and abnormal environments on nuclear weapon systems and components using an array of engineering science test equipment (e.g., the Annular Core Research Reactor, Z, Saturn, and HERMES), diagnostic tools, and techniques, as well as research and testing to support design, qualification, and surveillance.		
Challenges	***Strategies***	
	Current Strategy Being Implemented	***Future Strategies Needed***
The workload imposed by concurrent LEPs is stressing the capacity and capability of aging facilities and equipment and accelerating replacement needs. Experimental test capabilities to validate data models require more and higher-fidelity data to enable stronger coupling with integrated design codes.	• Prioritize facility and equipment investments to ensure continuity of the engineering sciences capabilities. • Support enhancement of the predictive capability by tightening the coupling and integration of modelers and the data necessary for model validation. • Advance diagnostic capabilities to capture higher-fidelity experimental data.	• Research and technology from current strategies and efforts will be applied to next -generation pulsed power and accelerator facilities (NGPP and CREST) • Continue to sustain infrastructure investments that advance diagnostic capabilities to capture higher-fidelity experimental data and ensure confidence in the nuclear stockpile. These investments would include SNL's Major Environmental Test Facilities.
NGPP experimental capabilities are needed to ensure models that validate safe, secure, and reliable performance of the Nation's weapons.	Work with NNSA and the other design laboratories to establish the mission need and program requirements for a NGPP capability.	
The ACRR delivers high-power, short bursts of neutron and combined neutron-gamma spectra to qualify designs under extreme combined radiation environments. The facility housing the reactor is older than 50 years and predates modern nuclear safety standards.	• Develop an Extended Life Plan to address near term facilities and infrastructure needs to sustain ACRR. • Mature CREST as a long-term replacement for ACRR.	
Radiation effects and high energy density sciences facilities are aging and require significant sustainment activities to maintain capability for stockpile assessments.	Execute Saturn refurbishment project and work with NNSA to support the Z Sustainment Plan.	Continue to partner with NNSA on long-term infrastructure needs (including CREST and NGPP).

Competition is high for certain specialists in radiation effects science.	• Develop a pipeline of scientific and engineering expertise in radiation effects via current campus and diversity recruiting programs and initiate targeted, innovative on-campus partnerships, internships, and fellowships to secure highly talented graduates. • SNL is working with NNSA to enhance compensation and benefits.	See Chapter 7 for enterprise recruitment and hiring challenges and strategies.
High Performance Computing / Simulation Codes and Models		
These capabilities include modeling and simulation capabilities of physical phenomena.		
Challenges	***Strategies***	
	Current Strategy Being Implemented	***Future Strategies Needed***
Enhance the predictive capabilities of IDCs to support design, development, qualification, and assessments of non-nuclear components and systems for normal, abnormal, and hostile environments.	• Continue to accelerate digital engineering to shorten design cycles, support weapon qualification via credible simulations and increase agility in responding to changed product needs. • Participate in the DOE Exascale Computing Initiative; design and conduct experiments to support validation of IDCs that increase understanding of the physical phenomena and close the gap between models and the physical world.	• Exascale computing platforms, machine learning techniques, new algorithms and quantum solutions will help us discover new solutions to complex problems focusing on weapon response in combined environments. • HPC platforms will be made more available and efficient by improving power reliability through local, renewable generation and, when appropriate, by obtaining cycles from commercial cloud providers.
Competition for high-demand disciplines, such as computational modeling with an emphasis on engineering analysis, makes recruiting, training, and retaining technical staff increasingly challenging.	• Leverage campus and diversity recruiting programs to develop a pipeline of future-generation HPC scientists and engineers. • SNL is working with NNSA to enhance compensation and benefits.	Training and sustaining a skilled, diverse workforce that thinks critically can quantify risk and incorporate innovative solutions with science-based confidence—a long-term strategy that transcends quarter-century planning.

ACRR = Annular Core Research Reactor
Alt = Alteration
CD = Critical Decision
CREST = Combined Radiation Effects for Survivability Testing
HERMES = High-Energy Radiation Megavolt Electron Source
HPC = high performance computing
LEP = life extension program
LIIST = Line-Item Investment Strategy & Timing
Mod = Modification
NGPP = Next Generation Pulse Power facility
Z = Z pulsed power facility

F.2.3.4 Accomplishments

Directed Stockpile Work/Weapon Engineering and Production Focus

- **B61-12 and the W88 Alt 370 progress:** SNL, in partnership with the nuclear security enterprise, successfully achieved the first production units for the B61-12 and W88 Alt 370 in 2021. SNL continues to support the B61-12 and the W88 Alt 370.
- **W80-4:** SNL, in partnership with the nuclear security enterprise, met critical W80-4 program deliverables, completing tests needed to support the System Baseline Design Review.
- **Stockpile Systems:** SNL completed all testing and analysis for each system in the national stockpile resulting in the Laboratories Director's Annual Assessment Letter. Improved modeling/simulation capabilities developed through the Advanced Scientific Computing portfolio were utilized.

- **W87-1 Weapon Development Cost Report (WDCR):** SNL, in partnership with the nuclear security enterprise, submitted the SNL portion of the W87-1 WDCR. SNL ensured that fundamental changes critical to future weapons systems such as model based design and cybersecurity were included in the baseline.
- **W93 Phase 1:** SNL, in partnership with Lockheed Martin and LANL, completed the W93 Phase 1 report that detailed system concept, resulting in the first Phase 2 authorization in over 40 years.
- **Production Agency (PA) success:** In SNL's PA role, SNL delivered over 50,300 non-nuclear parts, components, and technologies. These deliverables include neutron generators, power sources, explosive components and energetic materials, surety technologies and strategic, radiation-hardened microelectronics.
- **Mobile Guardian Transport (MGT):** SNL completed a coast-to-coast 4,500-mile road trip with the MGT Preproduction Unit Prototype 2 trailer, visiting many DOE and DoD sites, to advance complex integration objectives and demonstrate Enhanced Cargo Restrain Operations.

RDT&E/Weapon Science and Technology Focus

- **Delivering foundational science and engineering capabilities:** The Advanced Certification and Qualification Program developed a test platform that enables the recovery of material samples after exposure to thermomechanical shock on Z. The platform establishes a new experimental capability at Z, and SNL executed two consecutive Z experiments in partnership with LANL to compare the compressibility of new and aged Pu.
- **Implementation of 8-inch Wafers at Microsystems Engineering Science and Application (MESA):** MESA's Silicon Microfabrication demonstrated production of Complementary Metal-Oxide Semiconductor 7 technology on 8-inch wafers, which required upgrading or replacing every tool and redeveloping more than 500 Complementary Metal-Oxide Semiconductor 7 process and measurement recipes.
- **Distributed Bus-Based Architecture (DBBA):** SNL's Foundation Bus team analyzed radiation test results that highlight the DBBA Foundation Bus and Power Bus robustness to stockpile-to-target sequence requirements. SNL developed definitions and options for a secure foundation bus architectures and dependencies on microelectronics technologies.

Attract, Retain, and Develop Talent

- **Jill Hruby Fellowship:** Established in 2019, the fellowship honors SNL's former Director, Jill Hruby, who was NNSA's first female Laboratory Director, to develop women in engineering and science fields who are interested in technical leadership careers in national security. Two additional Hruby fellows were selected in FY 2022.
- **Weapons Engineering Professional Development:** SNL internal activities assure the nuclear weapons enterprise workforce has the requisite technical knowledge. This is accomplished through a series of activities, including four exemplary programs:
    1. Nuclear Weapons Management Orientation Course: Provides managers an accelerated introduction to the nuclear deterrence program with a focus on SNL's engineering role within the enterprise.
    2. Weapon Intern Program (WIP): Since 1998, SNL has sponsored the WIP to benefit the nuclear security enterprise to accelerate training technical professionals in nuclear weapon development.
    3. Knowledge Development Program: The Nuclear Deterrence Knowledge Development Program is a system of tools, trainings and readings pertaining to the weapons lifecycle.

4. Nuclear Weapons Legacy Program: The Legacy Hardware Program provides historical knowledge for everyday use by collecting and facilitating access to classified nuclear weapons related legacy hardware.

- **Laboratory Directed Research and Development Program:** In 1992, Congress authorized national laboratories to initiate Laboratory Directed R&D to encourage creative research and development in areas of national security, particularly in high-risk, potentially high-payoff activities that enable national security missions and advance the frontiers of science and engineering.
- **Academic Programs umbrella:** The Academic Programs umbrella encompasses SNL University Partnerships Network, the Faculty Loan Program for Joint Appointments, and the Postdoctoral Research Program Office. The largest branch of Academic Programs is the SNL University Partnerships Network, which establishes and cultivates strategic academic partnerships that are mutually beneficial.

Awards and Recognition

- **Inventions/patents:** During FY 2021 and FY 2022, SNL submitted a combined 588 invention disclosures, filed 462 patent applications, and received 237 granted patents.
- **Awards:** In FY 2022, SNL researchers captured four R&D 100 Awards and supported a fifth award with Idaho National Laboratory, Pacific Northwest National Laboratory, and Johns Hopkins University Applied Physics Laboratory. Additionally, the Proactive Intrusion Detection and Mitigation System also won the R&D 100's Special Recognition Market Disrupter Silver Award. In FY 2021, SNL received two Lawrence Awards and seven R&D 100 Awards (one in conjunction with the National Renewable Energy Laboratory), as well as two special awards for green technology and corporate responsibility.
- SNL received the 2021 Diversity Team Award from Profiles in Diversity Journal, which recognized SNL as one of 14 of the world's leading companies that take diversity and inclusion to a new level.
- In 2022, SNL received the Honoring Investments in Recruiting and Employing American Military Veterans Act Medallion Award, recognizing successful recruiting, hiring, and retaining of veterans.

Infrastructure Investments

- **Power Sources Capability: I**n December 2022, DOE/NNSA selected SNL/New Mexico as the preferred alternative location for Power Sources Capability, which consolidates the capabilities across the SNL/New Mexico campus.
- **Combined Radiation Effects for Survivability Testing (CREST)**: SNL with NNSA has continued to make progress to replace the Annular Core Research Reactor, an aging facility past its useful life, with CREST.

F.2.3.5 SNL Workforce

As of September 30, 2022, SNL has a headcount of 14,163 employees.[1] Additionally, SNL had 1,792 students and 467 post-docs on-roll throughout FY 2022. The average age of SNL's workforce is approximately 44 years, and 17 percent of the population is eligible for retirement. The average years of service is 9.7, and the population is heavily concentrated among those with 1–15 years of service. Currently, 78 percent of employees have 15 or less years of service, which reflects the hiring of 6,031 hires including both regular and limited-term

Early Engagement in FY 2022
Students: 1,791
Post-doctorates: 467

[1] Beginning FY 2022, all current year figures will include regular and limited term employees. Prior years' data does not include limited term employees.

employees over the past 5 years. Within SNL's workforce, 52.5 percent of the workforce have advanced degrees, of which 16.3 percent have PhDs and 36.2 percent have master's degrees.

From the figures below, the data illustrates a relatively even age distribution for the workforce, with the years of service clustered between 0 and 15 years. Each age group brings a unique skillset to SNL, creating a balanced workforce. The mix of both experienced and new college graduates assure that the necessary skills and capabilities are present to support SNL's mission work. A substantial percentage of employees are in earlier phases of their careers to replace those in later career phases, requiring an increased focus on knowledge transfer and training programs. Forty-six percent of employees have 5 or less years of service and 78 percent of employees have 15 or less years of service.

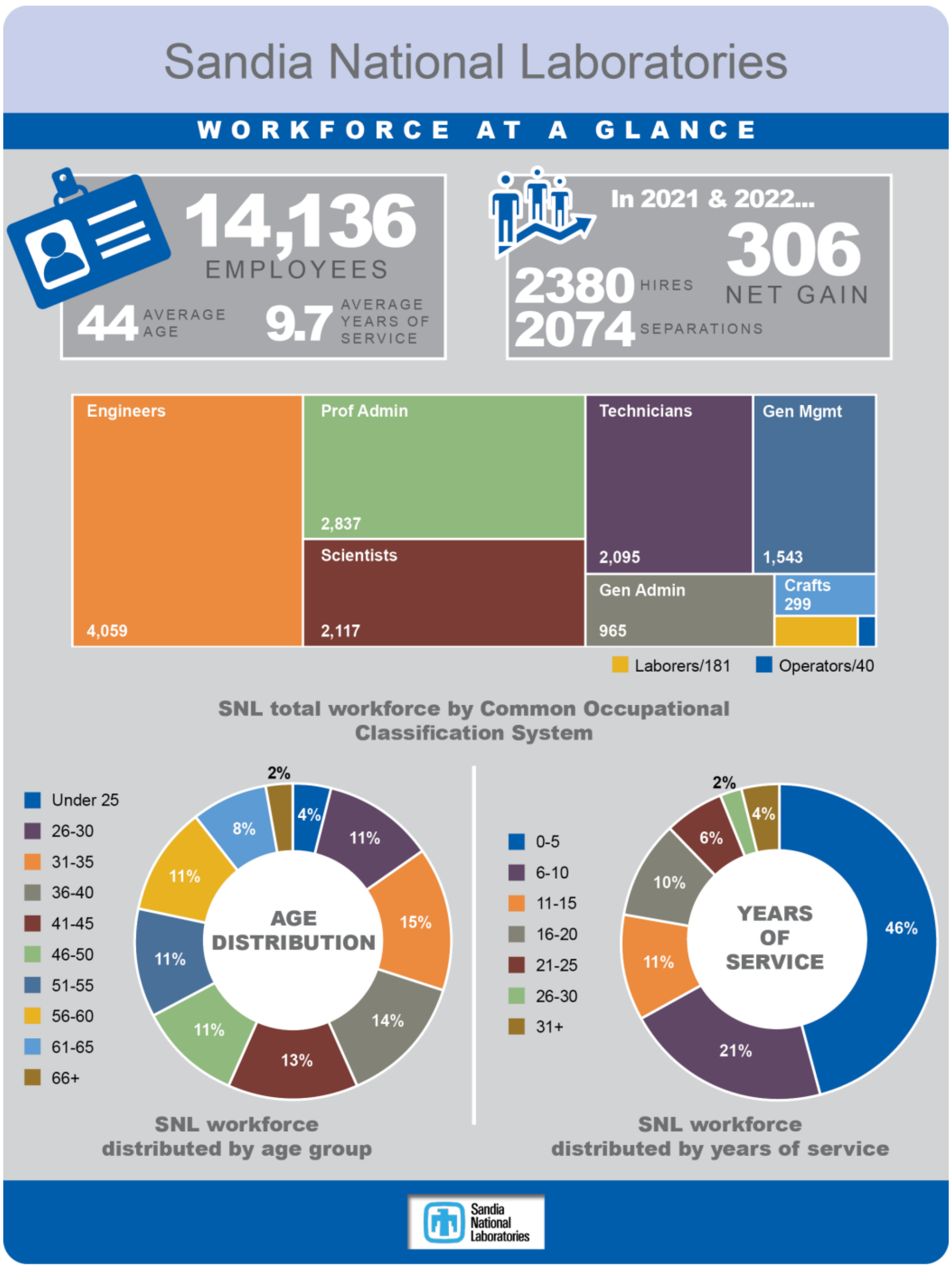


Figure F–13 illustrates separations by years of service, with most separations occurring due to retirements for employees with higher years of service and voluntary separation of employees with less than 10 years of experience. Most separations involve retirements among those 51 years of age or older and voluntary separations for early career age groups. High numbers of retirements are reflected in the age groups between 56 and 65 years of age, which represents 79.6 percent of retiring employees. Retirements were higher among those with 21–45 years of service, while a significant number of voluntary separations occurred among those with 0–5 years of service. Specifically, of the voluntary employee separations, 62.3 percent had 5 or less years of service, 91.4 percent for 10 or fewer years of service, and 97.3 percent had 15 or less years of service. This attrition may reflect the external demand for technical skills in a highly competitive market where SNL competes for talent. These workforce separations place increased importance on a relevant and acknowledged employee value proposition to draw talent from the external market as well as efficient and effective support processes, such as clearance process timeframes to get talent on mission work quickly. Another part of the solution to get talent started more quickly is internal training and knowledge transfer programs to enable new staff to engage and contribute on mission work. This separation population includes regular and limited term employees.

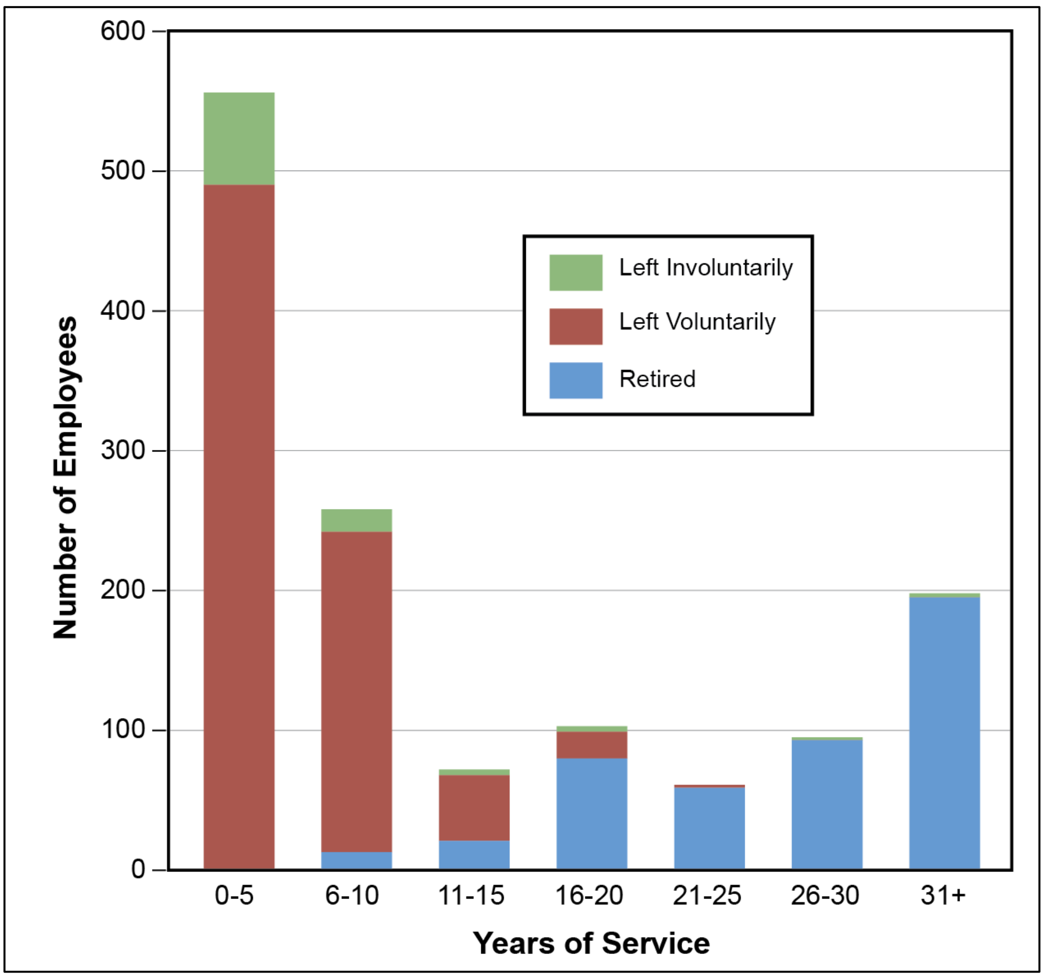


Figure F–13. SNL separations by years of service

Figure F–14 shows SNL's total workforce broken down by career stage defined by age groups. The trend line for the Advanced Career age group (employees over 51 years) is calculated as a percentage and is relative to the increase of workforce population.

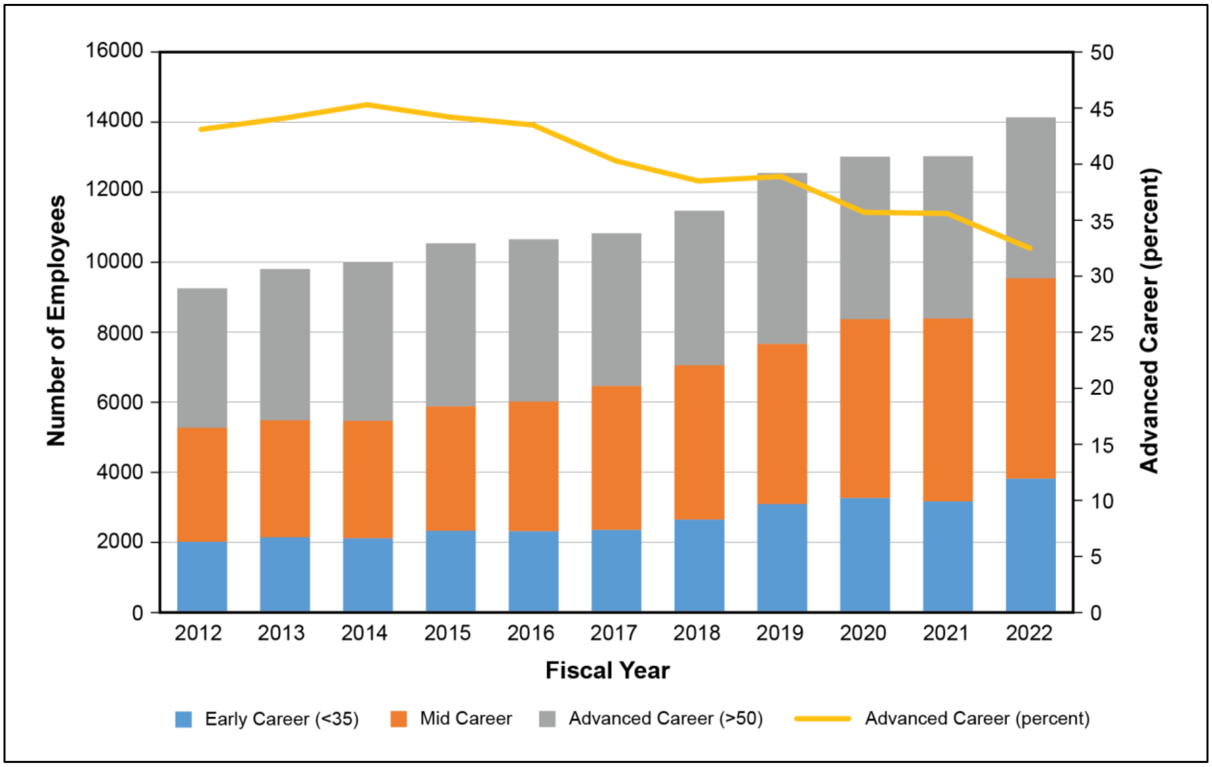


Figure F–14. SNL workforce participation trends by age career stage and percent advanced career

Figure F–15 provides SNL's retirement data from 2012 through 2022. The number of retirements were higher in FY 2011 and FY 2012 because of announced pending changes in retiree benefits, which prompted some employees to initiate retirement. The surge in retirement in FY 2011 and FY 2012 resulted in reduced retirements in FY 2013 and FY 2014. In FY 2015 through FY 2018, SNL returned to historical retirement rates. Total separations in FY 2021 increased as compared to the historical average. In FY 2022, both retirements and voluntary separations increased resulting from the pandemic; additionally, retirements increased potentially due to future retirement benefits changes and voluntary separations largely increased due to changes in the external job market.

Figure F–16 provides SNL's workforce outyear projection needs from 2024 through 2028.

Workforce is not only a function of workload but of retirements, separations, and internal movements as well. With SNL's current understanding of the FYNSP and resulting workload, SNL will monitor workload fluctuations and manage the stability of the workforce through leveraging Strategic Partnership Projects, temporary staffing options, cross-training within programs, and strategic hiring.

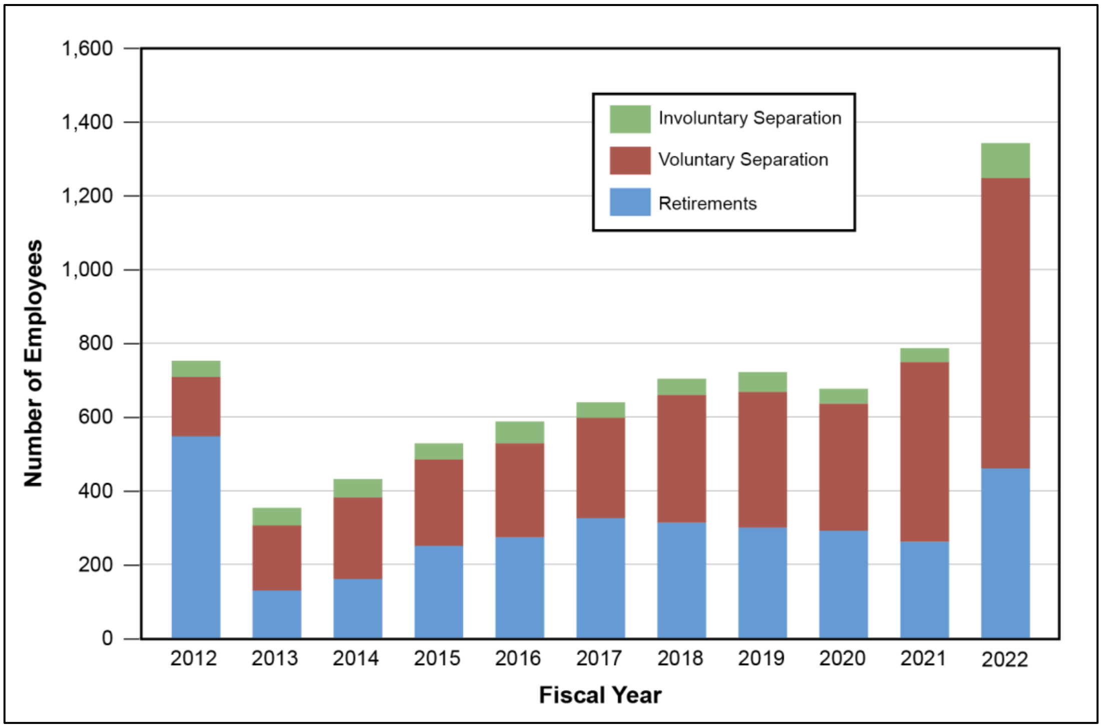


Figure F–15. SNL employee separation trends

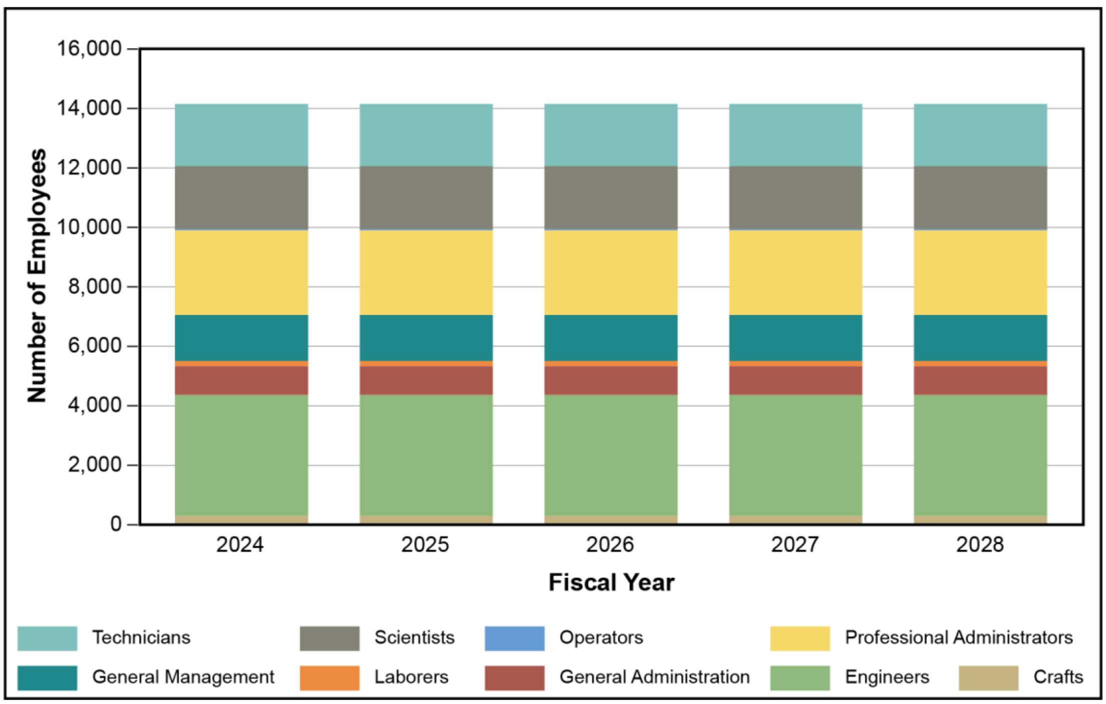


Figure F–16. SNL workforce projection needs by Common Occupational Classification System

F.3 Nuclear Weapons Production Facilities

F.3.1 Kansas City National Security Campus

F.3.1.1 Mission Overview

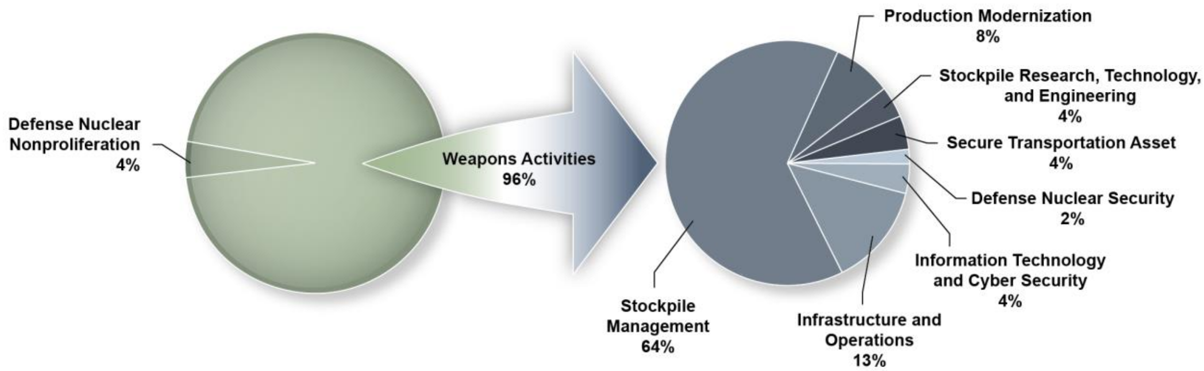
For over 70 years, the Kansas City National Security Campus (KCNSC) has supported national security objectives by providing exceptional solutions, managed operations, and targeted services through its diverse, inclusive, and talented workforce. Located in Kansas City, Missouri; Overland Park, Kansas; and Albuquerque, New Mexico, KCNSC is a trusted partner of NNSA and has earned a valued reputation of applying commercial best standards and driving innovations in engineering, manufacturing, and sourcing to fulfill its core mission supporting the safety, security, and reliability of the Nation's nuclear deterrent.

KCNSC provides essential weapons modernization production, supply chain management, production science and stockpile stewardship for the strategic deterrent, secure transportation systems, and support to other government agencies. These efforts include unclassified and classified product realization, external sourcing, receiving and inspection, environmental testing, long-term stockpile storage, and a wide range of support services. KCNSC manufactures or procures over 80 percent of non-nuclear components for the nuclear stockpile and emerging modernization systems. These products include radar systems; arming, fuzing, and firing (AF&F) systems; environmental sensing devices and stronglinks; gas transfer systems (GTSs); joint test assemblies (JTAs); specialty engineered material products; and electrical and mechanical components and assemblies for secure transportation vehicles and assets. Additionally, KCNSC produces items for stockpile support including DoD trainers, handling gear and field testers, code management systems, containers and military spares. Through collaboration with Design Agencies, KCNSC plays a crucial role in weapons modernization and sustainment from concept through design, production, delivery, and lifecycle management. In addition to its nuclear weapon programs mission, the site supports nuclear nonproliferation, emergency management, and counterterrorism missions. The site also supports a global security mission that involves developing and delivering field-ready engineering solutions for other government agencies' national security missions.

F.3.1.2 Funding

FY 2024 DOE request – site funding by source ***(total KCNSC FY 2022 request = $1,285 million)***

KCNSC split for the FY 2024 Weapons Activities President's Budget Request ***($1,231 million)***



F.3.1.3 Site Capabilities

KCNSC's capabilities support weapon systems currently in the stockpile and those being modernized via LEPs, Alts, and Mods. For legacy systems, these activities include Directed Stockpile Work in the management, production, processing, and delivery of hardware for limited life component exchanges and flight test systems; surveillance testing of components and materials; and maintenance and repair of weapons systems. For future stockpile systems, KCNSC's work scope includes development and maturation of manufacturing processes and technologies, production of prototypes to support design development, and manufacturing of components and systems.

KCNSC's capabilities are used to research and develop new materials for legacy and future stockpile systems. Production capabilities include over 40 manufacturing technologies and manufacturing over 1,000 unique product families, including AF&F devices; safing devices; electronics; machined parts; polymers; plastics; and other engineered materials. KCNSC also designs, develops, and produces associated support equipment, tooling, fixtures, and test equipment.

KCNSC provides capabilities integral to the Stockpile Stewardship Program and the Stockpile Responsiveness Program. KCNSC's primary capabilities and their associated challenges and strategies are described in **Table F–4**.

Table F–4. Kansas City National Security Campus capabilities

Non-nuclear Weapon Component Manufacturing and Assembly		
KCNSC is the primary site for manufacturing and procuring non-nuclear components including AF&F systems; GTSs; environmental sensing devices; strong links; and structural components and cushions made from engineered materials. The capability to manufacture and inspect these items depends on specialized equipment and facilities (cleanrooms, environmentally controlled areas, etc.) and the ability to maintain them (i.e., calibration and metrology). Mission success is highly dependent on an external and secure trusted supply chain.		
Challenges	***Strategies***	
	Current Strategy Being Implemented	***Future Strategies Needed***
• Insufficient manufacturing, storage and office space to support current Program of Record and preparation for future modernization programs in Kansas City and New Mexico.	• KC STEP is a series of construction activities in Buildings 2 and 3 and the addition of Building 23 to provide necessary factory capacity to support near term needs. KC STEP must be executed with minimal impact to existing production activities.	• KCNExT – a conceptual site plan for an expanded campus to consolidate existing office leases and provide additional manufacturing space to support long-term needs.

• Recruitment, retention, and availability of a skilled, diverse, and effective workforce.	• Develop long-term New Mexico plan for MGT, Integrated Surety Architecture Hub, weapon tester fabrication, and other emerging scope. • Streamline the recruiting, hiring, and onboarding processes. • Implement local and regional career fairs and other recruitment pipeline initiatives. • Deploy extended reality applications to safely and effectively enhance employee onboarding and training. • Leverage university partnerships to increase on-campus presence. • Expedite clearance processing. • Maximize onboarding efficiencies with training, certification, and working on unclassified product.	• Execute New Mexico plan. • Expand partnerships with Minority Serving Institutions, Military Collaboration programs, and Student Veteran Organizations. • Develop and deploy predictive analysis techniques to mitigate workforce fluctuations. • See Chapter 7, "Workforce," for enterprise workforce challenges and strategies.
Testing Equipment Design and Fabrication		
KCNSC designs and produces test equipment to support its mission and those of other sites within the nuclear security enterprise. Often, these test systems are integrated with various types of environmental conditioning equipment, such as thermal chambers or centrifuges, to perform automated testing for weapon environments. These test systems are vital to development, qualification, acceptance and long-term surveillance of weapon systems and components.		
Challenges	***Strategies***	
	Current Strategy Being Implemented	***Future Strategies Needed***
• Ability to staff appropriately in a dynamic business environment with a cyclical workload, which is very heavy during the development phases and lighter during the production phases. • DA-PA coordination and availability of definition and early hardware to support tester development. • Complexity of test systems to meet program requirements. New capabilities required by emerging programs (e.g., shock, vibration, combined environments). • Reduce the footprint required for production acceptance and surveillance test equipment • Decrease the cost and time to deliver new testers.	• Maintain the specialized workforce in this area, emphasize level loading of the workload to the extent possible, combined with flexibility in assignments. Provide increased opportunities for challenging work assignments. • Ensure milestones for test definitions and early hardware for tester development are included in weapon development schedules. • Incorporate multi-program, multi-product testers, common tester architecture, and tester miniaturization. Design test systems for full lifecycle support. • Incorporate model-based designs, digital information flow, simulation, and digital product realization within Test & Measurement. Upgrade design tools.	• Continue current strategies. • Be proactive in identifying and applying technologies and capabilities that offer solutions to enterprise issues. • Architect and deploy secure infrastructure to enable new technologies. • Further incorporate tester miniaturization, synthetic instrumentation.
Fabrication and Support of Secure Transportation Assets		
KCNSC prepares STA vehicles in its New Mexico facility, including fabrication, repair, and modification of tractors, trailers, and escort vehicles. KCNSC also supports design, fabrication, and maintenance of multiple system capabilities and facilitates safety engineering; technical documentation; and training of the Federal agents who perform STA functions.		
Challenges	***Strategies***	
	Current Strategy Being Implemented	***Future Strategies Needed***
• Inadequate manufacturing and development space to support MGT and future scope. • Manufacturability and sourcing limitations of future secure transportation programs, which could increase cost and schedule risks. • Implementing modifications and upgrades to existing STA systems for compatibility with Integrated Surety Architecture systems.	• Develop long-term New Mexico plan for MGT manufacturing. Includes support of ISA Hub, weapon tester fabrication and other emerging scope. • Continue partnering with design agencies to ensure that, early in the process, the design work incorporates lessons learned from past trailer production and manufacturability reviews and facilitate multiple-sourcing capabilities to reduce risks and costs.	• Implement long-term New Mexico plan. • Continue current strategies.

	• Early collaboration with design agencies to ensure manufacturability/sourcing risks are minimized.	
Weapon Component Surveillance and Assessment		
KCNSC supports surveillance and assessment of the Nation's nuclear weapons stockpile through enhanced testing of various weapon components and materials, as well as production of telemetry, JTAs, and other hardware for laboratory and flight testing. The results from those tests are used to demonstrate continued performance of stockpile systems and predict, detect, assess, and resolve aging trends and anomalies in the stockpile. New testing and evaluation methods are also developed and implemented.		
Challenges	***Strategies***	
	Current Strategy Being Implemented	***Future Strategies Needed***
• Long-term sustainment of testers to support weapon lifecycle surveillance requirements. • Engaging workforce in older technologies. • Material availability due to sunset technologies for legacy JTA programs.	• Execute the Surveillance Tester Sustainment Initiative plan. • Successfully execute hiring, retention, and knowledge preservation strategies. • Periodically update designs and modernize technology for JTA systems.	• Continue current efforts. • See Chapter 7, "Workforce," for enterprise workforce strategies.
Advanced Manufacturing		
KCNSC uses innovative technologies to maximize the efficiency and effectiveness of manufacturing processes and manufactured products. Some examples include Advanced Materials, Additive Manufacturing, Advanced Inspection Techniques, Digital Twins, Model-based Definitions, Modeling and Simulation, Automation, AI/ML, and Network and Connectivity.		
Challenges	***Strategies***	
	Current Strategy Being Implemented	***Future Strategies Needed***
• Many Advanced Manufacturing concepts require enhanced/expanded IT and data infrastructure to connect equipment, information systems and people and to store and perform analytics on data. • Attracting and retaining individuals in specific technology areas. • Materials are no longer available because of obsolescence or supplier interest.	• Deploy Digital Transformation tenants including Smart Factory, Next Generation Enterprise Resource Planning, Enterprise Information Management/Big Data, and Digital Engineering tools. • Partner with universities to identify and develop a pipeline of qualified candidates. • Re-engineer obsolete materials and use microreactors to produce specialty materials in the right quantities and improve safety.	• Deploy increased wireless use capabilities, connectivity, Radio Frequency Identification (commonly known as RFID) automated tracking, next generation Augmented Reality. • See Chapter 7, "Workforce," for enterprise workforce recruitment and hiring strategies. • Identify and leverage next generation disruptive technologies.

AF&F = arming, fuzing and firing
AI/ML = Artificial Intelligence/Machine Learning
DA-PA = design agency-production agency
GTS = gas transfer system
IT = information technology
JTA = joint test assembly
KCNExT = Kansa City Non-Nuclear Expansion
KC STEP = Kansas City Short-Term Expansion Plan
MGT = mobile guardian transporter
STA = Secure Transportation Asset

F.3.1.4 Accomplishments

- KCNSC achieved full rate production for B61-12 and W88 Alt 370.
- Kansas City Short-Term Expansion Program (KC STEP) research, development, testing, and engineering lab space completed early occupancy construction for equipment hotels, supporting test equipment, Nuclear Enterprise Assurance, and Collaborative Robot development work.
- KCNSC's Supply Chain Management Center saved $165 million across the enterprise against a goal of $109 million, exceeding goal by 51 percent.

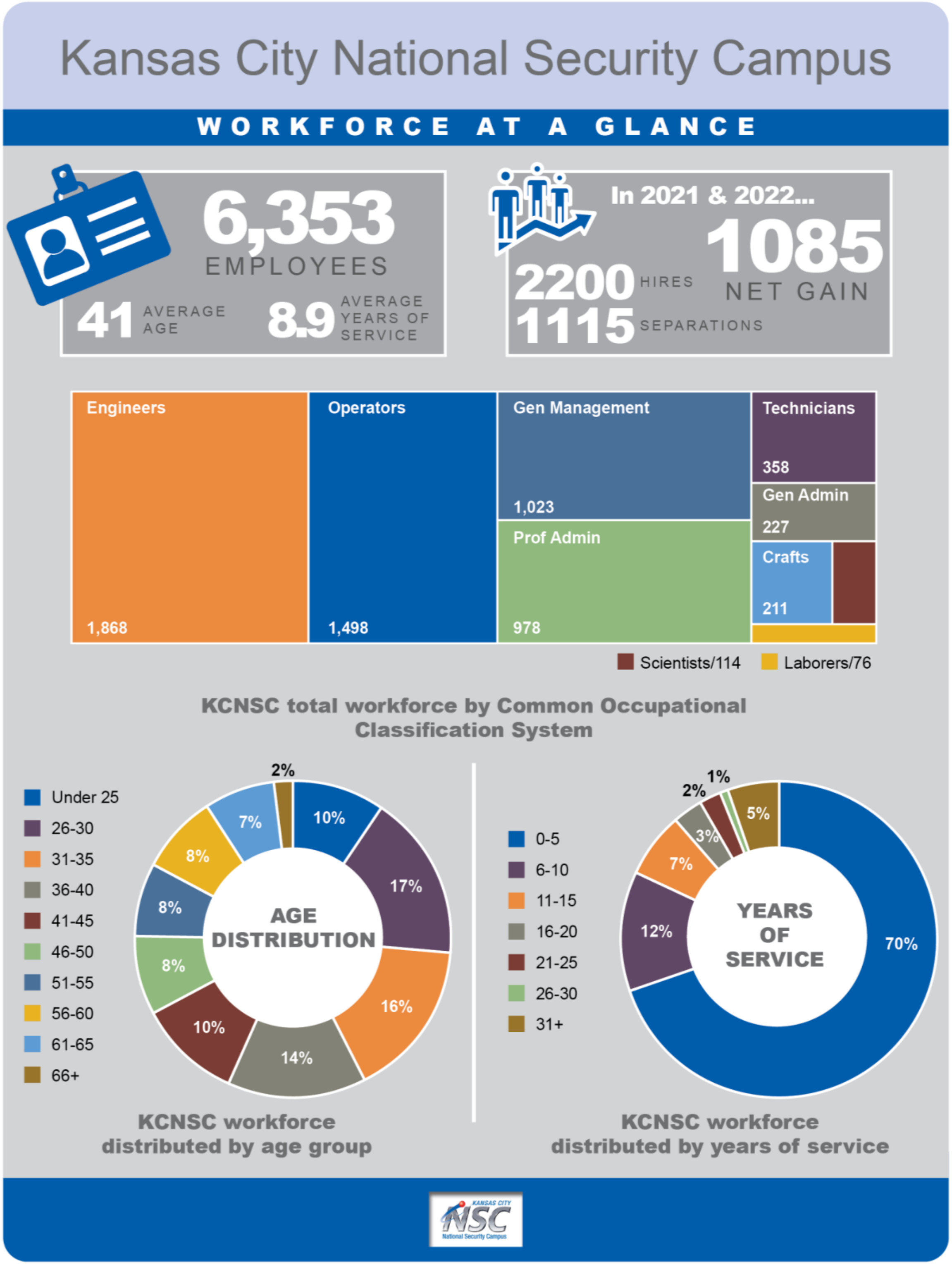
- KCNSC hired a record 1,430 external employees in FY 2022, significantly more than any of the last 3+ years, including hiring a record 103 interns. The last 4 months, KCNSC averaged 125 hires per month.
- KCNSC delivered components and assemblies to support achieving B61-12 System First Production Unit one week ahead of schedule.
- KCNSC completed last production unit deliveries for W76-1/Mk4A products in calendar year 2022.
- KCNSC established the capability to create next generation Direct Ink Write tooling by 3D-printing of Carbon Fiber-Polyetherketoneketone mandrels. This process saves 80 days of flow time and $50,000 for each mandrel relative to the legacy machined aluminum mandrels. Test Engineering Dashboard technologies enabled avoidance of over 2,600 non-conformance-report-eligible events.
- KCNSC developed a joint strategy for 3D Interactive Viewable end-to-end production demonstration and provided SNL with information to inform improvements in the model-based product definition effort. SNL is also leveraging Model Based Definition for mechanical part design and definition by generating higher quality CREO models with 3D annotations that allow earlier design feedback from KCNSC.
- KCNSC introduced Curie, its latest high-powered computer, which doubled its computing capacity and supports advanced simulations needed to help solve some of the nation's most complex national security challenges.
- KCNSC achieved Auxiliary Module first production unit for W88 Alt 940 12 days ahead of schedule and shipped to the customer 5 days ahead of schedule, beginning production of critical Integrated Surety Architecture components.
- KCNSC achieved first production unit for MC4972-1 Common High Efficiency Adaptable Telemetry Transmitter 1 month early; the Common High Efficiency Adaptable Telemetry Transmitter is a multi-program JTA transmitter.
- KCNSC deployed big data solutions, including the Test Engineering Dashboard, to monitor test system health using data science and artificial intelligence to avoid over 2,600 non-conformance-report-eligible tester events in FY 2022 as well as a system to perform automated analysis and anomaly detection of Record of Assembly data which has virtually eliminated Record of Assembly-related escapes.

F.3.1.5 Kansas City National Security Campus Workforce

Total headcount at KCNSC continues to grow year over year to support its growing scope of new LEP and Mod programs. KCNSC hired a record number of 1,430 new employees in FY 2022 and has more than doubled its headcount over the last 6 years. KCNSC continues to leverage an increased focus on university and industrial partnerships, recruiting and hiring events, and streamlining hiring and onboarding processes to support this growth. Modest growth is expected to continue in the coming years.

Early Engagement in FY 2022
Interns: 112

The average age of employees at KCNSC continues to decrease, going from 41.8 at the end of FY 2020 to 40.9 at the end of FY 2022. Employees 35 years of age and under account for 42.7 percent of all employees, and 56.9 percent are age 40 and younger. Average years of service at KCNSC remains relatively flat, increasing from 8.34 in FY 2020 to 8.85 in FY 2022, and years of service distribution is shown below. Employees that are retirement eligible decreased from 16 percent in FY 2020 to 12 percent in FY 2022.


Kansas City National Security Campus
WORKFORCE AT A GLANCE
6,353 EMPLOYEES
41 AVERAGE AGE
8.9 AVERAGE YEARS OF SERVICE
In 2021 & 2022...
2200 HIRES
1115 SEPARATIONS
1085 NET GAIN
Engineers 1,868
Operators 1,498
Gen Management 1,023
Prof Admin 978
Technicians 358
Gen Admin 227
Crafts 211
Scientists/114
Laborers/76
KCNSC total workforce by Common Occupational Classification System
Under 25
26-30
31-35
36-40
41-45
46-50
51-55
56-60
61-65
66+
AGE DISTRIBUTION
10%
17%
16%
14%
10%
8%
8%
8%
7%
2%
KCNSC workforce distributed by age group
0-5
6-10
11-15
16-20
21-25
26-30
31+
YEARS OF SERVICE
70%
12%
7%
3%
2%
1%
5%
KCNSC workforce distributed by years of service
KANSAS CITY NSC National Security Campus

Most of the voluntary separations (45.5 percent of all separations) come from the age group of 26–40, and retirements accounted for 20.4 percent of all separations. Two-thirds (66.3 percent) of all separations were from employees with 5 years of service or less at KCNSC and more than three quarters (77.4 percent) of all separations were from employees with 10 years of service or less at KCNSC, as shown in **Figure F–17**. Voluntary separations increased from 182 in FY 2020 to 504 in FY 2022, likely attributable to the ending of the COVID-19 pandemic and changes in the job market.

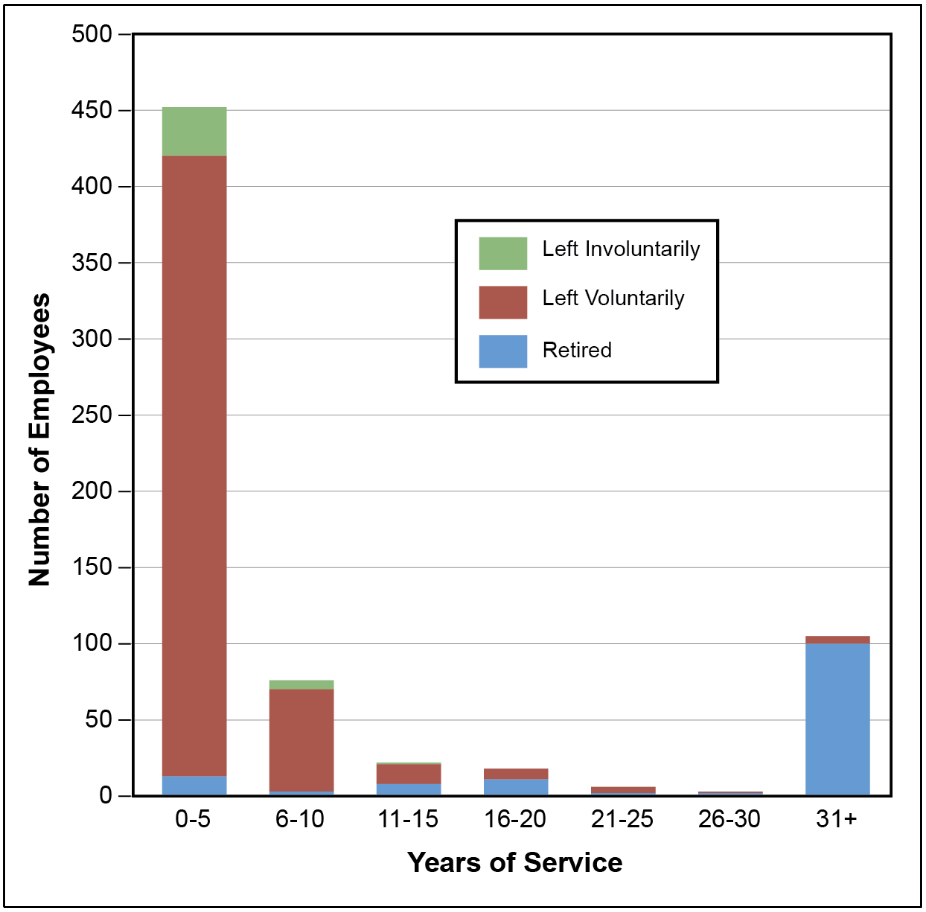


Figure F–17. KCNSC separations by years of service

A substantial portion (nearly 75 percent) of the workforce at KCNSC are in the early- and mid-phases of their careers in the nuclear security enterprise, as shown in **Figure F–18**. Nearly 70 percent of employees have 5 years of service or less at KCNSC, and 82.1 percent have 10 years or less of service. KCNSC is taking active steps to preserve and transfer knowledge from those with significant experience in the nuclear security enterprise. The People Center of Excellence at KCNSC has established a Knowledge Management Team to establish processes for preserving knowledge before subject matter experts with over 30 years of experience retire. Prototypes for some of these efforts were developed in FY 2022; testing with pilot groups continued through FY 2023.

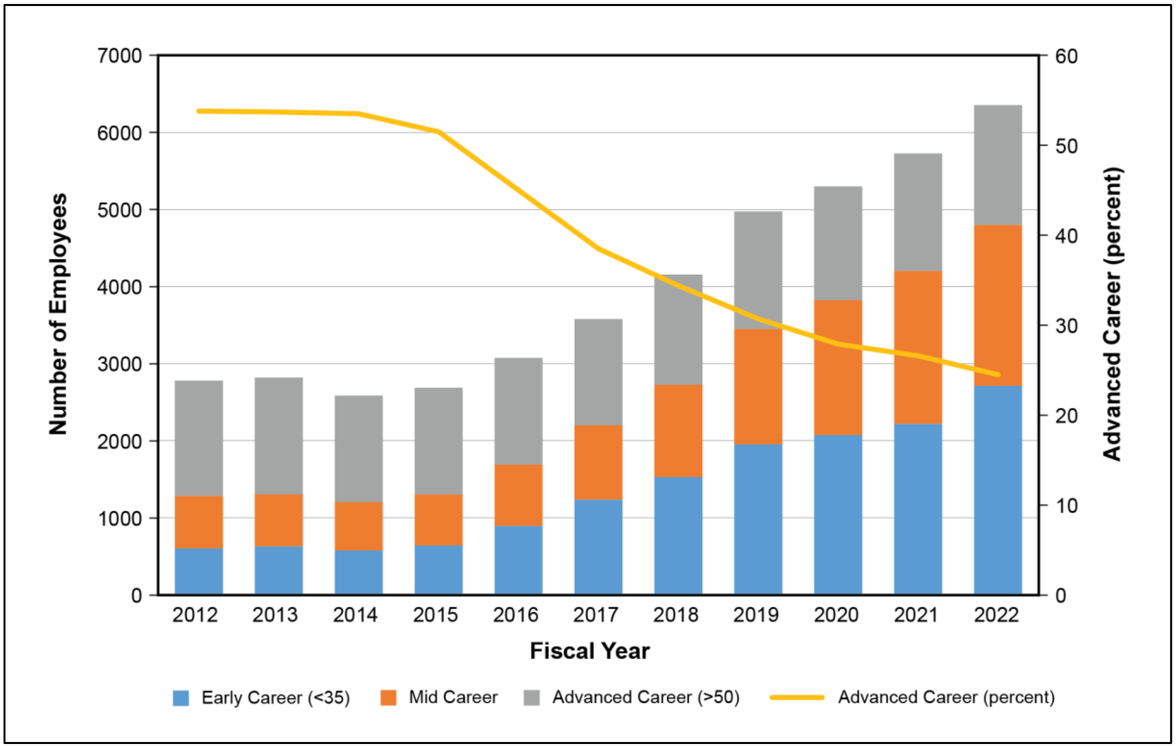


Figure F–18. KCNSC workforce participation trends by age category and percent advanced career

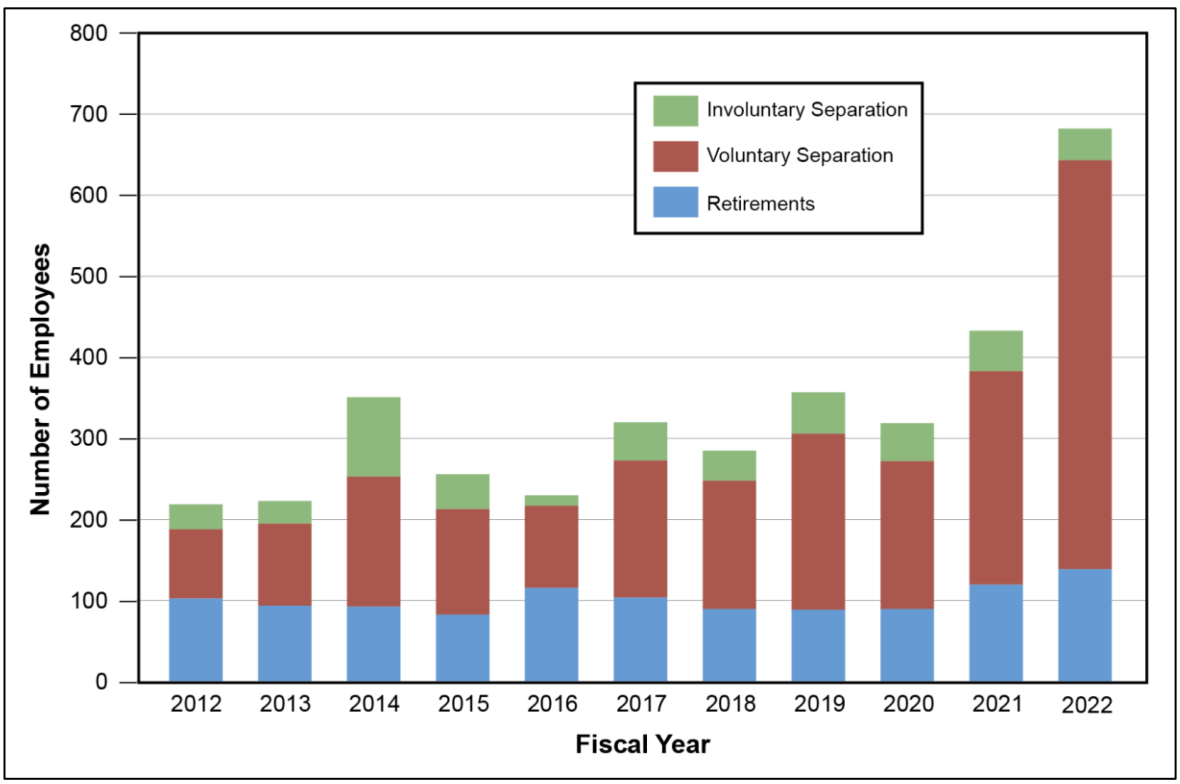


Figure F–19. KCNSC employee separation trends

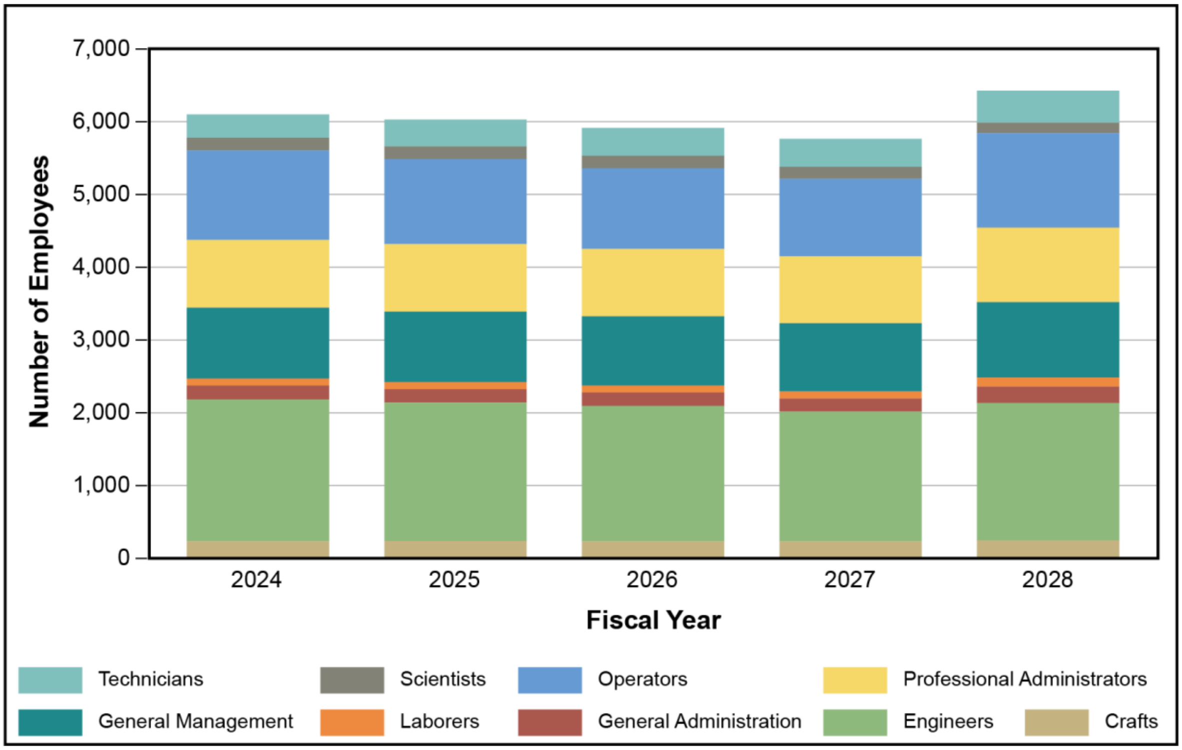


Figure F–20. KCNSC workforce projection needs by Common Occupational Classification System[1]

[1] Facilities and infrastructure are a limiting factor on workforce growth. Projections reflect early business cycle preliminary estimates.

F.3.2 Pantex Plant

F.3.2.1 Mission Overview

Pantex Plant (Pantex) is integral to national security interests and has adapted to emerging needs and delivered solutions for the Nation for more than 75 years. Pantex, located outside of Amarillo, Texas, is the only DOE/NNSA site authorized to assemble or disassemble nuclear weapons. The Weapons Assembly/Disassembly capability is central to nuclear weapons production, and this includes assembly, disassembly, refurbishment, maintenance, alteration, and surveillance of stockpile nuclear weapons and weapon components, as well as dismantlement of retired stockpile nuclear weapons.

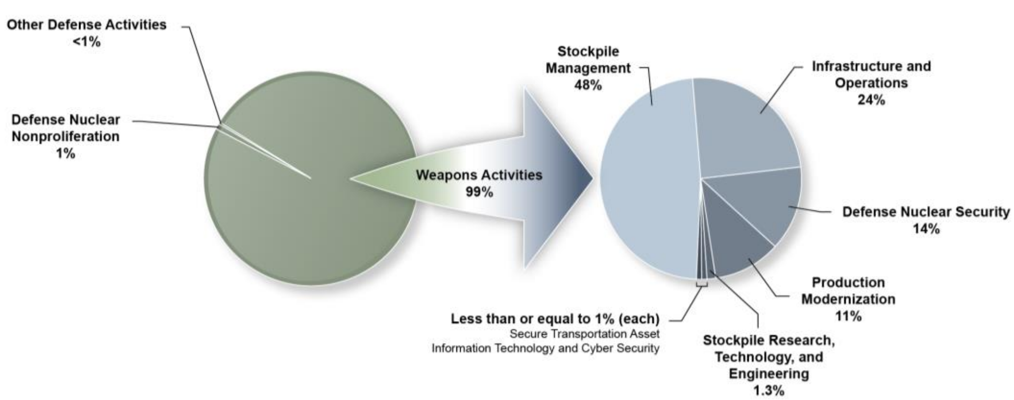
As DOE/NNSA's High Explosive Production Center of Excellence, Pantex provides cradle-to-grave HE products and services for the nuclear security enterprise. Pantex manufactures and delivers War Reserve HE main charges and boosters for all weapon programs through synthesis; formulation; pressing; machining; component assembly; and chemical, mechanical, safety, and performance testing. Pantex also tests stockpile returns for all weapon programs through small component disassembly; machining; chemical, mechanical, performance, and safety testing; and final disposition. As a collaborative partner with the national security laboratories, Pantex provides capabilities to transition HE R&D from bench-scale to production-scale. In addition, Pantex collaborates and provides capabilities to DoD, the United Kingdom, universities, and commercial vendors.

Pantex also supports the reduction of global nuclear threats through its nonproliferation activities.

F.3.2.2 Funding

FY 2024 DOE request – site funding by source
(total Pantex FY 2024 request = $1,209 million)

Pantex split for the FY 2024 Weapons Activities President's Budget Request *($1,196 million)*



F.3.2.3 Site Capabilities

Pantex's mission capabilities include manufacture of specialty explosives; fabrication and testing of HE components; assembly, disassembly, refurbishment, maintenance, alteration, and surveillance of stockpile nuclear weapons and weapon components; dismantlement of retired weapons; sanitization and disposition of components from dismantled weapons; interim staging and storage of nuclear components from dismantled weapons; pit requalification; pit surveillance; and pit packaging (including container surveillances and recertification).

Pantex's key capabilities and their associated challenges and strategies are described in **Table F–5**.

Table F–5. Pantex Plant capabilities

Weapons Assembly and Disassembly		
Assembly and disassembly of nuclear explosive warheads and bombs, assembly and post-mortem analysis of JTAs, assembly and disassembly analysis of test bed units, and electrical and mechanical tests of weapons and weapon components.		
Challenges	***Strategies***	
	Current Strategy Being Implemented	***Future Strategies Needed***
Development, establishment, and implementation of the Documented Safety Analysis process for new programmatic weapons activities.	While vast improvements have been made, continue to streamline the Documented Safety Analysis process methodology for efficiency and effectiveness.	Continue current strategy.
Weapons Assembly/Disassembly facilities continue to age and will require replacement at some point.	• Continue modernizing the existing bays and cells. • Conduct aging studies and develop strategy and required timing for replacement of bays and cells with new, modern assembly/disassembly facilities.	Continue current strategies.
Surveillance		
Nondestructive evaluation of pits and weapon components from stockpile units to support the Annual Assessment Reports and destructive and nondestructive evaluation of HE from stockpile units.		
Challenges	***Strategies***	
	Current Strategy Being Implemented	***Future Strategies Needed***
Production downtime associated with aging pit surveillance equipment.	Develop and evaluate options for upgrading or acquiring replacement equipment.	Continue current strategy.
High Explosives		
Pantex is responsible for conventional HE and insensitive HE manufacturing, qualification, and assembly for LEPs and stockpile rebuilds; disassembly and disposition of HE from surveillance and dismantlement units; and manufacturing, and qualification, and assembly of mock HE for JTAs.		
Challenges	***Strategies***	
	Current Strategy Being Implemented	***Future Strategies Needed***
Programmatic infrastructure (i.e., equipment) is aging, and some of the general-purpose infrastructure (i.e., buildings) is Manhattan-era.	• Planned projects such as the HE Science and Engineering; HE Synthesis, Formulation, and Production; and the HE Component Assembly facility are recapitalizing end-of-life equipment needs and establishing major modernization plans. • Continue replacement of end-of-life HE machining equipment.	Continue line-item planning, and coordination with DOE/NNSA. Initiate construction of replacement HE facilities as capacity allows.

Special Nuclear Material Accountability, Storage, Protection, Handling, and Disposition		
These capabilities involve requalification for pits for LEPs and storage of pits and weapons.		
Challenges	***Strategies***	
	Current Strategy Being Implemented	***Future Strategies Needed***
Pit storage capacity to support future directed stockpile work and production downtime associated with aging pit requalification equipment.	Implement pit staging projects to reconfigure operational facilities to increase the site storage capacity to address near-term staging constraints until the Material Staging Facility project is re-started. Implement actions to revitalize Zone 4 infrastructure to ensure staging capabilities are sustained until Material Staging Facility completion. Deploy new requalification equipment for upcoming LEPs. Upgrade existing requalification equipment.	• Continue implementation of pit staging projects and equipment upgrades. • Continue implementation of the Zone 4 Bridging Strategy Implementation Plan.

HE = high explosive LEP = life extension program
JTA = joint test assembly

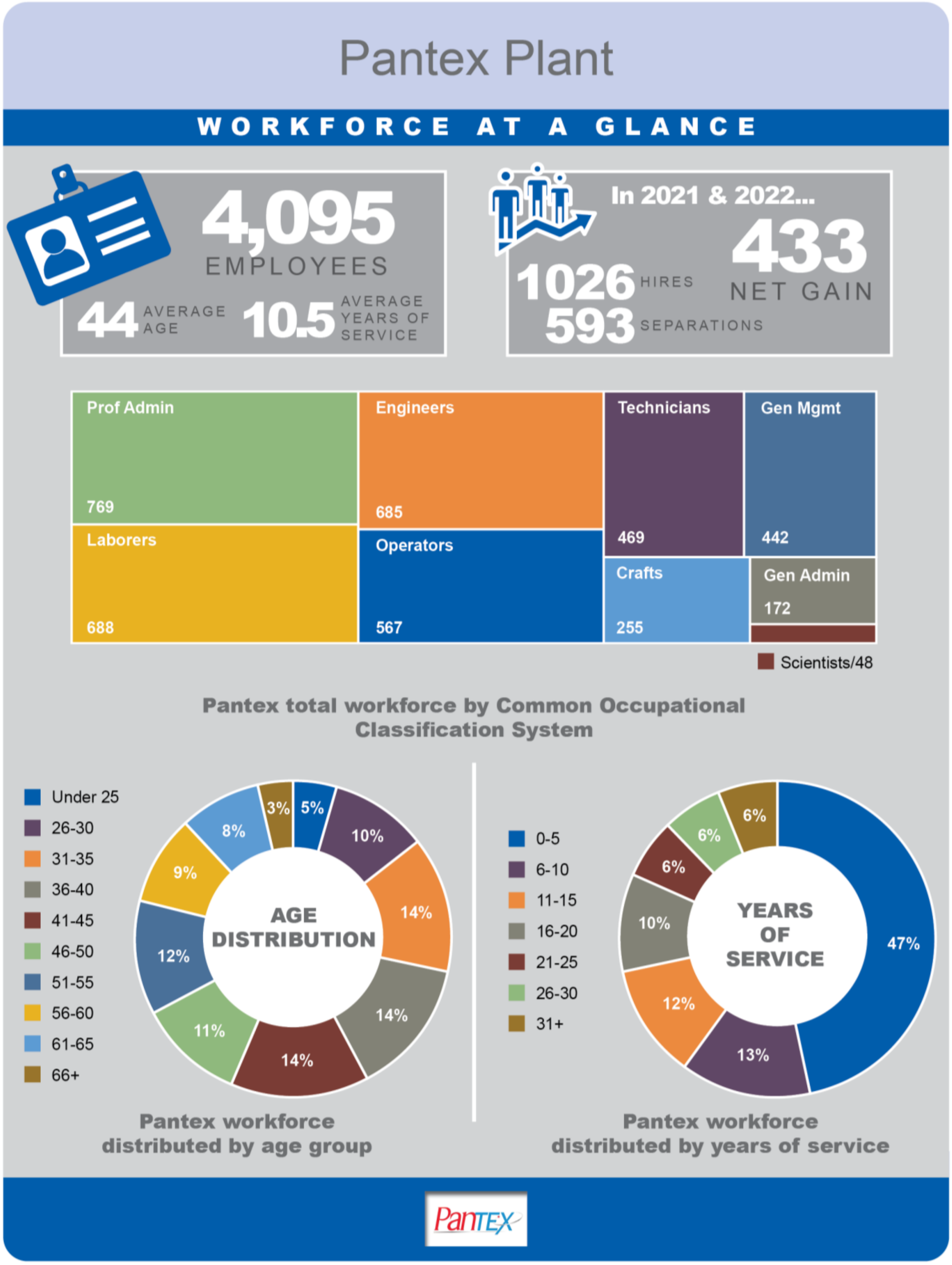
F.3.2.4 Accomplishments

- Completed the first production unit for the B61-12; completed the B61-12 JTA first production unit at Pantex.
- Met all external shipment commitments to DoD customers.
- Pantex shipped initial operational capability quantities for the W88 Alt 370 to the Navy, on schedule, representing a significant accomplishment for the nuclear security enterprise.
- Exceeded canned subassembly dismantlement schedule.
- Established the Pantex Production Optimization, a cross-functional team created to maximize the output of Pantex production for near-term Directed Stockpile Work deliverables and to ensure sustainable stewardship of future Directed Stockpile Work deliverables at the site.
- HE Science and Engineering Facility: Critical Decision (CD)-2/3 authorization was received in April 2022, and the main construction subcontract was awarded in April 2022.
- Construction continues on schedule for the Advanced Fabrication Facility, which will provide expanded capability for non-hazardous machining operations, thereby expanding capacity for hazardous material machining in the HE facilities.
- The Flexible Support Facility, which provides housing for around 90 personnel for on-site project and maintenance teams, held a ribbon-cutting in February 2023.

F.3.2.5 Pantex Plant Workforce

Total headcount has continued to increase year over year, from 3,807 at the end of FY 2021 to 4,095 at the end of FY 2022. Significant recruiting and hiring efforts replaced vacancies from attrition and built the technical skill base in preparation for the increased workload in FY 2022 and beyond. The workforce has a fairly even age distribution while recent increases in hiring mean that almost half of employees have less than 5 years of service with 18.6 percent of full-time employees are eligible for retirement.[1]

[1] Retirement eligibility is calculated with the following method: Age 55 with 10 years of service, age 65 with 5 years of service, or Pantex exempt/nonexempt age 50 with 10 years of service.


Pantex Plant
WORKFORCE AT A GLANCE
4,095 EMPLOYEES
44 AVERAGE AGE
10.5 AVERAGE YEARS OF SERVICE
In 2021 & 2022...
1026 HIRES
593 SEPARATIONS
433 NET GAIN
Prof Admin 769
Engineers 685
Technicians 469
Gen Mgmt 442
Laborers 688
Operators 567
Crafts 255
Gen Admin 172
Scientists/48
Pantex total workforce by Common Occupational Classification System
AGE DISTRIBUTION
Under 25 5%
26-30 10%
31-35 14%
36-40 14%
41-45 14%
46-50 11%
51-55 12%
56-60 9%
61-65 8%
66+ 3%
Pantex workforce distributed by age group
YEARS OF SERVICE
0-5 47%
6-10 13%
11-15 12%
16-20 10%
21-25 6%
26-30 6%
31+ 6%
Pantex workforce distributed by years of service
Pantex

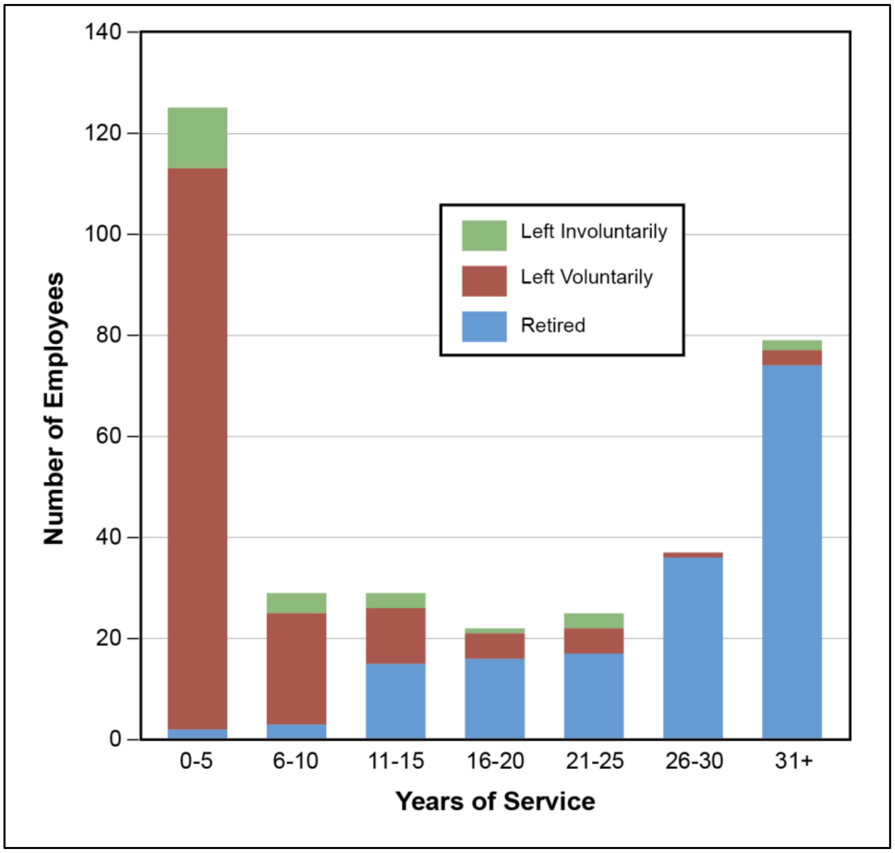


Figure F–21. Pantex separations by years of service

As shown in **Figure F–22**, Mid-Career continues to comprise the largest age category; for the first time in 10 years, workforce participation in the 35-to-50-year-old range surpassed over 50-year-old employee participation. Early Career continues increasing with hiring, while Advanced Career slowly decreases.

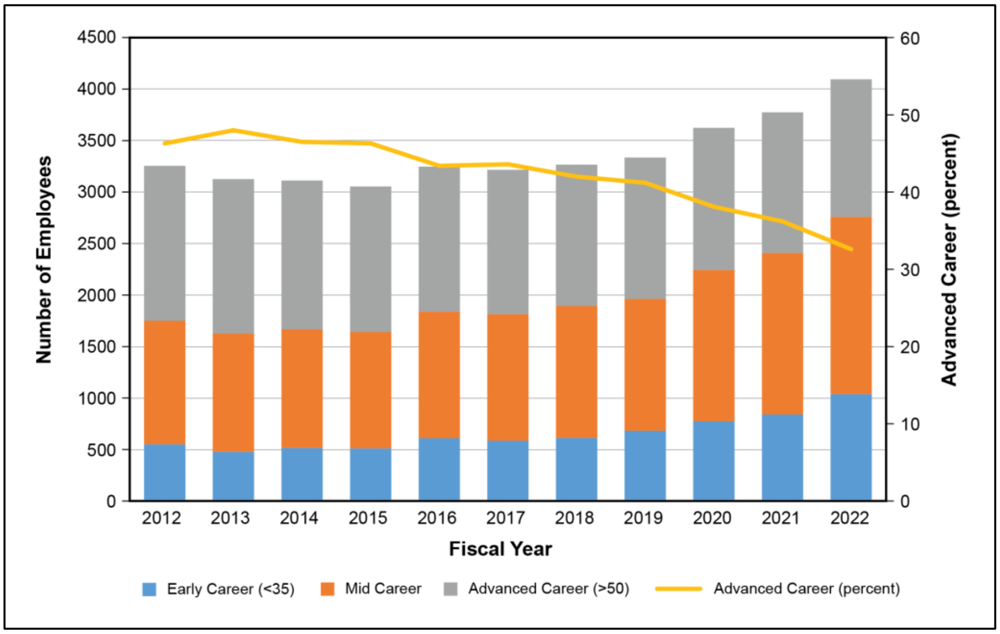


Figure F–22. Pantex workforce participation trends by age category and percent advanced career

As **Figure F–23** shows, over half of separations are due to retirements. The average age of retirees is increasing as more retirement-eligible employees are electing to work longer, and many workers choose not to retire until after age 66 so they can receive full social security benefits. Pension plans were phased out for new hires around 2012 and were replaced by enhanced 401(k) plans. Voluntary separations continue trending upwards, and retention efforts are ongoing. Involuntary terminations have returned to pre-COVID-19 pandemic levels.

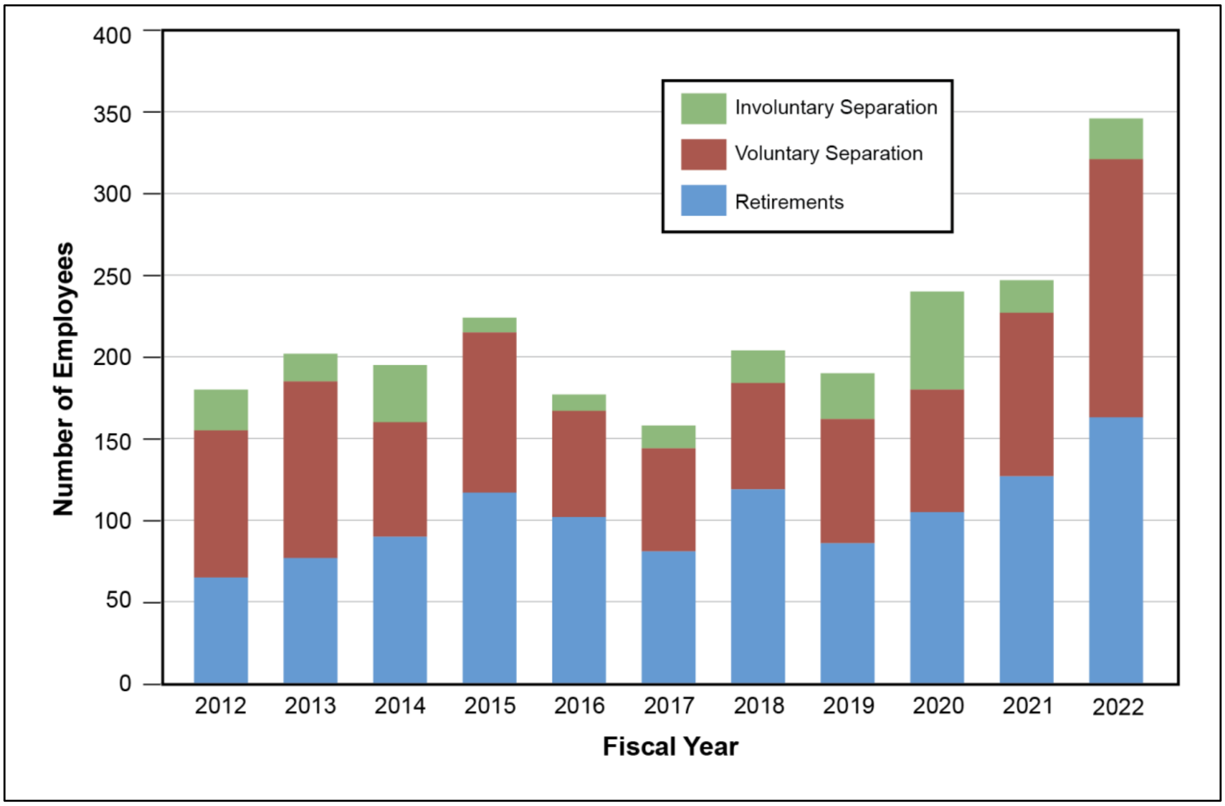


Figure F–23. Pantex employee separation trends

Workforce projections, shown in **Figure F–24**, are now made using a robust suite of human resource management tools; in FY 2021 the Multi-Year Staffing Plan for Headcount was integrated to the suite of tools, improving their accuracy. While the total estimated number of personnel needed to support work in the near term is relatively static, Pantex anticipates hiring for attrition replacement, with emphasis on engineers, safety basis, information technology, technicians, and security. Crafts, technicians, and administrators typically have lower attrition, while engineers have higher attrition due to high national demand. Pantex is working with Oak Ridge Associated Universities through the Supply Chain Management Center to improve sourcing and recruiting capabilities and is working with local students to expose them to Pantex's unique mission.

Early Engagement in FY 2022

Students: 18

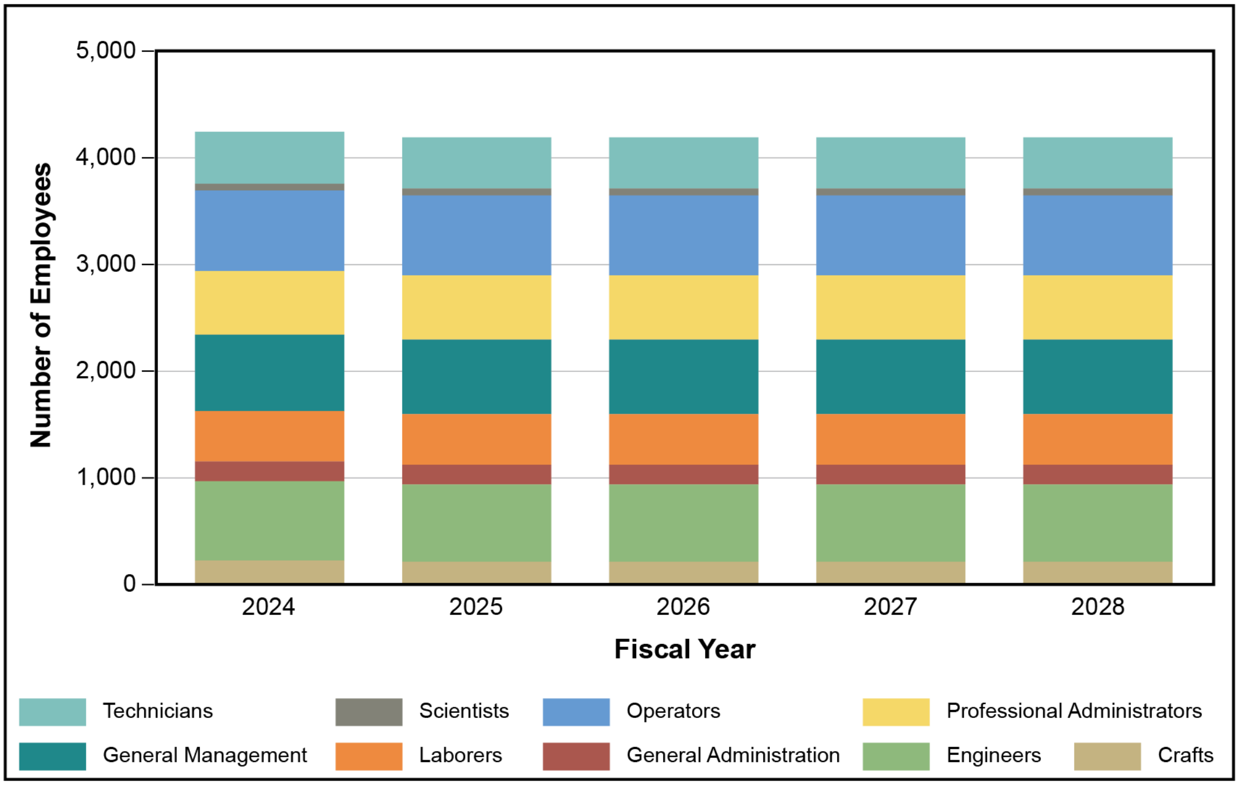


Figure F–24. Pantex workforce projection needs by Common Occupational Classification System[2]

[2] FY 2024 and FY 2025 headcount is based on actual FY 2024 program plans and anticipated funding for FY 2025 scope. Projections for FY 2026 and beyond reflect a stable work scope and funding, pending finalization of outyear funding projections.

F.3.3 Savannah River Site

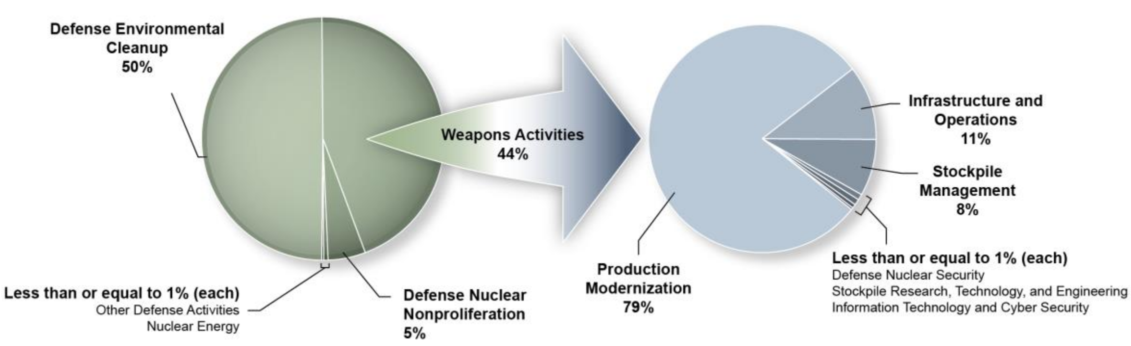
F.3.3.1 Mission Overview

The Savannah River Site (SRS), which spans Aiken, Allendale, and Barnwell Counties in South Carolina, includes mission areas in tritium supply, stockpile maintenance, stockpile evaluation, tritium R&D, and helium-3 recovery. Missions at SRS are also expanding to include plutonium pit production through the Savannah River Plutonium Processing Facility (SRPPF). SRS is managed by the DOE Office of Environmental Management with DOE/NNSA as a tenant, making it unique across the nuclear security enterprise sites. Approximately 58 percent of the SRS M&O workforce is dedicated to NNSA missions. DOE/NNSA pays its share of an indirect allocation for personnel to maintain infrastructure and services (e.g., roads, steam, fire water, electricity, medical, emergency services personnel). Of note, DOE/NNSA plans to take over managing SRS over the next 2–3 years. A transition team consisting of NNSA-Headquarters and Savannah River Field Office personnel is currently working all plans necessary to complete this effort. The scope of the Office of Defense Programs work resides in the Savannah River Tritium Enterprise[1] (SRTE), which is managed as a separate entity within SRS, and through the Plutonium Sustainment Program and the planned SRPPF.

F.3.3.2 Funding

FY 2024 DOE request – site funding by source *(total SRS FY 2024 request = $3,045 million)*

SRS split for the FY 2024 Weapons Activities President's Budget Request *($1,347 million)*



[1] SRTE is the collective term for the facilities, capabilities, people, and expertise at SRS related to tritium, and the SRTE umbrella extends beyond the tritium area to include vital mission-support functions. Unless otherwise noted, the information in this appendix will reference SRTE.

F.3.3.3 Site Capabilities

SRS has unique capabilities related to nuclear weapon limited life components (LLC) and the broader national security mission of reducing global nuclear security threats to the United States and its allies. Tritium is a critical component of the Nation's defense systems and must be continually replenished to meet deterrent needs. SRS conducts large-scale tritium operations, and SRTE is the DOE/NNSA Center of Excellence Involving Large Quantities of Tritium. To sustain the tritium inventory, tritium is obtained from two sources: recovery from end-of-life GTS reservoirs that are returned to SRS and extraction from irradiated tritium-producing burnable absorber rods (TPBARs) received from the Tennessee Valley Authority.

SRPPF will support plutonium pit production by repurposing the former Mixed Oxide Fuel Fabrication Facility (MFFF) into a safe, secure, compliant, and efficient pit production facility. The former MFFF is a Security Category 1/Hazard Category 2 structure that provides an opportunity to achieve pit production in a facility designed to meet stringent security and safety requirements for plutonium operations. As described in Chapter 3, Section 3.1.1.3, SRPPF will provide a sustained production capacity of no fewer than 50 War Reserve ppy as close to 2030 as possible.

SRS's key capabilities and associated challenges and strategies are described in **Table F–6**.

Table F–6. Savannah River Site capabilities

Tritium Recycling (Tritium Recycle and Recovery Program)		
Systems for recovering and recycling tritium from returned GTS reservoirs.		
	Strategies	
Challenges	***Current Strategy Being Implemented***	***Future Strategies Needed***
Tritium inventory systems contain LLCs, many of which are nearing life expectancy. Recovering the contents of the LLCs requires careful planning and coordination to avoid mission interruption.	In the short-term, schedule replacement projects to maximize efficiency and reduce impact on operating schedules.	In the long-term, deploy new technologies to enhance system operating efficiency and reduce footprint.
Tritium Extraction (Tritium Modernization Program)		
Tritium extraction from irradiated TPBARs.		
	Strategies	
Challenges	***Current Strategy Being Implemented***	***Future Strategies Needed***
To meet supply requirements, SRTE requires additional workforce with training, qualifications, and proficiencies.	SRTE examines multi-year staffing needs and develops appropriate processes to ensure a continuous pipeline of knowledge, skills, and abilities to sustain tritium capabilities.	Continue to examine multi-year staffing needs and work on retention of current employees through leadership engagement and focus on career development.
Replenishing Tritium in Gas Transfer System Reservoirs		
Replenishing tritium in GTS reservoirs.		
	Strategies	
Challenges	***Current Strategy Being Implemented***	***Future Strategies Needed***
Maintain facilities and equipment to support stockpile deliverables and future warhead modernization activities.	SRTE uses a strategic investment process and prioritizes its infrastructure needs to ensure mission continuity. Priorities are identified through engineering analysis and risk assessment, vetted by leadership teams, and captured on a strategic roadmap and integrated priority list. This process also includes infrastructure and equipment improvements.	Continue current strategy.

Addressing infrastructure needs in a high-hazard area without interrupting the mission schedule while adapting for multiple, more complex operations.	SRTE is modifying the process and infrastructure equipment and executing a strategic investment process to ensure continuity. SRTE is also evaluating critical systems to ensure optimal product capacity while carefully planning the production outages to maximize benefit. Obsolete systems are being replaced to ensure adequate risk until long term plans are completed.	Completing the Tritium Finishing Facility will reduce mission risk and provide long-term, safe operations.
Gas Transfer System Surveillance and Tritium Research and Development		
SRTE function testing for GTS surveillance and tritium R&D.		
Challenges	***Strategies***	
	Current Strategy Being Implemented	***Future Strategies Needed***
Maintaining original, specialty engineered equipment.	SRTE is initiating R&D projects in a clean environment to test specialty engineered equipment for future facility application. Planning extended outages to incorporate rework if needed due to tritium environment.	Develop Tritium R&D capability and execute R&D projects for development of replacement specialty engineered equipment.
SRS Plutonium Modernization		
Proposed pit production mission at SRS.		
Challenges	***Strategies***	
	Current Strategy Being Implemented	***Future Strategies Needed***
• Navigating procurement challenges associated with supply chain shortages, which has also caused prices to increase dramatically • Hiring and retaining a qualified workforce capable of supporting the construction project and the enduring Pu Modernization mission once the facility is operational	Implement a tailored approach to achieve CD-2 (*Approve Performance Baseline*) and CD-3A Long Lead Procurements, to support producing 50 WR ppy as close to 2030 as possible.	Re-establish the supply chain for weapons-related components and commodities needed to support the 50 ppy mission.

CD = Critical Decision
GTS = gas transfer system
LLC = limited life component
MFFF = Mixed Oxide Fuel Fabrication Facility
ppy = pits per year
SRTE = Savannah River Tritium Enterprise
TPBAR = tritium-producing burnable absorber rod
WR = War Reserve

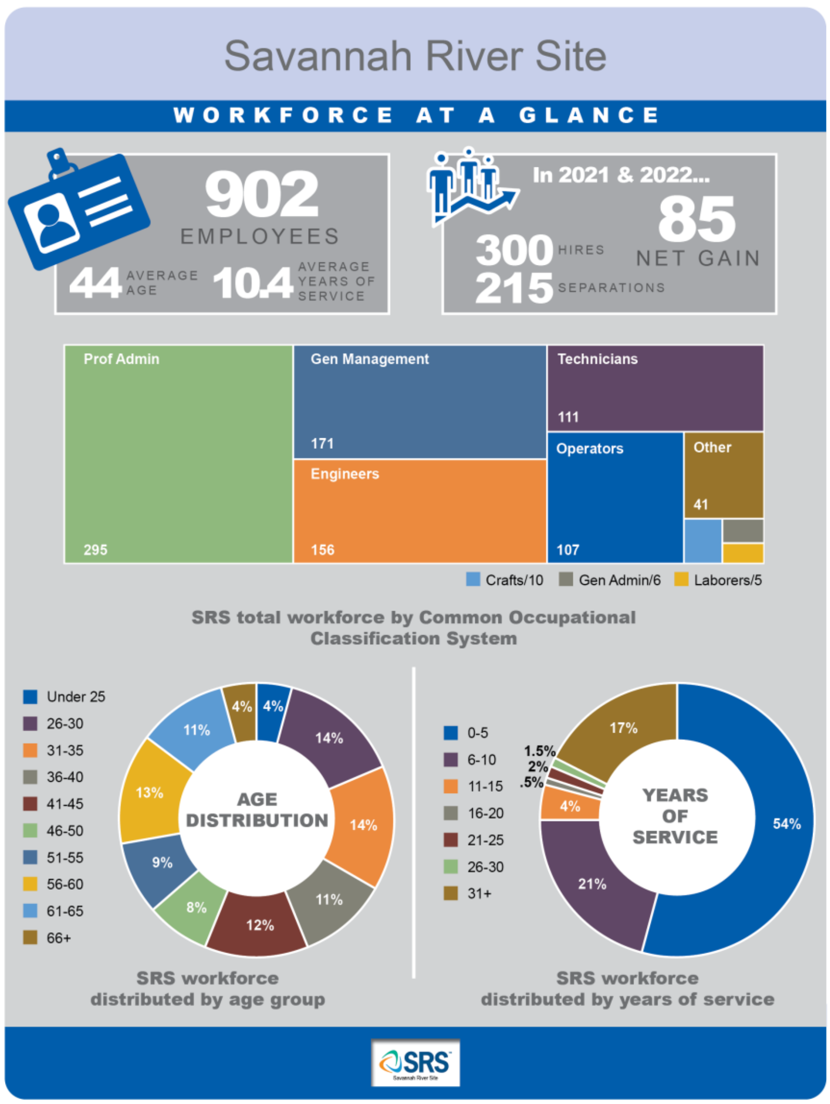
F.3.3.4 Accomplishments

- Delivered all LLC exchanges, JTAs, and minor Alts on schedule. Accommodated 34 schedule changes inside 90-day window.
- Met all tritium mission deliverables with 100 percent on-time shipment, and far exceeded all standards for product quality.
- Completed the first B61-12 loading run, unloaded a W76 GTS reservoir for the first time, loaded commitments on all five operational load lines, loaded more tritium in January 2022 than in any month since 2011, completed the most unloading runs in August 2022 than in any month since 2011, received two shipments in one day from the Tennessee Valley Authority for the first time, and loaded four cylinders of helium-3.
- Enhanced Knowledge Transfer collaboration to support pit production at both SRS and LANL.
- Developed a solution with LLNL to execute High-Fidelity Training and Operations Center plans that will modernize training and accelerate the SRPPF path to full plant operations.
- Managed three Capital Projects concurrently.
- Submitted the SRPPF CD-3A Demolition and Removal package along with six contract packages to accelerate the start of work.

- Delivered the SRPPF design performance baseline, including strategies to accelerate procurement and construction activities, thereby minimizing time needed to achieve CD-4 delivery.
- Initiated construction of the Tritium Finishing Facility site preparation sub-project.

F.3.3.5 Savannah River Site Workforce[2]

The SRS M&O workforce is dedicated to the NNSA Weapons Activities mission. The scope of the Office of Defense Programs work resides in the Savannah River Nuclear Solutions (SRNS) Tritium organization, and the NNSA Capital Project team for the NNSA line-item projects. In FY 2023, several traditionally direct Tritium resources (i.e., engineering, risk, maintenance, continuous improvement, and radiological controls) were moved from the Tritium reporting organization (i.e., SRTE) to a site functional organization. These personnel will continue to support the tritium scope full time in a matrixed capacity. They will also continue to be included in the employee site count. The plutonium scope continues to be managed as a separate organization under the NNSA Capital Projects group.



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[2] All workforce numbers account for the STRE and Plutonium missions at SRS.

The Tritium and Plutonium programs continued to execute an aggressive strategic hiring plan to meet mission needs. The SRTE organization experienced steady attrition through FY 2021, consistent across the nuclear security enterprise, but in FY 2022, SRTE experienced more than double the attrition forecasted, as shown by the large change from FY 2021 to FY 2022 in Figure F–27. **Figure F–25** breaks down these separations by years of service. SRNS is reviewing compensation practices, teleworking, and benefits programs to increase retention.

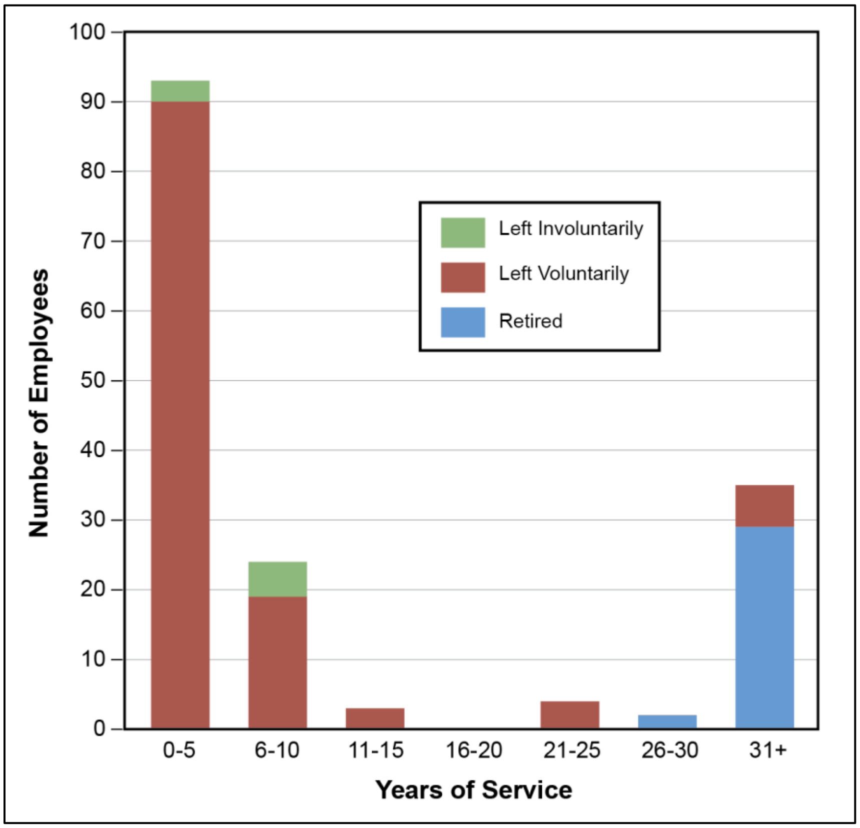


Figure F–25. SRTE and Plutonium separations by years of service

As **Figure F–26** shows, increased and sustained hiring, combined with a steady level of retirement and transfers or promotions to other opportunities, has led to an increase in early career and mid-career workers and a decrease in the advanced-career populations at SRNS-Tritium, as well as in the newer plutonium mission. The mid-career population will continue to be monitored to help ensure career development opportunities are available to retain and grow the workforce. This effort, combined with compelling workplace improvements, should impact all career groups in a positive way.

SRNS-Tritium continues to plan and execute workforce growth commensurate with mission requirements to recapitalize process equipment and surrounding infrastructure, increasing GTS work scope due to LEPs, and expected retirements; it is working to hire ahead-of-need to allow time for security clearance and training processes for new personnel. As shown in **Figure F–27**, voluntary separations increased as a result of promotional opportunities on site and mission-related business needs. Workforce retirement is expected to remain steady over the next 5 years. SRS strives to remain aware of the constantly changing business conditions and environment, continue to hire replacements and workers to support increased work scope, and to retain new employees by providing meaningful work, leadership engagement, development opportunities and a compelling place to work.

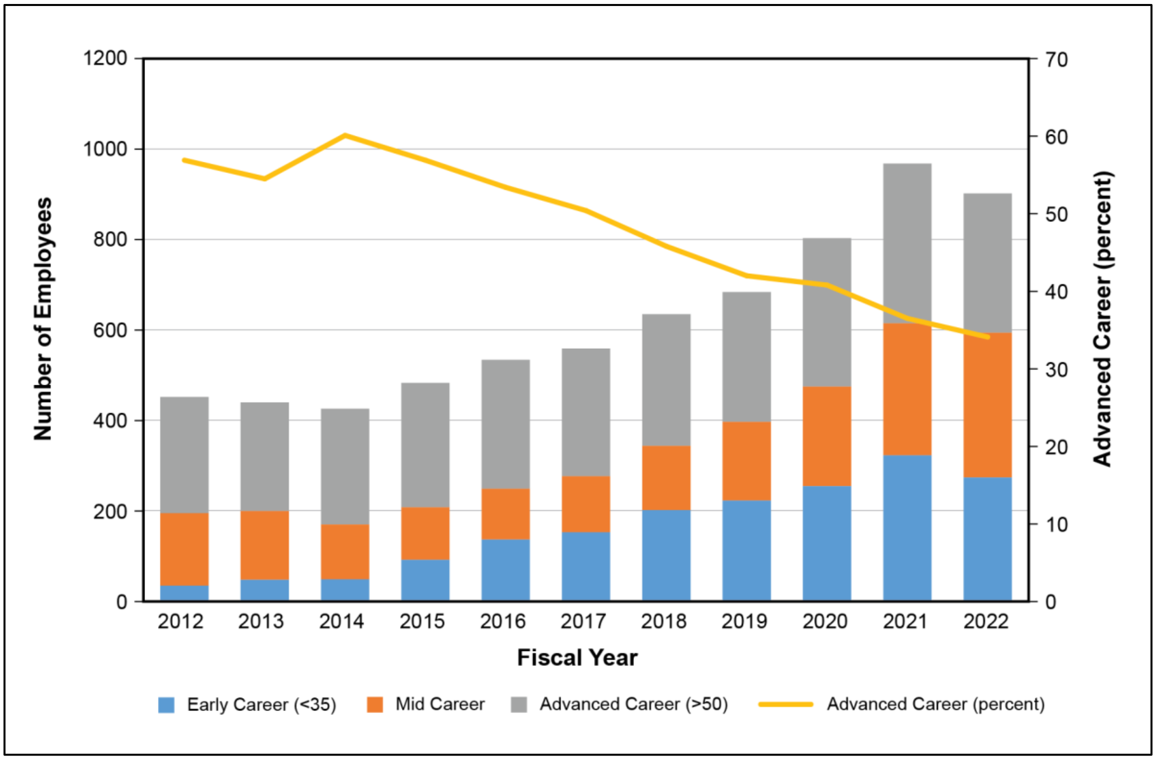


Figure F–26. SRTE and Plutonium trends by career stage and percent advanced career

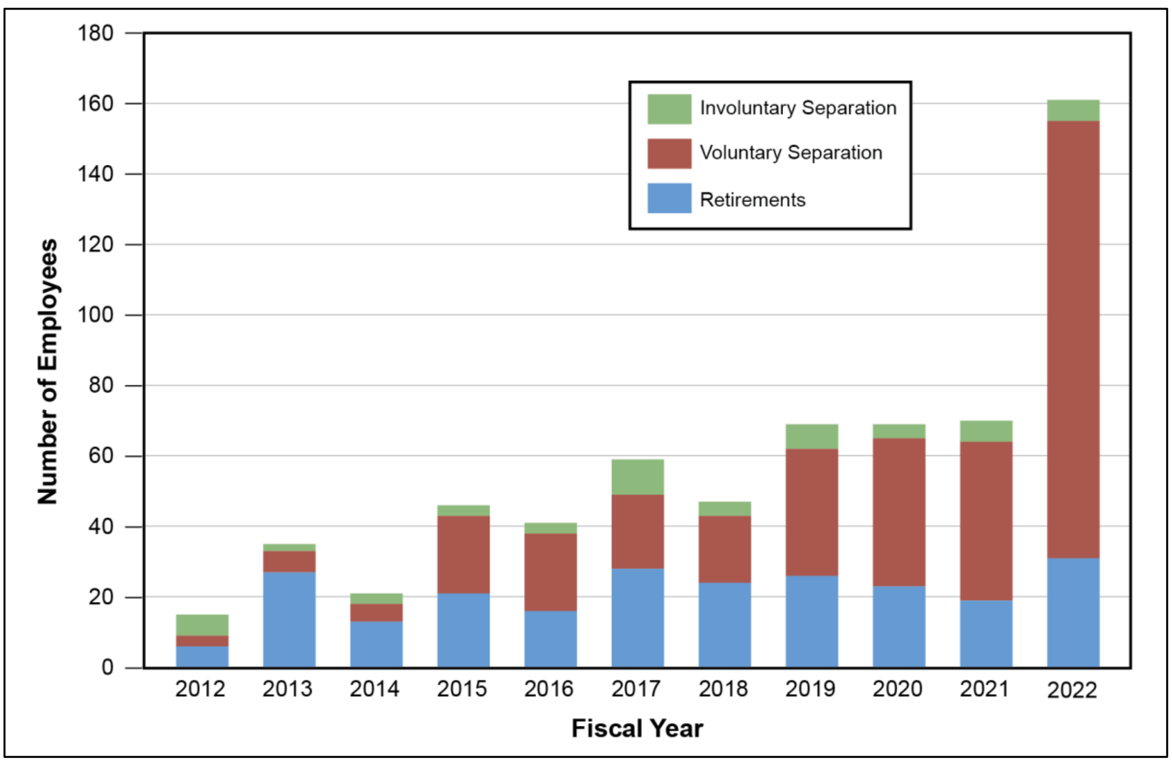


Figure F–27. SRTE and Plutonium employee separation trends

Figure F–28 reflects expected mission growth primarily due to the Tritium Extraction Facility tritium supply production increase; the plutonium mission; increased project activity; and a growing effort to reduce the maintenance backlog on facilities and infrastructure; and implementation of Nuclear Enterprise Assurance requirements. SRTE will also experience some growth in reservoir processing and surveillance due to increases in workload complexity to support LEPs. Workforce growth will increase housing requirements, including the need for new office space. In addition to mission increases, SRS will continue to manage steady attrition (retirements and resignation) and employee retention.

In order to respond to continued steady attrition and increased mission needs, the SRS strategic staffing plan is aligned to funding and monitored closely each month. Adequate and timely funding to allow hiring in advance is crucial. SRS has established partnerships with local universities, implemented an apprenticeship program, and increased social media presence to attract candidates. have provided opportunities for graduates to be hired. Corporate reachback and restructured staffing forecast and recruiting practices offer greater organizational efficiencies and external sources of experienced personnel.

Early Engagement in FY 2022

Interns: 7

Workforce retirement is expected to remain steady over the next several years and overall attrition predicted to level out from the significant spike experienced in FY 2022 due to ongoing engagement and development efforts as well as compensation and benefit program enhancements. In FY 2022, voluntary separations increased significantly. These were attributed to transfers to other opportunities on site (Defense Nuclear Nonproliferation missions, DOE Office of Environmental Management missions, and Savannah River National Laboratory) and other off-site opportunities.

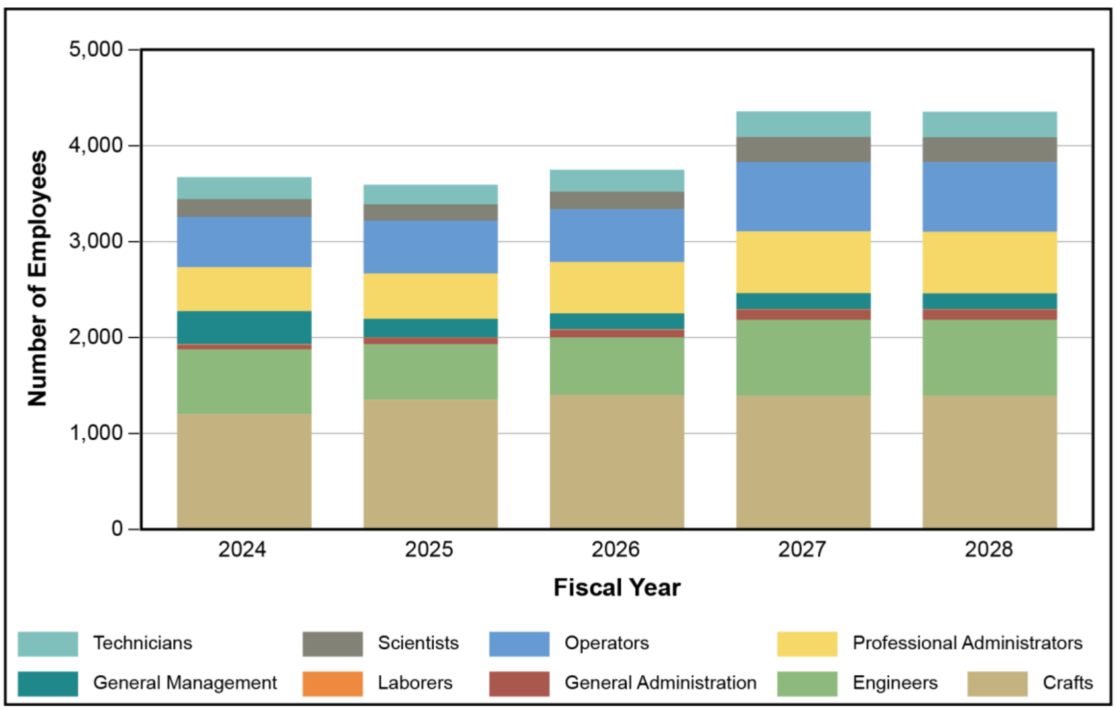


Figure F–28. SRTE and Plutonium workforce projection needs by Common Occupational Classification System

F.3.4 Y-12 National Security Complex

Y-12 National Security Complex

Oak Ridge, TN

Multi-program nuclear weapons production facility

www.y12.doe.gov

Operated By: Consolidated Nuclear Security, LLC (CNS), a corporate subsidiary of Bechtel National, Leidos, ATK Launch Systems, and SOC, LLC

NNSA Production Office

- Manufacture, assembly, disassembly, quality evaluation, storage of nuclear weapons and components
- Nuclear material for naval nuclear propulsion
- Global nonproliferation efforts

F.3.4.1 Mission Overview

The Y-12 National Security Complex (Y-12) is integral to national security interests. The site has adapted to emerging needs and delivered solutions to support national security missions for more than 75 years. The site is committed to:

- Taking decisive action to maintain existing capabilities, increase throughput capacity, and complete new mission requirements
- Meeting increasing mission deliverables and making infrastructure improvements in the near-term while simultaneously positioning our site for long-term success
- Finding innovative solutions while adjusting to a changing geopolitical landscape, growing NNSA missions, shifting workforce dynamics, and lingering impacts of a global pandemic

Y-12 provides capabilities instrumental to NNSA missions and priorities, including producing uranium weapon components and subassemblies for the Office of Defense Programs; recycling retired weapon components and production by-products; producing feedstock for naval and research reactors; supporting nuclear nonproliferation and global security; special materials processing and production; and storing the nation's highly enriched uranium inventory. This mission encompasses many facilities and processes for enriched and depleted uranium. Y-12's strategy aims to enhance nuclear safety and reduce the risk of mission interruption inherent in aging facilities and processes while maintaining critical mission capabilities.

For more than 70 years, Y-12 has produced and recycled enriched lithium to support life extension programs, joint test assemblies, and strategic partnership projects. Because of this work, the nation can maintain a functional, effective nuclear deterrent. The lithium capability requires specialized areas and equipment to chemically process, machine, inspect, assemble, certify, disassemble, and store materials. Y-12 recently reestablished a lithium purification capability to augment a limited inventory of recycled material to meet demands until the Lithium Processing Facility becomes operational. The deteriorating condition of aging lithium processing facilities and limited material supply pose significant risks to our ability to meet current and future Defense Programs requirements. Y-12 has worked with the NNSA to develop a lithium strategy that will ensure the capability is maintained.

Y-12 has handled, processed, and stored a majority of the Nation's special nuclear materials. The site has a dynamic operating envelope that includes multiple high-security facilities, classified networks and information systems, critical infrastructure and equipment, and skilled personnel. As mission and project scope expand—bringing additional people on-site, increasing special nuclear material operations, and inserting more project work into operating facilities—the challenge of executing security measures also grows.

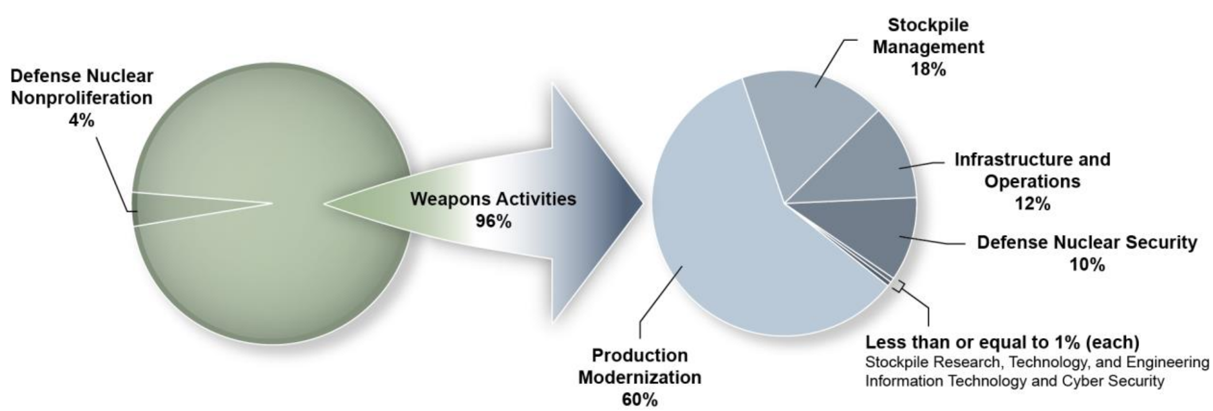
Y-12's strategic approach includes restarting equipment, processes, and material streams that have not been operational since the Cold War ended. With national policy indicating that future activities may include the design and build of new weapon systems, Y-12 is working to establish the skills, processes, infrastructure, equipment, and technology needed to support a broad range of weapon activities and systems.

Y-12 exists to sustain and modernize the nuclear weapons stockpile, provide feedstock for naval propulsion, and support nuclear threat reduction. Accomplishing Y-12's national security missions depend not only on the hands-on workers who execute core capabilities but also on the thousands of other workers who provide expertise in safety, security, emergency management, business, training, maintenance, and management. At Y-12, every employee is essential to delivering or enabling the mission. The site aspires to develop the capability to fabricate any component, build any weapon, and qualify any system on any day and to digitally transform from a "document control" culture to a real-time, information-driven culture. Y-12's actions in support of NNSA's mission priorities will help to protect the Nation, its allies, and its partners by providing resilient and a responsive production and manufacturing site.

F.3.4.2 Funding

FY 2024 DOE request – site funding by source
(total Y-12 FY 2024 request = $2,580 million)

Y-12 split for the FY 2024 Weapons Activities President's Budget Request ***($2,485 million)***



F.3.4.3 Site Capabilities

Key mission capability areas at Y-12 are primarily uranium and canned subassembly production, lithium, and material and process R&D. Critical to all of these capabilities is the supporting infrastructure that provides power, water, and other services. Y-12's key capabilities and their associated challenges and strategies are described in **Table F–7**.

Table F–7. Y-12 National Security Complex capabilities

Uranium and Canned Subassembly Production Capability		
Y-12 produces uranium weapon components to refurbish the Nation's nuclear stockpile, and recycles and reprocesses the Nation's existing supply of enriched uranium. The recycled metal serves as feedstock for the Navy's nuclear-powered submarines and aircraft carriers, commercial power reactors that generate U.S. electricity, medical isotope production, and some domestic and foreign research reactor programs. Y-12 also helps recover and secure at-risk nuclear materials around the globe. The Highly Enriched Uranium Materials Facility at Y-12 houses the Nation's cache of weapons-grade uranium. The Uranium Processing Facility now under construction will be a state-of-the-art facility for the enriched uranium operations that are currently performed in Building 9212. Depleted Uranium operations produce and maintain a reliable inventory of depleted uranium, depleted uranium alloy, and other non-nuclear industrial material components and tooling through a variety of metalworking processes in support of LEPs, JTAs, and other national security and government programs.		
Challenges	***Strategies***	
	Current Strategy Being Implemented	***Future Strategies Needed***
To continue supporting all uranium missions, Y-12 must address its aging infrastructure. Current facilities are aging, necessitating sustainment through the Extended Life Program. Enriched uranium capabilities must be maintained while the Uranium Processing Facility is being constructed, which necessitates relocating enriched uranium functions to other Y-12 facilities, and startup and proving of replacement technologies before uranium programmatic operations cease in current facilities by 2025. Y-12 must also complete reduction of material-at-risk quantities in current processing facilities by consolidating storage into the HEU Manufacturing Complex.	The Uranium Processing Facility will replace most of the HEU production functions currently performed in Building 9212. The uranium strategy also includes upgrades and advanced technologies that will be started in existing facilities.	Additional replacement facilities Enriched Uranium Manufacturing Center and Assembly and Disassembly Capability will be needed and are currently planned for the late 2030s and 2040s.
Depleted uranium infrastructure is aging. Increased throughput and capacity, which includes additional equipment and personnel, is required for future programs.	• Purchase the limited commercial HPDU supplies available. Invest in feedstock capabilities to ensure there is a steady stream of HPDU in the future. • Invest in maintaining the legacy alloying processes. Plan to purchase additional equipment to reduce the strain on legacy equipment and processes. • Identify bottlenecks and develop bridging strategies to fulfill near-term mission requirements should new technology not be employed in the immediate future	Replace depleted uranium fabrication/manufacturing functions in current facilities with the Agile Radiation Case and Component Capability.
Lithium Capability		
Y-12 provides material purification, material preparation, component fabrication and inspection, salvage operations, and storage for lithium operations to support LEPs, JTAs, and complementary work.		
Challenges	*Strategies*	
	Current Strategy Being Implemented	***Future Strategies Needed***
Current lithium capabilities are housed in a Manhattan Project-era facility with infrastructure well beyond its expected life and rapidly deteriorating. The process equipment is inefficient for its current mission scope, is rapidly deteriorating, and has far exceeded its life expectancy. Current lithium production capabilities will be placed under additional strain because of material supply	• DOE/NNSA's lithium strategy necessitates sustaining the current infrastructure, sustaining the supply to meet customer demand, and maturing and deploying technologies to replace hazardous processes.	• Continue to maintain legacy processing lines of effort through identified facility lifecycle extension projects until the Lithium Processing Facility is fully operational.

issues and the projected increase in mission scope. Combined, these challenges represent significant risk to the mission.	• Design and construct the Lithium Processing Facility.	• Future projects to maintain capability include electrical, utility upgrades, and other identified structural life extending efforts.
Material and Process Research and Development Capability		
Y-12's Development Division serves as the focal point for development and preservation of uranium and lithium materials sciences and manufacturing technologies. R&D activities include material and metallurgical synthesis, forming, evaluation techniques and processes, material purification, and material characterization. Advanced technologies have been developed and are at varying stages of deployment readiness for enriched uranium and lithium.		
Challenges	***Strategies***	
	Current Strategy Being Implemented	***Future Strategies Needed***
Development is essential to Y-12's production mission, providing a ready pool of subject matter experts to tackle production problems, developing new technology to meet future production requirements, and performing strategic partnership projects as needed to support global security missions. Aging electrical, cooling water, and other process support systems in Y-12's infrastructure increase risk to mission work as the infrastructure ages.	The current strategy for development includes modernization of the NNSA-procured off-site 103 Palladium facility for subsequent relocation and installation of designated Development capabilities. Implementation of electrical and cooling water system recapitalization projects within existing Development facilities will address infrastructure concerns, until replacement facilities are available.	The development strategy ultimately results in either a new line-item replacement facility (Applied Technologies Laboratory) or multiple campus-like buildings to consolidate remaining development capabilities and the continued use of the 103 Palladium facility for the relocated Development capabilities.

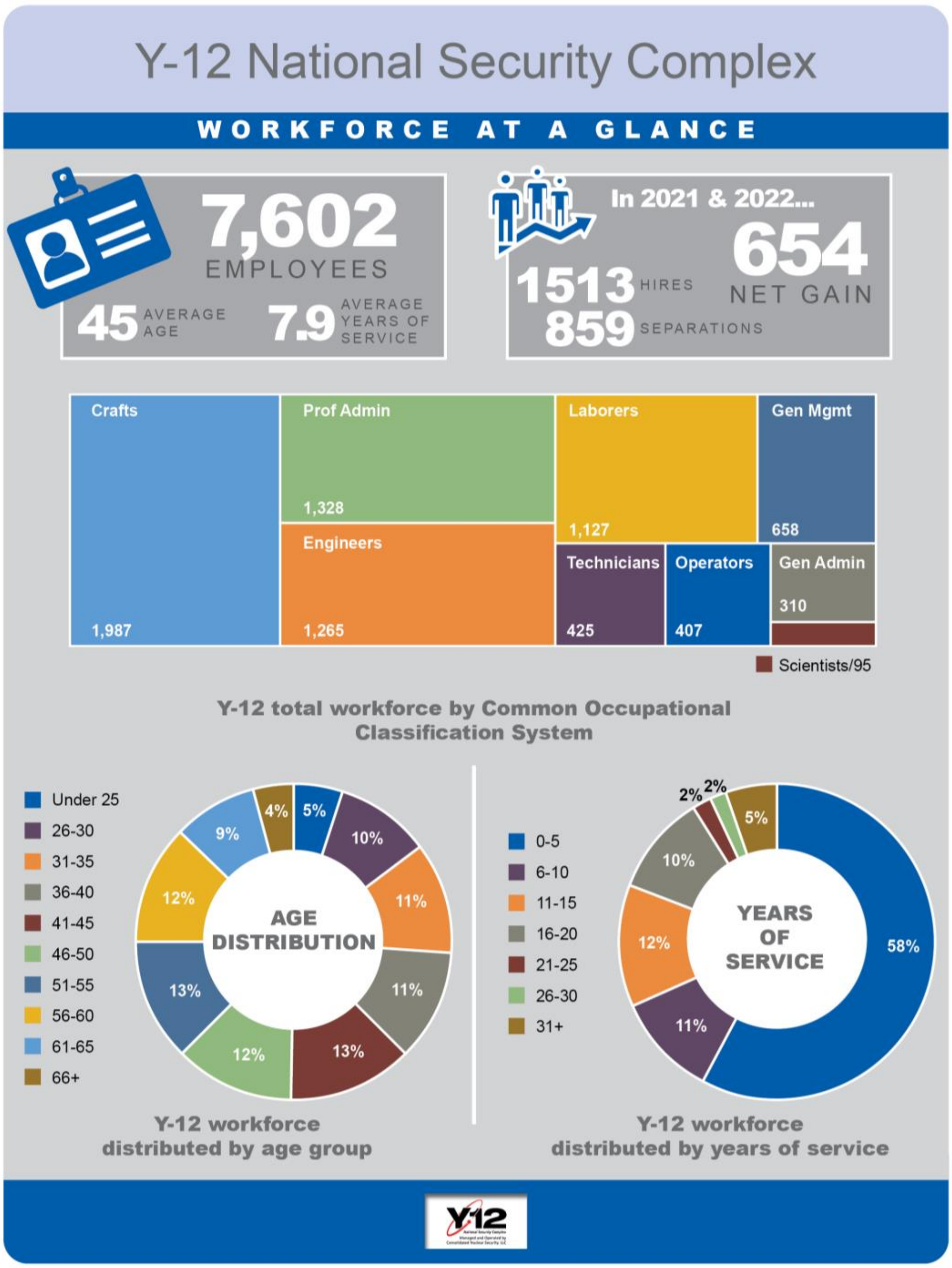
HEU = highly enriched uranium
HPDU = high-purity depleted uranium
JTA = joint test assembly
LEP = life extension program

F.3.4.4 Accomplishments

- Achieved full rate production for the B61-12 and the W88 Alt 370.
- Legacy Risk Reduction continued in Uranium Processing through early deactivation and clean-out of systems no longer in use in Building 9212 and the dispositioning of material at risk. Completely eliminated a backlog of legacy enriched uranium briquettes, representing some of the highest hazard materials stored on the site.
- Y-12 advanced the Lithium Strategy, ensuring adequate supply of lithium for stockpile work until the Lithium Processing Facility reaches beneficial occupancy.
- A Y-12 team completed the removal and shipment of highly enriched uranium from Japan, wrapping up a 4-year effort that included overcoming hurdles of travel and shipping during the pandemic.
- Achieved significant improvements in infrastructure modernization:
  - The Uranium Processing Facility's Personnel Support Building and the Main Process Building both achieved full enclosure, putting the entire Uranium Processing Facility Project "in the dry."
  - Y-12's Emergency Operations Center and Fire Station, both pilot commercial-like build projects, were completed. Y-12 also completed the transition of plant power loads from Elza-1 to the new Pine Ridge Substation.

F.3.4.5 Y-12 National Security Complex Workforce

Total headcount increased from 7,315 at the end of FY 2021 to 7,602 at the end of FY 2022; these numbers include limited term employees, who add about 1,400 to the permanent headcount. Significant recruiting and hiring efforts filled vacancies from attrition and built the technical skill base in preparation for the increased workload in FY 2022 and beyond. These workforce efforts included developing new tools for planning headcount; recruitment efforts towards sourcing with a "Make, Take, Attract" model; and efforts to reduce the full onboarding cycle time to avoid losing candidates in the onboarding period. Over half of the workforce has 0–5 years of experience, indicating that Y-12 is replenishing its workforce for future needs and offsetting attrition due to retirements and other separations.



Early Engagement in FY 2022

Students: 38

Figure F–29 shows that the demographic experiencing the greatest number of voluntary separations is those with 0–5 years of service, which correlates with their large share of the workforce. Data from optional exit interviews show the top three reasons for leaving Y-12: career advancement opportunities, flexible work options, and compensation. Y-12 addressed these concerns by enacting several changes, including increased teleworking for select positions, improved work environments, implemented talent management opportunities for career development, improved clearance processing cycle time by increasing investigators, and redesigned compensation to attract and retain candidates with critical skills. Retention is on a positive trend.

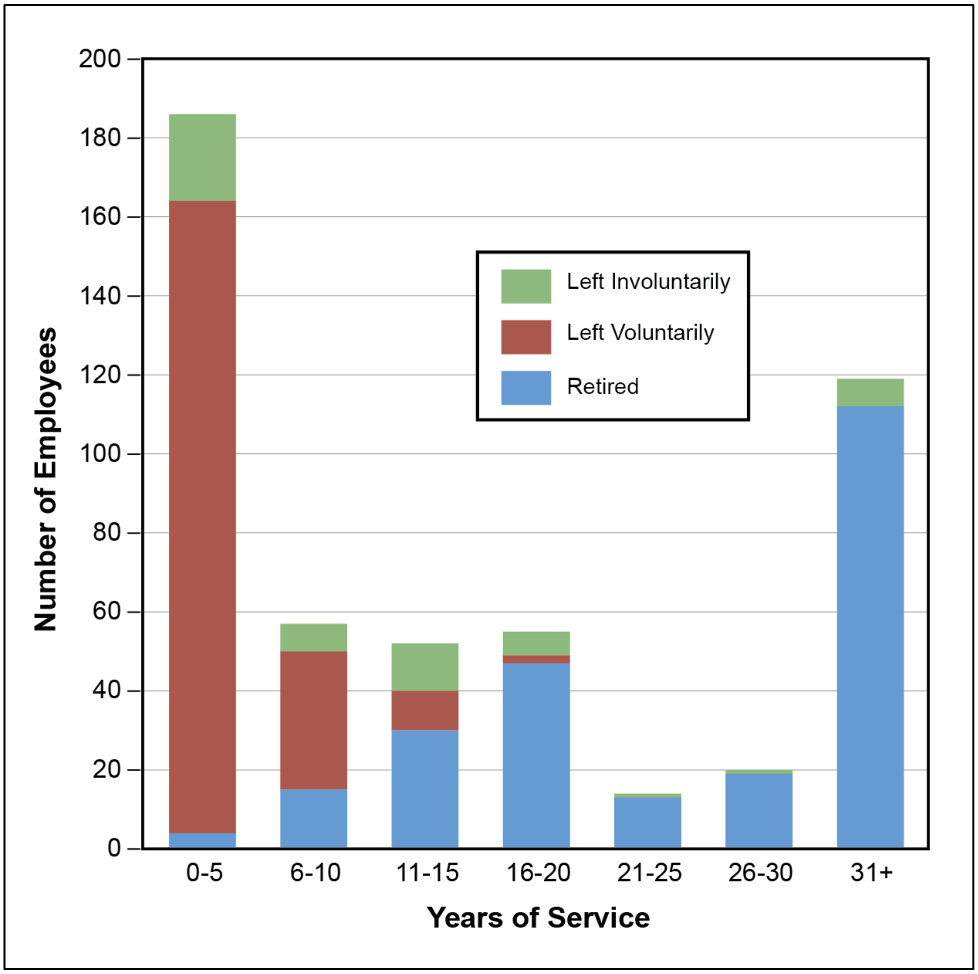


Figure F–29. Y-12 separations by years of service

Early and mid-career levels and total population grew due to increased hiring as shown in **Figure F–30**. Many advanced career employees are electing to work longer, and the percentage of advanced career personnel is relatively stable. The increase in Early Career levels to 24 percent of the workforce is partially due to including limited term employees, who are more often 35 years old or younger.

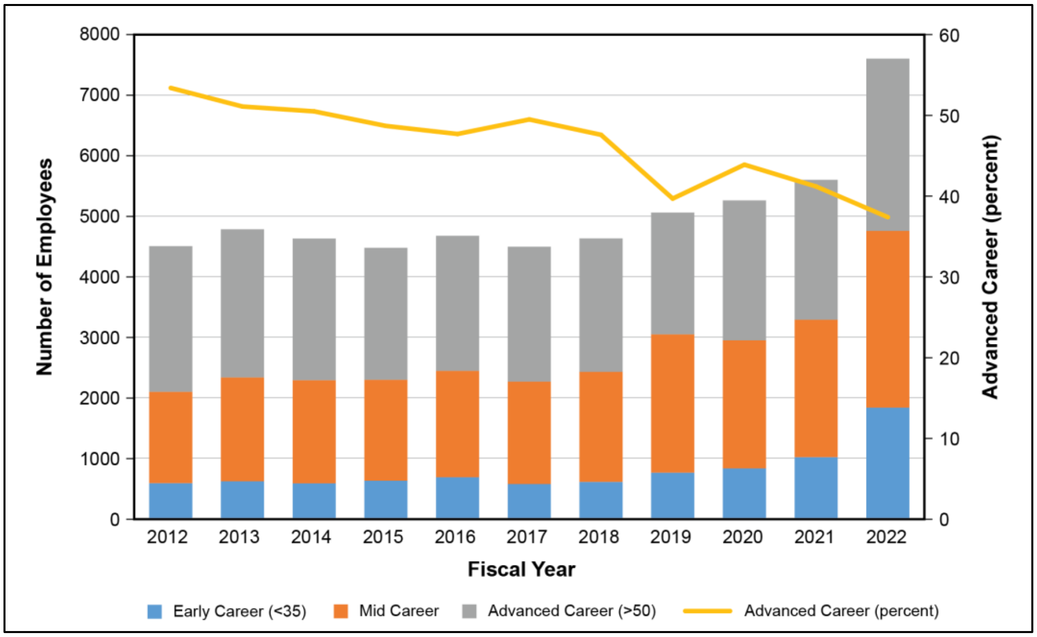


Figure F–30. Y-12 workforce participation trends by age category and percent advanced career

As **Figure F–31** shows, over half of separations are due to retirements. The average age of retirees is increasing as more retirement-eligible employees are electing to work longer. Several factors contribute to this shift, such as better health and cognitive activity, opportunity to telecommute, and uncertainty about the pandemic and its impact on travel, family, and the economy; additionally, many workers choose not to retire until after age 66 so they can receive full social security benefits. Pension plans were phased out for new hires around 2012 and replaced by enhanced 401(k) plans; this change removed the perceived retirement trigger (pension eligibility at age 55 with 10 years of service) for those hired after 2012. Voluntary separations continue trending upwards, and involuntary terminations have returned to pre-pandemic levels.

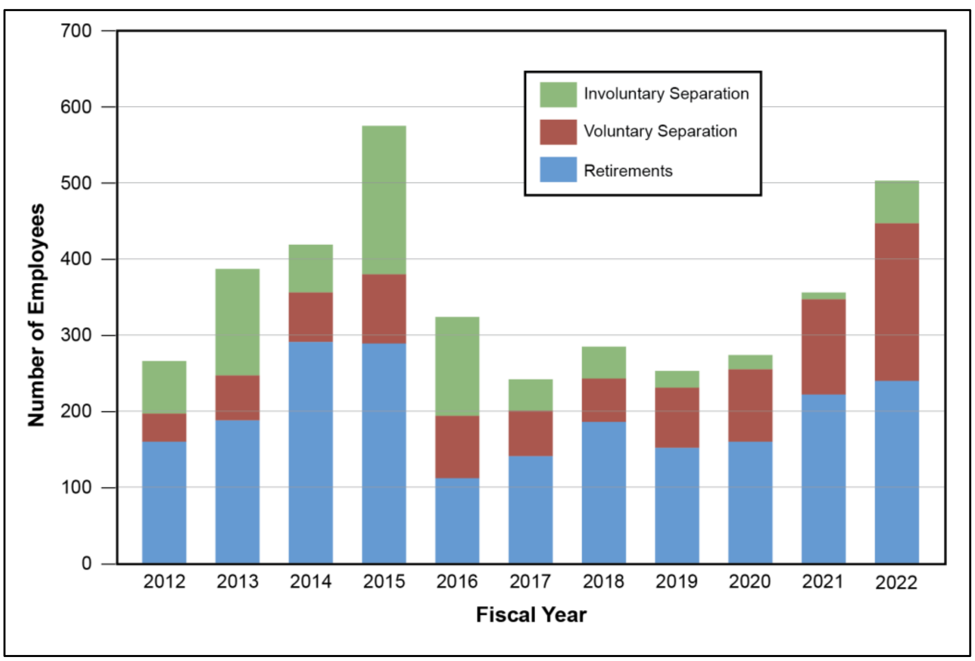


Figure F–31. Y-12 employee separation trends

Workforce projections, shown in **Figure F–32**, are now made using a robust suite of Human Resources management tools. In FY 2021, the Multi-Year Staffing Plan for Headcount was integrated to the suite of tools, improving their accuracy. Y-12 anticipates hiring for attrition replacement since the total estimated number of personnel needed to support the work in the near term is relatively static, with emphasis on hiring engineers, safety basis, IT specialists, technicians, and security. Crafts, technicians, and administrators typically have lower attrition, while engineers have higher attrition due to high national demand. Internal realignment is used in some cases to fill critical vacancies. Y-12 is working with Oak Ridge Associated Universities through the Supply Chain Management Center to improve sourcing and recruiting capabilities.

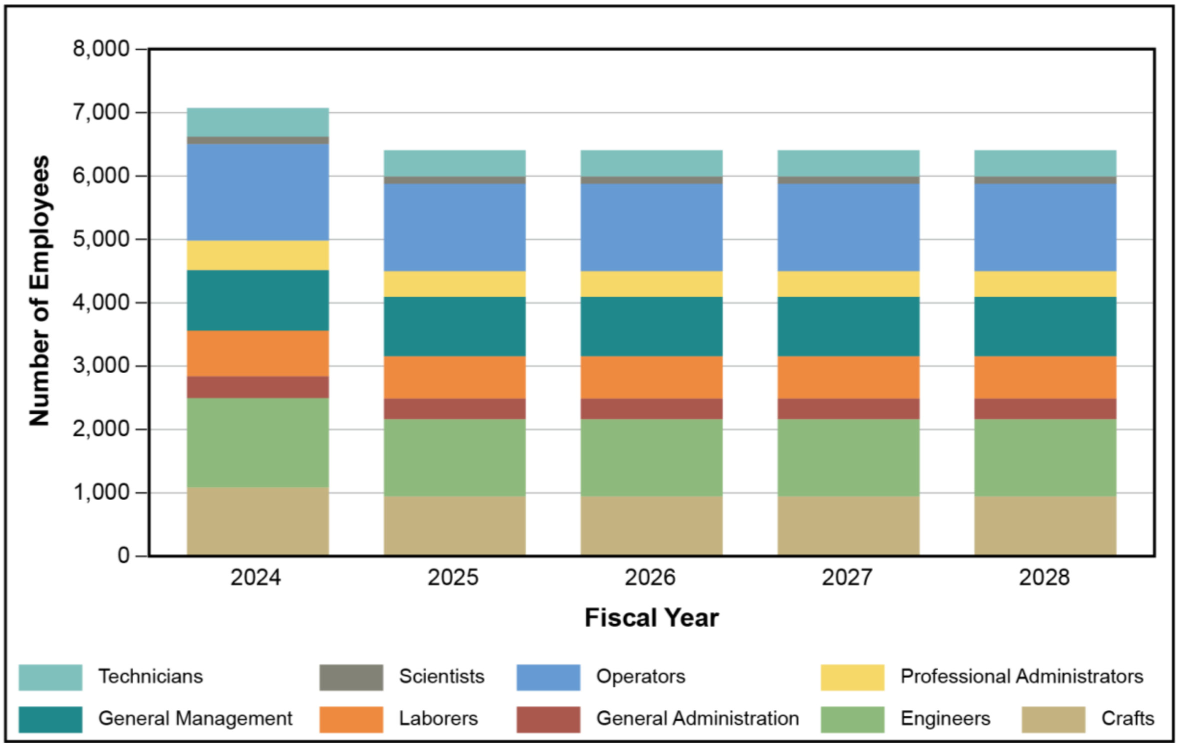


Figure F–32. Y-12 workforce projection needs by Common Occupational Classification System[1]

[1] Projections do not include construction craft or Uranium Processing Facility. FY 2024 and FY 2025 headcount is based on actual FY 2024 program plans and anticipated funding for FY 2025 scope. Projections for FY 2026 and beyond reflect a stable work scope and funding, pending finalization of outyear funding projections.

F.4 The National Security Site

F.4.1 Nevada National Security Site

Nevada National Security Site

Las Vegas, NV

Multi-program experimental site

www.nnss.gov

Operated By: Mission Support and Test Services LLC, a joint venture between Honeywell International, Inc.; Jacobs Engineering Group; and Huntington Ingalls Industries Nuclear, Inc.

Nevada Field Office

- Subcritical experiments: high explosives with plutonium
- Global security experiments and training
- Weapons physics experiments using high-hazard materials
- Criticality experiments

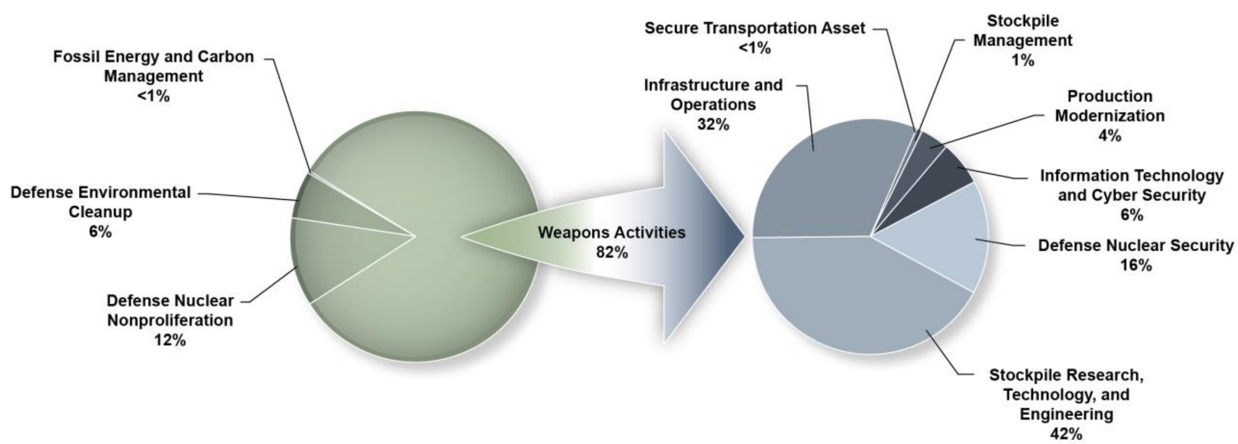
F.4.1.1 Mission Overview

The Nevada National Security Site (NNSS), located outside of Las Vegas, Nevada, is the primary location within the DOE/NNSA complex where high-hazard experiments with radioactive and other high-hazard materials are conducted. It is the only location in the United States that is authorized to conduct subcritical experiments with weapons-relevant geometries and quantities of both HE and plutonium.

F.4.1.2 Funding

FY 2024 DOE request – site funding by source ***(total NNSS FY 2024 request = $918 million)***

NNSS split for the FY 2024 Weapons Activities President's Budget Request ***($756 million)***



F.4.1.3 Site Capabilities

NNSS supports stockpile stewardship through plutonium experiments in collaboration with LANL, LLNL, and SNL; data analyses from those experiments; diagnostic R&D; and reanalysis of legacy underground test data.

NNSS' capabilities and their associated challenges and strategies are described in **Table F–8**.

Table F–8. Nevada National Security Site capabilities

Hydrodynamic and Subcritical Experiments at Weapons-Relevant Scales		
NNSS performs subcritical experiments at U1a, enabling characterization of early explosion-time hydrodynamic behavior of plutonium, plutonium surrogates, and other relevant materials in weapon-relevant geometries. NNSS, LLNL, LANL, and SNL are in the process of enhancing U1a to enable well-diagnosed, early- and late-time radiographic and neutron reactivity measurements on hydrodynamic tests. These new data will inform efforts to assess the effects of aging and manufacturing processes on stockpile weapons.		
Challenges	***Strategies***	
Increase the tempo, flexibility, and sophistication of subcritical experiments.	***Current Strategy Being Implemented***	***Future Strategies Needed***
	• Implement a multi-user U1a operating model and an integrated, logic-linked framework schedule to optimize critical path contributors. • Invest in U1a, DAF, diagnostics, and transportation for future subcritical experiments.	• Ensure operational sustainability for all necessary radiographic capabilities in U1a. • Enhance efficiencies in experimental operations to reduce fielding time and the number of experiments required for assessment and certification. • Field next generation diagnostics to meet stockpile experimentation needs.
Weapons Science Experiments Using High-Hazard Materials		
Activities include maturing capabilities in shock and compression experiments; dynamic phase change studies; capture of thermodynamic and constitutive properties; platform and source development; and materials diagnostic R&D on the JASPER, the ShARC launcher at North Las Vegas, Z at Sandia; and a variety of shock physics platforms at NNSS and the Special Technologies Laboratory. JASPER is a two-stage light gas gun for studying the behavior of plutonium and other materials at high pressures, temperatures, and strain rates. ShARC is a single-stage gas gun located on the North Las Vegas campus; it is used to support DMP-related work, test diagnostics, and train diagnostic personnel. Material property data are obtained on a wide variety of national security materials of interest in various phases and compositions owing to differences in manufacturing processes, surface preparations, and ages.		
Challenges	***Strategies***	
Breakthroughs in materials science are limited by the rate of experimentation, staffing constraints, the range of dynamic conditions that are available to DOE/NNSA, as well as the need for higher-precision diagnostics that can measure phase changes, temperature, density, and two-dimensional displacement/velocity-fields at very short time scales and very high temperatures, pressures, and densities.	***Current Strategy Being Implemented***	***Future Strategies Needed***
	NNSS is seeking efficiencies in operations to increase scientific throughput at its many shock physics platforms. Some of these efficiencies are realized through increased recruitment activities and development of newer, higher-precision diagnostics.	NNSS will leverage site-directed, R&D-initiated new diagnostics; mature these diagnostics; and optimize them for multi-platform use (e.g., hydrodynamic experiments, subcritical experiments, and JASPER) interferometry, diffractometry, radiography, pyrometry, and other spectroscopic techniques.
Device Assembly Facility		
DAF supports nuclear weapons experimental capabilities and is one of two facilities in the nuclear security enterprise that allows collocation of HE and SNM, including staging of large quantities of SNM in independent buildings and provides the backbone to support various missions using those materials in conjunction. For Stockpile Stewardship, the facility's glovebox, downdraft table, and radiography capabilities support assembly of SNM targets for JASPER, as well as SNM and HE packages for subcritical experiments at U1a. DAF also hosts the NCERC, a unique national asset. NCERC supports a mix of critical and subcritical benchmark quality experiments, detector development, inspector and first responder training, criticality safety training, and handling of damaged nuclear weapons. NCERC has the largest collection of nuclear critical mass assembly machines in the western hemisphere.		
Challenges	***Strategies***	
As demand for DAF's wide range of unique capabilities grows across DOE/NNSA, space and scheduling challenges will grow.	***Current Strategy Being Implemented***	***Future Strategies Needed***
	• Maintain current capabilities. • Explore options to increase these capabilities on a timescale complementary to anticipated experimental needs (e.g.,	• Enhance efficiencies in experimental operations to reduce fielding time and number of experiments required for assessment and certification.

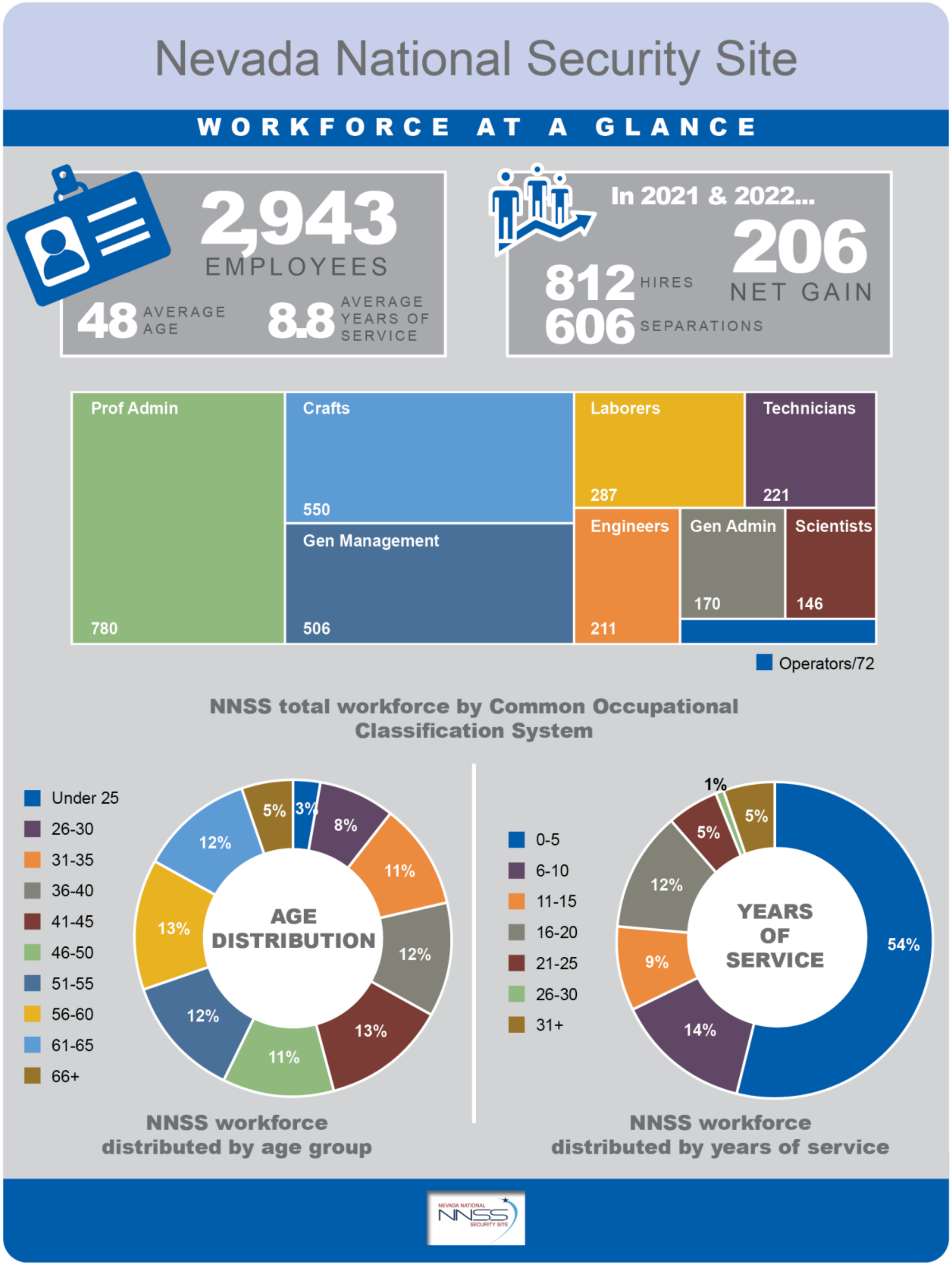
	enhanced surveillance and storage).	• Field next-generation diagnostics to meet stockpile experimentation needs.
Advanced Experimental Diagnostics and Sensors		
NNSS develops the next generation of high-precision, transformational diagnostics for subcritical, hydrodynamic, and dynamic materials experiments. Some of these groundbreaking diagnostics include photon Doppler velocimetry, optical ranging (i.e., broadband laser ranging), surface imaging, soft X-ray radiography, holography, dynamic pyrometry and emissivity, dynamic X-ray diffraction, prompt neutron and X-ray detectors, and advanced radiography sources for subcritical experiments and other hydrodynamic platforms.		
Challenges	***Strategies***	
	Current Strategy Being Implemented	***Future Strategies Needed***
Advanced diagnostics and sensors provide detailed measurements of materials, objects, and dynamic processes critical to weapon operation. Standard diagnostics provide lower-resolution data that are suitable for basic inquiries, but not detailed part, process, or physics qualification. Continued diagnostic and sensor development is critical to addressing these limitations.	NNSS involves nuclear security enterprise laboratories in defining and prioritizing diagnostic needs for future experiments at NNSS and other facilities.	• Continue current strategy. • Develop and field next generation diagnostics to meet stockpile experimentation needs.

DAF = Device Assembly Facility
DMP = Data Management Plan
HE = high explosive
JASPER = Joint Actinide Shock Physics Experimental Research Facility
NCERC = National Criticality Experiments Research Center
ShARC = Shock Activated Research Collaboration
SNM = special nuclear material
U1a = U1a Complex
Z = Z pulsed power facility

F.4.1.4 Accomplishments

- The U1a Complex (U1a) Enhancements Project 10 achieved CD-4 in June of 2022. The U1a Enhancements Project 20 achieved CD-2/3 in June of 2022. These projects will provide infrastructure modifications to the U1a at NNSS to house and field multi-pulse radiography. These projects include structures, systems, and components necessary for deploying the Enhanced Capabilities for Subcritical Experiment (ECSE) Advanced Sources and Detectors (ASD) project's pulsed X-ray radiography equipment.
- ASD achieved CD-2/3 in November 2022. ASD is a major item of equipment that will fill the pulsed x-radiography capability gap through developing a multi-pulse linear induction electron accelerator. The scope includes design, technical maturation, fabrication, testing, installation, commissioning, and readiness execution at U1a.
- NNSS completed the refurbishment of the Cygnus radiograph machine, significantly increasing the lifespan and efficiency of the Cygnus source. This source is approaching 5,000 shots and has been the sole U.S. radiographic capability for shock wave studies involving plutonium.
- Diagnostic development: NNSS delivered next-generation diagnostic R&D to national laboratories to support stockpile experiments. NNSS developed two revolutionary diagnostics capabilities to advance the understanding of ejecta and to improve radiographic tools. The first quantitative atomic ejecta diagnostic, the Atomic Ejecta source Optical Probe, addresses fundamental questions about ejecta sources is and has future fielding application on subcritical experiment-class platforms. NNSS also demonstrated multi-pulse source capabilities and evaluated source characteristics of first- and second-pulse size, dose and diode lifetime to capture "first of a kind" double-pulse X-ray images from a single anode, providing measurements not previously achievable with multi-anode sources for dynamic properties of thin materials. Investments will provide control systems, software, detectors, instruments, and camera systems in 2 to 5 years.

F.4.1.5 Nevada National Security Site Workforce



NNSS continues hiring to meet increasing mission needs. Total site headcount increased by 6.1 percent in FY 2022, and all Common Occupational Classification System categories experienced an increase in headcount with the exception of Scientists. Overall, non-bargaining personnel increased by approximately 4.1 percent and bargaining unit personnel (crafts/laborers/operators) increased by approximately 12.6 percent in FY 2022. Due to hiring, the average years of service decreased from 10 percent to 8.84 percent; the 25 and underage category experienced the largest increase at 23 percent. The age category of 56–60 experienced a decrease in headcount of 3 percent due to early retirements. Of note, a large portion of the security workforce at NNSS is not managed by the M&O contractor and is not included in the site headcount or subsequent charts, though the security contractor, SOC LLC, does have employees funded by Weapons Activities.

Early Engagement in FY 2022

Students: 116

Interns: 2

Post-doctorates: 4

NNSS supports diverse and sustainable education programs focused on improving STEM at the elementary school, middle school, high school, and collegiate levels. It continues to leverage its academic partnerships to familiarize students, interns, and post-docs with the site and its mission.

Similar to FY 2021, over half of all terminations occurred within the 0–5 years of service category, as shown in **Figure F–33**, and the majority of these terminations were voluntary.

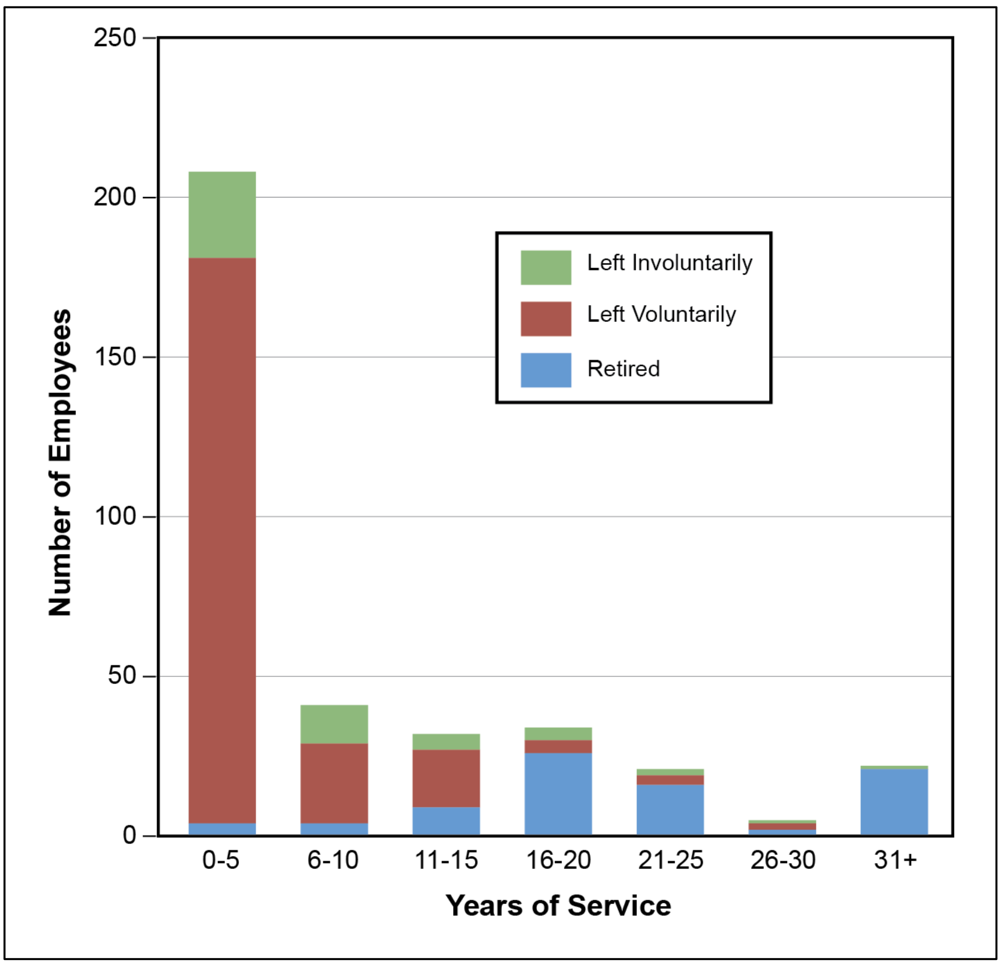


Figure F–33. NNSS separations by years of service

Advanced Career employees represent the largest workforce contingent at 45 percent of the workforce, and that number has remained relatively stable as shown in **Figure F–34**. Early and Mid-Career employees went up slightly from last fiscal year, approximately 1 percent in each category.

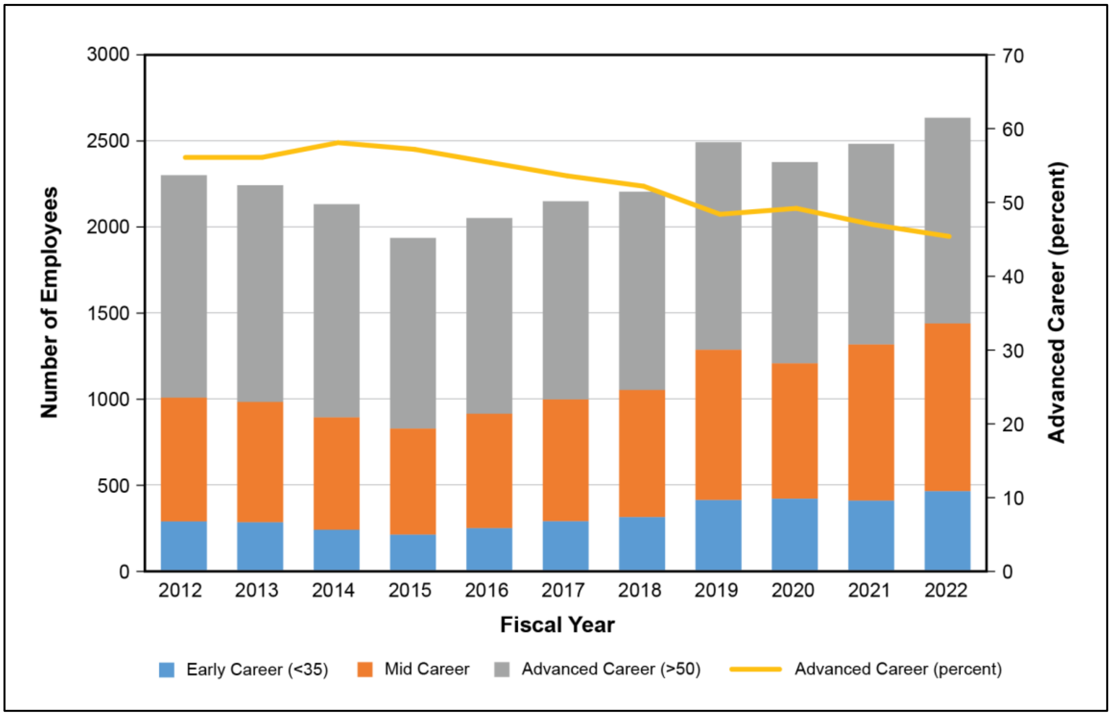


Figure F–34. NNSS workforce participation trends by age category and percent advanced career[3]

As shown in **Figure F–35**, the number of normal and early retirements remained consistent from last year. Voluntary terminations went up by 45 percent from last fiscal year, with the primary reasons being "Resigned" and "Career Advancement Opportunity." Involuntary terminations also went up by 83 percent from FY 2021, primarily due to "Discharge for Cause" and "Failure to Return from a Leave of Absence." Approximately 58 percent (80 employees) of bargaining unit employee terminations were due to layoffs. Retirements and voluntary turnover went down in FY 2020, which was expected due to the pandemic's impacts on the economy and job market. NNSS will continue tracking the reasons for all terminations, analyzing for trends, and focusing on attracting, retaining, and growing employees, especially in the early and mid-career positions.

As **Figure F–36** shows, workforce remain consistent across the near-term with minor increases anticipated for engineers and technicians to support ECSE. FY 2028 reflects a shift from construction to preparing for operations in new ECSE test beds.

[3] The percentage of advanced-career workers is calculated by taking the ratio of employees over age 50 and total workforce. Age 50 assumes the minimum age for retirement eligibility.

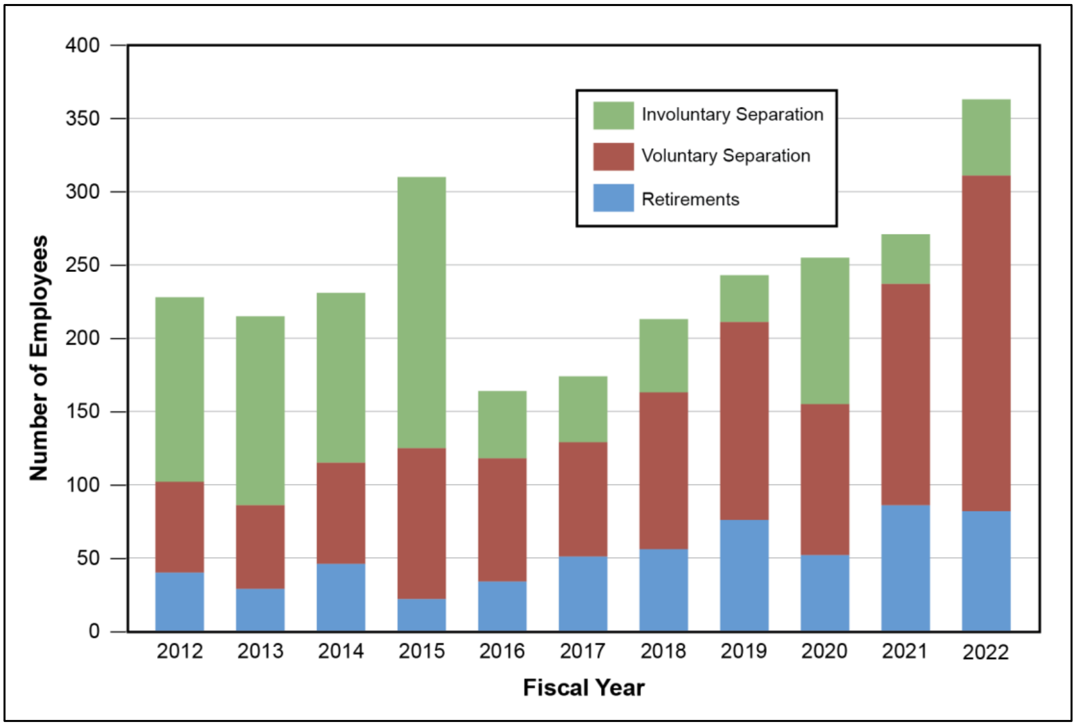


Figure F–35. NNSS employee separation trends

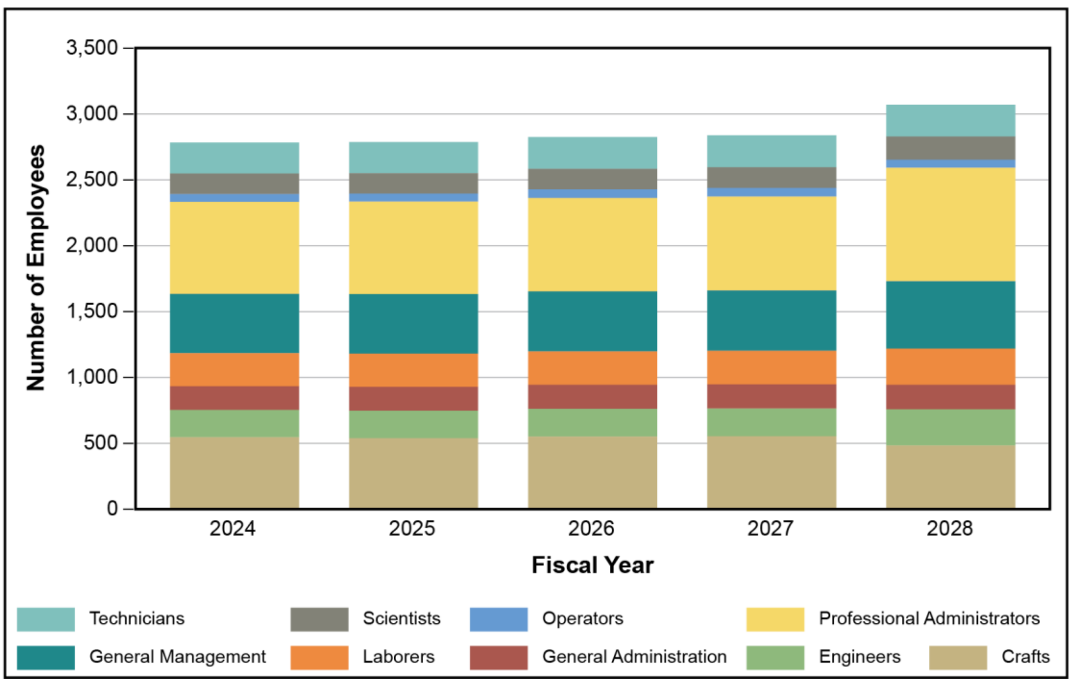


Figure F–36. NNSS workforce projection needs by Common Occupational Classification System[4]

[4] FY 2024–FY 2027 projections were updated to include the Protective Force, which was previously excluded since it was not part of the M&O contract. Protective Force became part of the M&O contract in April 2023.

Appendix G
Glossary

abnormal environment, abnormal and hostile environment, abnormal conditions—An environment, as defined in a weapon's stockpile-to-target sequence and military characteristics, in which the weapon is not expected to retain full operational reliability, or an environment that is not expected to occur during nuclear explosive operations and associated activities.

additive manufacturing—A manufacturing technique that builds objects layer by layer, according to precise design specifications, compared to a traditional manufacturing technique in which objects are carved out of a larger block of material or cast in molds and dies.

advanced manufacturing—Modern technologies necessary to enhance secure manufacturing capabilities and provide timely support for critical needs of the stockpile.

alteration—A material change to, or a prescribed inspection of, a nuclear weapon or major assembly that does not alter its operational capability, yet is sufficiently important to the user regarding assembly, maintenance, storage, or test operations to require controlled application and identification.

annual assessment—The authoritative method to evaluate the safety, reliability, performance, and military effectiveness of the stockpile by subject matter experts based upon new and legacy data, surveillance, and modeling and simulation. It is a principal factor in the Nation's ability to maintain a credible deterrent without nuclear explosive testing. The Directors of the three national security laboratories complete annual assessments of the stockpile, and the Commander of the U.S. Strategic Command provides a separate assessment of military effectiveness. The assessments also determine whether underground nuclear explosive testing must be conducted to resolve any issues. The Secretaries of Energy and Defense submit the reports unaltered to the President, along with any conclusions they deem appropriate.

arming, fuzing, and firing—The electronic and mechanical functions that ensure a nuclear weapon does not operate when not intended during any part of its manufacture and lifetime, but also ensure the weapon will operate correctly when a unique signal to do so is properly activated.

artificial intelligence—Computer systems able to perform tasks intelligently, similar to humans, such as visual perception, speech recognition, decision-making, and translating between languages.

B61—An air-delivered thermonuclear gravity bomb.

B61-12 Life Extension Program (LEP)—An LEP to consolidate four families of the B61 bomb in the active stockpile into one and improve the safety and security of the oldest weapon system in the U.S. arsenal.

calciner—A dry thermal treatment process to convert low-equity enriched uranium liquids to a dry stable form for storage.

certification—The process whereby all available information on the performance of a weapon system is considered and the laboratory directors responsible for that system certify, before the weapon enters the stockpile, that it will meet, with noted exceptions, the military characteristics within the environments defined by the stockpile-to-target sequence.

component—An assembly or combination of parts, subassemblies, and assemblies mounted together during manufacture, assembly, maintenance, or rebuild. In a system engineering product hierarchy, the component is the lowest level of shippable and storable entities, which may be raw material, procured parts, or manufactured items.

conventional high explosive—A high explosive that detonates when given sufficient stimulus by a high-pressure shock. Stimuli from severe accident environments involving impact, fire, or electrical discharge may also detonate a conventional high explosive. See also "insensitive high explosive."

critical decision (CD)—The five levels a U.S. Department of Energy project typically progresses through, which serve as major milestones approved by the Chief Executive for Project Management. Each CD marks an authorization to increase the commitment of resources and requires successful completion of the preceding phase. These five phases are CD-0, Approve Mission Need; CD-1, Approve Alternative Selection and Cost Range; CD-2, Approve Performance Baseline; CD-3, Approve Start of Construction/Execution; CD-4, Approve Start of Operations or Project Completion.

cybersecurity—The physical, technical, administrative, and management controls for providing the required and appropriate levels of protections of information and information assets against unauthorized disclosure, transfer, modification, or destruction, whether accidental or intentional. Cybersecurity also ensures the required and appropriate level of confidentiality, integrity, availability, and accountability for the information stored, processed, or transmitted on electronic systems and networks.

depleted uranium—Uranium from which most of the fissile isotope uranium-235 has been removed. It is required for nuclear component production to maintain and modernize the stockpile through life extension, modification, and limited life component exchange programs.

design agency—Any of the management and operating partners in the nuclear security enterprise who serve as lead designers for nuclear weapon components or systems, usually one of the three national security laboratories.

design life—The length of time, starting from the date of manufacture, during which a nuclear weapon is designed to meet its stated military requirements.

dismantlement and disposition—Disassembling retired weapons into major components that are then assigned for reuse, storage, surveillance, or disposal.

downblending—Processing highly enriched uranium into a uranium byproduct that contains less than 20 percent uranium-235.

down-select—The process of narrowing the range of design options during the *Phase X/6.X Process*, culminating in a final design (normally exercised when moving from Phase 1/Phase 6.1 to Phase 2/Phase 6.2, from Phase 2/Phase 6.2 to Phase 2A/Phase 6.2A, and from Phase 2A/6.2A to Phase 3/Phase 6.3). Down-selecting involves analysis of the option's ability to meet military requirements, and assessment of schedule, cost, material, and production impacts.

electrorefining—An electrochemical metal purification system designed to provide a replacement capability for the current metal purification process.

enriched uranium—Uranium that contains higher concentrations of the fissile uranium-235 isotope than natural uranium. It is required at varied enrichment levels for national security and medical isotope production.

exascale computing—Computing systems capable of at least one exaFLOPS, or one billion billion calculations per second. Such capacity represents a thousand-fold increase over the first petascale computer that came into operation in 2008. See also "floating point operations per second (FLOPS)."

first production unit—The first system, subsystem, or component manufactured and accepted by the National Nuclear Security Administration (NNSA) as verifiably meeting all applicable quality and qualification requirements. The first production unit for a weapon is a production milestone. For milestone completion, two events must occur: (1) the Department of Defense or the Nuclear Weapons Council accepts the design and (2) the Department of Energy/NNSA verifies that the first produced weapon meets the design specifications.

fiscal year—The Federal budget and funding year that starts on October 1 and goes to the following September 30.

fission—The process whereby the nucleus of a particular heavy element splits into (generally) two nuclei of lighter elements, with the release of substantial energy.

floating point operations per second (FLOPS)—The number of arithmetic operations performed on real numbers in a second; used as a measure of the performance of a computer system.

fusion—The process whereby the nuclei of two light elements, especially the isotopes of hydrogen (i.e., deuterium and tritium), combine to form the nucleus of a heavier element with the release of substantial energy and a high-energy neutron.

Future Years Nuclear Security Program—A detailed description of the program elements (and associated projects and activities) for the fiscal year for which the annual budget is submitted and the four succeeding fiscal years.

gas transfer system—A warhead component that enables tritium, a radioactive isotope of hydrogen, to boost the yield of a nuclear weapon.

high energy density physics—The physics of matter and radiation at very high energy densities, i.e., extreme temperatures and pressures.

high explosives (HE)—Materials that detonate, with the chemical reaction components propagating at supersonic speeds. HE are used in the main charge of a weapon primary to compress the fissile material and initiate the chain of events leading to nuclear yield. See also "conventional high explosive" and "insensitive high explosive."

high performance computing—The use of supercomputers and parallel processing techniques with multiple computers to perform computational tasks.

ignition—The point at which a nuclear fusion reaction becomes self-sustaining—that is, more energy is produced and retained in the fusion target than the energy used to initiate the nuclear reaction.

information technology—The equipment or interconnected system or subsystem of equipment used in the automatic acquisition, storage, manipulation, management, movement, control, display, switching, interchange, transmission, or reception of data or information. Information technology includes computers, ancillary equipment, software, firmware, and related procedures, services, and resources.

infrastructure—For the purposes and scope of the Stockpile Stewardship and Management Plan, infrastructure refers to the comprehensive inventory of facilities, structures, utilities, equipment, and other physical assets required to operate the national security enterprise in service to its national security missions.

insensitive high explosive—A high explosive substance that is so insensitive that the probability of accidental initiation or transition from burning to detonation is negligible.

integrated design code (IDC)—A simulation code containing multiple physics and engineering models that have been validated experimentally and computationally. An IDC is used to simulate, understand, and predict the behavior of nuclear and non-nuclear components and nuclear weapons under normal, abnormal, and hostile conditions.

joint test assembly—(1) An electronic unit that contains sensors and instrumentation that monitor weapon hardware performance during flight tests to ensure that the weapon components will function as designed. (2) A National Nuclear Security Administration (NNSA)-developed configuration, based on NNSA-Department of Defense requirements, for use in the flight test program.

life extension program (LEP)—A program that refurbishes warheads of a specific weapon type to extend the service life of a weapon. LEPs are designed to extend the life of a warhead by 20 to 30 years, while increasing safety and security.

lifecycle—The series of stages through which a component, system, or weapon passes from initial development until it is consumed, disposed of, or altered to extend its lifetime.

lightning arrestor connector—Advanced interconnected nuclear safety devices designed to limit voltage during lightning strikes and in other extreme, high-voltage, high-temperature environments.

limited life component—A weapon component or subsystem whose performance degrades with age and must be periodically replaced. Examples are gas transfer systems, power sources, and neutron generators.

line-item project—A distinct design, construction, betterment and/or fabrication of real property for which Congress will be requested to authorize and appropriate specific funds.

lithium—A soft, lightweight, silvery-white alkali metal (symbol: Li) used as a target element in nuclear weapons. Lithium reacts with a neutron to produce tritium. It is considered a strategic material in nuclear weapon manufacture.

machine learning—A type of artificial intelligence characterized by computer algorithms that improve automatically through experience, so the computer learns without being explicitly programmed.

Manufacturing Readiness Level (MRL)—A means of communicating the degree to which a component or subsystem is ready to be produced. MRLs represent many attributes of a manufacturing system (e.g., people, manufacturing capability, facilities, conduct of operations, and tooling). There are nine MRLs, with the lowest being product development and the highest being steady-state production.

military characteristics—Required characteristics of a nuclear weapon upon which depend its ability to perform desired military functions, including physical and operational characteristics, but not technical design characteristics.

modernization—The changes to nuclear weapons or infrastructure due to aging, unavailability of replacement parts, or the need to enhance safety, security, and operational design features. In the context of the physical infrastructure that support the nuclear security missions, modernization refers to recapitalization and refurbishment investments to restore and refresh aging facilities, structures, utilities, equipment, and other physical assets to a state that fully supports mission functionality and underpins key Weapons Activity capabilities into the future.

modification (Mod)—A program that changes a weapon's operational capabilities. A Mod may enhance the margin against failure, increase safety, improve security, replace limited life components, and/or address identified defects and component obsolescence.

national security laboratories—Los Alamos National Laboratory, Sandia National Laboratories, and Lawrence Livermore National Laboratory. These laboratories guide research and development on behalf of Department of Energy/National Nuclear Security Administration Mission needs and address science and engineering challenges, from basic science questions through weapons design and production. They also support nuclear counterterrorism and counterproliferation.

network—In relation to information technology and cybersecurity, a network is composed of a communications medium responsible for the transfer of information and all components attached to that medium.

network monitoring—The use of a system that constantly monitors a computer network, providing vulnerability management and policy compliance tools; operating system, database, and application logs; and compilation of external threat data. A key focus is monitoring and managing user and service privileges, directory services, and other system configuration changes. Network monitoring also provides log auditing and review of incident responses.

non-nuclear components—The parts or assemblies designed for use in nuclear weapons or in nuclear weapons training that do not contain special nuclear material; such components (e.g., radiation-hardened electronic circuits or arming, fuzing, and firing components) are not available commercially.

nuclear explosive package—An assembly containing fissionable and/or fusionable materials, as well as the main charge high-explosive parts or propellants capable of producing a nuclear detonation.

nuclear forensics—The investigation of nuclear materials to find evidence for the source, trafficking, and enrichment of the material.

nuclear security enterprise—The physical infrastructure, technology, and workforce at the national security laboratories, the nuclear weapons production sites, and the Nevada National Security Site, that sustain the research, development, production, and dismantlement capabilities needed to support the nuclear weapons stockpile.

nuclear stockpile—The nuclear stockpile includes both active and inactive warheads. Active warheads include strategic and non-strategic weapons maintained in an operational, ready-for-use configuration, warheads that must be ready for possible deployment within a short timeframe, and logistics spares. They have tritium bottles and other limited life components installed. Inactive warheads are maintained at a depot in a non-operational status, and have their tritium bottles removed. A retired warhead is removed from its delivery platform, is not functional, and is not considered part of the nuclear stockpile. Warheads awaiting dismantlement constitute a significant fraction of the total warhead population. A dismantled warhead is a warhead reduced to its component parts.

Nuclear Weapons Council—The joint Department of Energy/Defense of Defense Council composed of senior officials from both Departments who recommend the stockpile options and research priorities that shape national policies and budgets to develop, produce, surveil, and retire nuclear warheads and weapon delivery platforms, and who consider the safety, security, and control issues for existing and proposed weapons programs.

nuclear weapons stockpile—Both active and inactive nuclear warheads. Active warheads include strategic and non-strategic weapons maintained in an operational, ready-for-use configuration, ready for possible deployment within a short timeframe, with logistics spares.

neutron generator—A limited life component that provides neutrons at specific times and rates to initiate weapon function.

Other Program Money—Funding that is found outside of a life extension program (LEP) funding line (in other program lines), but is directly (uniquely) attributed to an LEP. Such funding would not be needed were it not for the LEP, although the activity or effort might still be done at some future point along a different timeline.

out-years—The years that follow the 5-year period of the Future Years Nuclear Security Program.

Phase X/Phase 6.X Process—The *Phase X process* provides a common framework to conduct and manage activities for new production and refurbishments of nuclear weapons. Stockpile refurbishment activities are divided into sub-elements of Phase 6, denoted by Phase 6.X, that correspond to Phases 1 through 6 of the nuclear weapons lifecycle. The *Phase 6.X Process* provides a time and organizational framework to manage the existing nuclear weapon systems that are undergoing evaluation and implementation of refurbishment options to extend their stockpile life or enhance system capabilities.

physical security—The physical or technical methods that protect personnel; prevent or detect unauthorized access to facilities, material, and documents; protect against espionage, sabotage, damage, and theft; and respond to any such acts that occur.

pit—The critical core component in the primary of a nuclear weapon that contains fissile material.

power source—Compact, specialized, limited-life components that fulfill power requirements for current and future planned nuclear weapons and life-extended warheads.

primary—The first stage of a two-stage nuclear weapon.

production sites—Savannah River Site, Y-12 National Security Complex, Kansas City National Security Campus, and Pantex Plant sites produce most of the designed weapon components and assemble weapons. (Production sites are sometimes also referred to as production facilities, plants, and agencies.)

programmatic infrastructure—Specialized experimental facilities, computers, diagnostic instruments, processes, and capabilities that allow the nuclear security enterprise to carry out research, testing, production, sustainment, and other direct programmatic activities to meet national security missions.

qualification—The process of ensuring that design, product, and all associated processes are capable of meeting customer requirements. Qualification authorizes the listed items for an intended use (i.e., War Reserve, Training, Evaluation, etc.), and it generally includes national security laboratory (design) review of production and inspection processes. Qualified items are reviewed for possible requalification after a significant process change or if production is inactive for 12 months.

recapitalization—In the context of physical infrastructure that supports nuclear security missions, recapitalization refers to investments in existing facilities, structures, utilities, equipment, and other assets that upgrade, renew, or otherwise improve and extend the usable life of the asset.

reservoir—A vessel containing deuterium and tritium that permits its transfer as a gas in a nuclear weapon.

resilience—The ability of the nuclear security enterprise to recover from an insult or stress in a sufficiently timely manner to not compromise the national deterrence mission.

responsive—The capability and capacity of the nuclear security enterprise to respond in a timely manner to technical and/or geopolitical surprises (and the requirements they generate).

Safeguards Transporter—A highly specialized trailer designed to safeguard nuclear weapons and special nuclear materials while in transit.

secondary—The second stage of a two-stage nuclear weapon that provides additional energy release in the form of fusion, and is activated by energy from the primary.

security—An integrated system of activities, systems, programs, facilities, and policies to protect classified matter, unclassified controlled information, nuclear materials, nuclear weapons, nuclear weapon components, and Department of Energy's and its contractors' facilities, property, and equipment.

security system—The combination of personnel, equipment, hardware and software, structures, plans and procedures, etc., used to protect safeguards and security interests.

service life—The duration of time that a nuclear weapon is maintained in the stockpile from Phase 5/6.5 (*First Production*) to Phase 7 (*Retirement, Dismantlement, and Disposition*). Service life can include the terms "stockpile life," "deployed life," and "useful life."

significant finding investigation—A formal investigation by a committee, chaired by an employee of a national security laboratory, to determine the cause and impact of a reported anomaly and to recommend corrective actions as appropriate.

special nuclear material (SNM)—Plutonium, uranium-233, or uranium enriched in the isotopes uranium-233 or uranium-235. The Nuclear Regulatory Commission defines three categories of quantities of SNM according to the risk and potential for its use in the creation of a fissile explosive. Category I is the category of the greatest quantity and associated risk; Category II is moderate; Category III is the lowest.

stockpile sustainment—The activities responsible for the day-to-day health of the stockpile, including surveillance, annual assessments, and routine maintenance, to ensure weapons remain safe, secure, and reliable for their projected life cycle.

Stockpile System—Weapons systems that are currently in the stockpile (B61-3/4/10/11/12, B83, W80-1, W88-0 [and Alt 370], W87-0, W76-0/1/2, W78).

stockpile-to-target sequence—The order of events involved in removing a nuclear weapon from storage and assembling, testing, transporting, and delivering it to the target. The term also refers to a document that defines the logistical and employment concepts and related physical environments involved in delivering a nuclear weapon to a target.

subcritical experiment—An experiment specifically designed to obtain data on nuclear weapons for which less than a critical mass of fissionable material is present and, hence, no self-sustaining nuclear fission chain reaction can occur, consistent with the Comprehensive Nuclear Test Ban Treaty.

surety—The assurance that a nuclear weapon will operate safely, securely, and reliably if deliberately activated and that no accidents, incidents, or unauthorized detonations will occur. Factors contributing to that assurance include model validation for weapon performance based on experiments and simulations, material (e.g., military equipment and supplies), personnel, and execution of procedures.

surveillance—Activities that provide data for evaluation of the stockpile, giving confidence in the Nation's deterrent by demonstrating mission readiness and assessment of safety, security, and reliability standards. These activities may include laboratory and flight testing of systems, subsystems, and components (including those of weapons in the existing stockpile, newly produced weapons, or weapons being disassembled); inspection for unexpected wear or signs of material aging; and destructive or nondestructive testing.

sustainment—A National Nuclear Security Administration program to modify and maintain a set of nuclear weapon systems (see "stockpile sustainment"). In the context of physical infrastructure that supports the nuclear security missions, sustainment refers to the set of activities over an asset's lifetime that provide for maintaining, operating, refurbishing, upgrading, and recapitalizing that asset until retirement and disposition.

technology maturation—Advancing laboratory-developed technology to the point where it can be adopted and used by U.S. industry.

test readiness—The preparedness to conduct underground nuclear explosive testing if required to ensure the safety and effectiveness of the stockpile, or if directed by the President for policy reasons.

tritium—A radioactive isotope of hydrogen whose nucleus contains two neutrons and one proton. It is produced in nuclear reactors by the action of neutrons on lithium nuclei.

uranium—A naturally occurring radioactive, metallic element (symbol: U) that is found in the earth as a mineral ore. It has three primary isotopes: uranium-238, -235, and -234. It is a strategic material, with several uses related to nuclear weapons and therefore is critical to national security.

uranium enrichment—The process of increasing the concentration of the uranium-235 isotope in a sample of uranium by separating it from uranium-238.

Verification and validation—Independent procedures that are used together for checking that a product, service, or system meets requirements and specifications, and that it fulfills its intended purpose. For example, in the context of software testing, verification provides evidence of the correctness of computer codes in solving pertinent equations, while validation assesses the adequacy of the physical models used to represent reality. Verification and validation is also applied to nuclear weapons to ensure that they fulfill their intended function with sufficient precision to meet military and other specifications.

W76-1 LEP—A life extension program for the W76 submarine-launched ballistic missile warhead, delivered by a Navy Trident II.

W78—An intercontinental ballistic missile warhead, delivered by an Air Force Minute Man III LGM-30.

W80-4 LEP—A life extension program for the W80 warhead aboard a cruise missile, delivered by the Air Force B-52 bomber and future launch platforms.

W88—A submarine-launched ballistic missile warhead, delivered by a Navy Trident II.

W88 Alteration (Alt) 370—An Alt of the W88 warhead to replace the arming, fuzing, and firing components and to refresh the conventional high explosive main charge.

W87-1—An intercontinental ballistic missile warhead designed to replace the W78 and support the Air Force's ground-based strategic deterrent missile system planned to replace the Minuteman III.

warhead—The part of a missile, projectile, torpedo, rocket, or other munition that contains either the nuclear or thermonuclear system intended to inflict damage.

War Reserve—Nuclear weapons and nuclear weapon material intended for use in the event of war.

weapon—(1) Warhead and its delivery system (missile, etc). (2) A gravity bomb (e.g., B61-12) can be referred to as a weapon even when separate from the aircraft carrying it.

Weapons Activities—Sustaining, modernizing, and dismantling nuclear weapons; maintaining and modernizing production operations; and optimizing the scientific tools underpinning these efforts. The term also refers to the portion of the National Nuclear Security Administration budget covering these activities.

Weapon System—The combination of the National Nuclear Security Administration nuclear weapon and ancillary equipment and the Department of Defense carriers and ancillary items including aircraft, missiles, ships, submarines, launchers, hardware, and software.

Appendix H
Acronyms and Abbreviations

ACCESS	Apprenticeships for Complete and Committed Employment for Specialized Skills
ACRR	Annular Core Research Reactor
Alt	Alteration
AoA	Analysis of Alternatives
ASC	Advanced Simulation and Computing
ASD	Advanced Sources and Detectors
BCR	Baseline Cost Report
CBI	Capabilities-Based Investments
CD	Critical Decision
CEAG	Cost Estimating and Analysis Group
CFIUS	Committee on Foreign Investment in the United States
COVID-19	Coronavirus Disease 2019
CREST	Combined Radiation Environments for Survivability Testing
CSTART	Center for Security Technology, Analysis, Response, and Testing
CTCP	Office of Counterterrorism and Counterproliferation
CUAS	counter unmanned aircraft system
D&I	disassembly and inspection
DARHT	Dual-Axis Radiographic Hydrodynamic Test
DM	deferred maintenance
DNS	Defense Nuclear Security
DoD	Department of Defense
DOE	Department of Energy
DU	depleted uranium
DUE	domestic uranium enrichment
DUF_4	depleted uranium tetrafluoride
DUF_6	depleted uranium hexafluoride
ECI	Exascale Computing Initiative
ECP	Exascale Computing Project
ECSE	Enhanced Capabilities for Subcritical Experiments
EMC	Energetic Materials Characterization
EMC^2	Enhanced Minor Construction and Commercial Practices
FA	Federal Agent
FFRDC	Federally Funded Research and Development Center
FITARA	Federal IT Acquisition Reform Act
FY	fiscal year
FYNSP	Future Years Nuclear Security Program
G2	Generation 2
GAO	Government Accountability Office
GTS	gas transfer system
HE	high explosives

HE&E	high explosives and energetics
HESFP	High Explosive Synthesis, Formulation, and Production Facility
HED	high energy density
HESE	high explosives science and engineering
HEU	highly enriched uranium
HPC	high performance computing
HPDU	high purity depleted uranium
ICF	inertial confinement fusion
IDA	Institute for Defense Analyses
IDC	integrated design code
IMI	Infrastructure Modernization Initiative
IT	information technology
JASPER	Joint Actinide Shock Physics Experimental Research
JTA	joint test assembly
KCNExT	Kansas City Non-Nuclear Expansion Transformation
KCNSC	Kansas City National Security Campus
KC STEP	Kansas City Short-Term Expansion Plan
kV	kilovolt
LAMP	LANSCE Modernization Project
LANL	Los Alamos National Laboratory
LANSCE	Los Alamos Neutron Science Center
LAP4	Los Alamos Plutonium Pit Production Project
LEP	Life Extension Program
LEU	low-enriched uranium
LLC	limited life component
LLNL	Lawrence Livermore National Laboratory
LRSO	Long Range Standoff
M3	material management and minimization
M&O	management and operating
MESA	Microsystems Engineering, Science and Applications
MFFF	Mixed Oxide Fuel Fabrication Facility
MGT	Mobile Guardian Transporter
MIE	major item of equipment
MJ	megajoules
Mod	Modification
MRL	manufacturing readiness level
MSIPP	Minority Serving Institution Partnership Program
NEA	Nuclear Enterprise Assurance
NEST	Nuclear Emergency Support Team
NIB	nuclear security enterprise industrial base
NIF	National Ignition Facility
NNSA	National Nuclear Security Administration
NNSS	Nevada National Security Site
NPAC	nonproliferation and arms control
NRC	Nuclear Regulatory Commission
OCIO	Office of the Chief Information Officer
OMB	Office of Management and Budget
Omega	Omega Laser Facility

OT	operational technology
Pantex	Pantex Plant
PF-4	Plutonium Facility
PPBE	planning, programming, budget, and evaluation
ppy	pits per year
R&D	research and development
RACR	Radiography/Assembly Capability Replacement
RPV	replacement plant value
RTG	radioisotope thermoelectric generators
SAR	Selected Acquisition Report
SFI	significant finding investigation
SGT	Safeguards Transporter
SIRP	Security Infrastructure Revitalization Program
SME	subject matter expert
SNL	Sandia National Laboratories
SNM	special nuclear material
SRNS	Savannah River Nuclear Solutions
SRP	Stockpile Responsiveness Program
SRPPF	Savannah River Plutonium Processing Facility
SRS	Savannah River Site
SRTE	Savannah River Tritium Enterprise
SRT&E	Stockpile Research, Technology, and Engineering
SSMP	Stockpile Stewardship and Management Plan
STA	Secure Transportation Asset
STAR	Standardized Acquisition and Recapitalization
STEM	science, technology, engineering, math
STS	stockpile-to-target sequence
TA	Technical Area
TA2	Test Article 2
TEPP	Tribal Education Partnership Program
TFF	Tritium Finishing Facility
TMP	Tritium Modernization Program
TPBAR	tritium-producing burnable absorber rod
TRL	technology readiness level
TSRH	Trusted and Strategic Radiation-Hardened
TVA	Tennessee Valley Authority
U1a	U1a Complex
UAS	uncrewed aircraft system
UCEP	U1a Complex Enhancements Project
USSTRATCOM	U.S. Strategic Command
VIM	Vacuum Induction Melt
VAR	Vacuum Arc Remelt
WBN	Watts Bar nuclear reactors
WDCR	Weapon Design and Cost Report
WDD	Weapons Dismantlement and Disposition
WIP	Weapon Intern Program
WR	War Reserve
WTMM	weapon technology and manufacturing maturation

Y-12	Y-12 National Security Complex
Z	Z pulsed power facility

Appendix I
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A Report to Congress

Fiscal Year 2024 Stockpile Stewardship and Management Plan

November 2023

U.S. Department of Energy
National Nuclear Security Administration
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Washington, DC 20585