U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

Fiscal Year 2017

# Stockpile Stewardship and Management Plan – Biennial Plan Summary

Report to Congress

March 2016

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

# Message from the Administrator

This Department of Energy's (DOE) National Nuclear Security Administration (NNSA) *Fiscal Year 2017 Stockpile Stewardship and Management Plan (SSMP) – Biennial Plan Summary* (*FY 2017 SSMP*) is a key planning document for the nuclear security enterprise. This year's summary report updates the *Fiscal Year 2016 Stockpile Stewardship and Management Plan* (*FY 2016 SSMP*), the 25-year strategic program of record that captures the plans developed across numerous NNSA programs and organizations to maintain and modernize the scientific tools, capabilities, and infrastructure necessary to ensure the success of NNSA's nuclear weapons mission. The SSMP is a companion to the *Prevent, Counter, and Respond: A Strategic Plan to Reduce Global Nuclear Threats (FY 2017-2021)* report, the planning document for NNSA's nuclear threat reduction mission. New versions of both reports are published each year in response to new requirements and challenges.

Much was accomplished in FY 2015 as part of the program of record described in this year's SSMP. The science-based Stockpile Stewardship Program allowed the Secretaries of Energy and Defense to certify for the twentieth time that the stockpile remains safe, secure, and effective without the need for underground nuclear explosive testing. The talented scientists, engineers, and technicians at the three national security laboratories, the four nuclear weapons production plants, and the national security site are primarily responsible for this continued success.

Research, development, test, and evaluation programs have advanced NNSA's understanding of weapons physics, component aging, and material properties through first-of-a-kind shock physics experiments, along with numerous other critical experiments conducted throughout the nuclear security enterprise. The multiple life extension programs (LEPs) that are under way made progress toward their first production unit dates. The W76-1 LEP is past the halfway point in total production, and the B61-12 completed three development flight tests.

Critical to this success is the budget. The Administration's budget request for NNSA's Weapons Activities has increased for all but one of the past seven years, resulting in a total increase of approximately 45 percent since 2010. If adopted by Congress, the FY 2017 budget request will increase funding by $396 million (about 4.5 percent) from the enacted FY 2016 level. A significant portion of the increase would fund the research for multiple life extension programs, support the programs in Directed Stockpile Work, and modernize the physical infrastructure of the nuclear security enterprise.

Pursuant to the statutory requirements, this SSMP is being provided to the following members of Congress:

- **The Honorable Thad Cochran**
  Chairman, Senate Committee on Appropriations
- **The Honorable Barbara Mikulski**
  Ranking Member, Senate Committee on Appropriations
- **The Honorable John McCain**
  Chairman, Senate Committee on Armed Services
- **The Honorable Jack Reed**
  Ranking Member, Senate Committee on Armed Services

- **The Honorable Lamar Alexander**
  Chairman, Subcommittee on Energy and Water Development
  Senate Committee on Appropriations
- **The Honorable Dianne Feinstein**
  Ranking Member, Subcommittee on Energy and Water Development
  Senate Committee on Appropriations
- **The Honorable Jeff Sessions**
  Chairman, Subcommittee on Strategic Forces
  Senate Committee on Armed Services
- **The Honorable Joe Donnelly**
  Ranking Member, Subcommittee on Strategic Forces
  Senate Committee on Armed Services
- **The Honorable Harold Rogers**
  Chairman, House Committee on Appropriations
- **The Honorable Nita M. Lowey**
  Ranking Member, House Committee on Appropriations
- **The Honorable Mac Thornberry**
  Chairman, House Committee on Armed Services
- **The Honorable Adam Smith**
  Ranking Member, House Committee on Armed Services
- **The Honorable Mike Simpson**
  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 Mike Rogers**
  Chairman, Subcommittee on Strategic Forces
  House Committee on Armed Services
- **The Honorable Jim Cooper**
  Ranking Member, Subcommittee on Strategic Forces
  House Committee on Armed Services

If you have any questions or need additional information, please contact me or Mr. Clarence Bishop, Associate Administrator for External Affairs, at (202) 586-8343.

Sincerely,

Frank G. Klotz

# Message from the Secretary

The Department of Energy's (DOE) National Nuclear Security Administration (NNSA) is the principal steward of the U.S. science, technology, and engineering expertise of the nuclear security enterprise. This expertise is resident in the DOE national laboratories, nuclear weapons production plants, the Nevada National Security Site, and the NNSA Headquarters and field offices. With this expertise, our Nation applies scientific solutions to some of the world's most pressing national security problems, including maintaining a safe, secure, and effective nuclear weapons stockpile; reducing the threat of nuclear proliferation and nuclear terrorism; and designing, developing, and sustaining the reactor systems that power the U.S. Navy's aircraft carriers and submarines.

The science-based Stockpile Stewardship Program (SSP) was established to sustain the credibility of the nuclear deterrent without nuclear explosive testing. National investment in the SSP has provided more detailed knowledge of the stockpile than could have been obtained through nuclear explosive testing alone. Through this program, NNSA has developed leading-edge expertise in advanced simulation and computing, hydrodynamic and subcritical experiments, high energy density physics, and materials and weapons effects science. These capabilities also support NNSA's two other vital missions, nuclear threat reduction and naval nuclear propulsion.

The SSP is a remarkable accomplishment in national security and will remain central to U.S. nuclear weapons policy and nuclear threat reduction goals now and for the foreseeable future. Having commemorated the $20^{th}$ anniversary of this program, as we look forward to the next generation of successful science-based stockpile stewardship, we must lay the foundation for the science, technology, and engineering capabilities necessary to support the Nation's strategic deterrent well into the future.

The national laboratories play a critical role in the SSP, and their unique and vital capabilities must be developed, sustained, and nurtured over decades. Sound stewardship of the DOE national laboratories has been one of my highest priorities as Secretary. Top talent must be attracted and retained by providing a vibrant research environment focused on challenging problems that call for multidisciplinary teams integrating scientific, engineering, and management expertise.

This stewardship and further strengthening of the national laboratories is both a major responsibility of and opportunity for DOE in service of the national interest. This ongoing effort includes improving the strategic partnership between the Department and the national laboratories, forming networks of labs with complimentary capabilities to deliver results, and providing an environment in which DOE sets the mission needs and provides oversight, while the managing contractor and laboratory leadership and staff put together the teams and structure programs in response to the mission needs, all in the public interest. In addition to ensuring sound stewardship, we are also focused on enhancing the responsiveness of the nuclear security enterprise. Along these lines, the uranium and plutonium pit production programs and budgets described in this plan will position the enterprise to meet the requirements specified in the *National Defense Authorization Act of Fiscal Year 2015*.

Finally, current world events confirm the dynamic nature of the global threat environment and reaffirm the need for a strong nuclear deterrent. Talented scientists, engineers, and technicians from across the nuclear security enterprise will continue to make advances in modeling and simulation of U.S. and adversary weapon systems; conduct experiments in extreme environments at our advanced high energy density facilities; and pursue other scientific, experimental, engineering, and directed stockpile management activities to identify and address evolving global threats. This approach will enhance our ability to maintain strategic stability, strengthen regional deterrence, and provide assurance to our allies and partners, while we work toward reducing the overall size of the U.S. nuclear weapons stockpile and sustaining the safety, security, and effectiveness of our nuclear arsenal. The SSMP and DOE/NNSA's *Prevent, Counter, and Respond: A Strategic Plan to Reduce Global Nuclear Threats* report provide the path forward for future planning and program activities in these two enduring mission areas.

Sincerely,

Ernest J. Moniz

# Executive Summary

This *Fiscal Year 2017 Stockpile Stewardship and Management Plan (SSMP) – Biennial Summary Plan* (*FY 2017 SSMP*) updates last year's full report on the Department of Energy's (DOE) National Nuclear Security Administration (NNSA) strategic program for maintaining the safety, security, and effectiveness of the nuclear stockpile over the next 25 years. The SSMP is published annually either in full report form or as a summary, in response to statutory requirements, to support the President's budget request to Congress for Weapons Activities. This annual plan is also used to provide a single, integrated picture of current and future nuclear security enterprise activities funded by the Weapons Activities account in support of the Nation's nuclear deterrent.

After an overview in Chapter 1, Chapter 2 addresses the status of the stockpile, the status of life extension programs (LEPs) and major alterations (Alts), and the methods used to assess and certify the stockpile. Chapter 3 discusses the challenges and strategies associated with the critical capabilities necessary to execute the Stockpile Stewardship and Stockpile Management Programs. Chapter 4 summarizes the budget for the key programmatic elements, the FY 2015 accomplishments, and the milestones and objectives. Chapter 5 presents a brief conclusion. The plan is organized to clarify the linkages among the essential capabilities of the nuclear security enterprise. Consideration of the combined effects of programmatic changes is important to ensure (1) an appropriate balance among near-term and long-term needs of managing the stockpile; (2) necessary sustainment and recapitalization of infrastructure; (3) essential investment in research, development, experiments, and evaluation; and (4) activities to maintain the expertise of a highly skilled workforce.

While no significant changes have been made to the long-term strategic program of record since the *Fiscal Year 2016 Stockpile Stewardship and Management Plan* (*FY 2016 SSMP*) was issued in March 2015, much has been achieved. Extending the life of the warheads, stewardship of the stockpile without nuclear explosive testing, and recapitalization of key capabilities for the production of plutonium, uranium, and non-nuclear and high explosive components are progressing on or ahead of schedule.

In FY 2015, NNSA continued to maintain the current stockpile while also laying the foundation for the future deterrent by making substantial progress on LEPs, leveraging world-class facilities to perform experiments that yield critical information, proposing and executing projects to enhance core capabilities, and addressing the risks posed by the aging infrastructure.[1]

[1] As defined in Chapter 4 of the *FY 2016 SSMP* (March 2015), NNSA's infrastructure is funded and managed in two categories. General Purpose Infrastructure includes the roads, utilities, and equipment as well as the building envelopes (walls, roofs) that house the programmatic infrastructure. Programmatic Infrastructure includes the scientific tools, specialized equipment, experimental facilities, computers, *etc.* that are used to carry out research, subsystem tests, experiments, production, sustainment, and disposition activities.

Specific FY 2015 achievements include the following:

- W76-1 production passed the halfway mark of deliveries for the U.S. Navy's submarine-launched ballistic missile fleet. With production nearing completion, NNSA and the U.S. Navy agreed to conclude joint flight testing of the W76-0 in FY 2016. When the LEP is completed in 2019, the warhead will have an additional 30 years of service life.
- NNSA and the U.S. Air Force completed three development flight tests of a B61-12 nuclear gravity bomb. An F-15E from Nellis Air Force Base released the B61-12 test asset and demonstrated its performance in a realistic guided flight environment. Additionally, the program has demonstrated system performance in ground tests and completed aircraft compatibility testing on four platforms (F-15, F-16, F-35, B-2). When finished, the B61-12 LEP will add at least 20 years to the life of the system and will allow NNSA to consolidate four variants of the B61 into one.
- NNSA capitalized on recent efficiency improvements at the National Ignition Facility, located at Lawrence Livermore National Laboratory in Livermore, California, to achieve an unprecedented number of experiments, with 356 laser shots in support of the Stockpile Stewardship Program. Four of these were first-of-a-kind shock physics experiments to explore dynamic properties of plutonium that have never been investigated.
- The seventeenth dynamic compression experiment using plutonium was conducted at the Z facility at Sandia National Laboratories in Albuquerque, New Mexico, the world's most powerful pulsed power device. The data will improve the understanding of material properties of plutonium under extreme pressures and temperatures to inform decisions on pit reuse for warhead LEPs.
- The first hardware delivery for NNSA's next-generation, high-performance computer, Trinity, was received at Los Alamos National Laboratory in Los Alamos, New Mexico. Trinity will have at least seven times better code performance than Cielo, NNSA's leading supercomputer, and will be one of the most advanced computers in the world, with 40 petaflops of processing power.

Additional information regarding these and other advances that ensure the ability to achieve our mission is included in the chapters that follow.

# Information at a Glance

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# Fiscal Year 2017 Stockpile Stewardship and Management Plan – Biennial Plan Summary

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# List of Acronyms and Abbreviations

| | |
|---|---|
| Alt | Alteration |
| ARES | Advanced Radio Enterprise System |
| ASC | Advanced Simulation and Computing |
| ASCR | Advanced Scientific Computing Research |
| CD | Critical Decision |
| CRISP | Core Infrastructure, Risk-Informed Strategic Planning |
| DARHT | Dual-Axis Radiographic Hydrodynamic Test |
| DM | Deferred Maintenance |
| DNS | Defense Nuclear Security |
| DOD | Department of Defense |
| DOE | Department of Energy |
| DSW | Directed Stockpile Work |
| ECSE | Enhanced Capabilities for Subcritical Experiments |
| ERM | Enterprise Risk Management |
| FISMA | *Federal Information Security Management Act* |
| FY | Fiscal Year |
| FYNSP | Future Years Nuclear Security Program |
| G2 | Generation 2 |
| GTS | Gas Transfer System |
| HE | High Explosives |
| HED | High Energy Density |
| HEU | Highly Enriched Uranium |
| HVAC | Heating, Ventilating, and Air Conditioning |
| ICE | Independent Cost Estimate |
| IDC | Integrated Design Code |
| IDS | Intrusion Detection Systems |
| IW | Interoperable Warhead |
| KCNSC | Kansas City National Security Campus |
| LANL | Los Alamos National Laboratory |
| LANSCE | Los Alamos Neutron Science Center |
| LEP | Life Extension Program |
| LEU | Low Enriched Uranium |
| LLC | Limited Life Component |
| LLNL | Lawrence Livermore National Laboratory |

| | |
|---|---|
| M&O | Management and Operating |
| MaRIE | Matter-Radiation Interactions in Extreme |
| MESA | Microsystems and Engineering Sciences Applications |
| MGT | Mobile Guardian Transporter |
| Mod | Modification |
| NIF | National Ignition Facility |
| NNSA | National Nuclear Security Administration |
| Pantex | Pantex Plant |
| PF-4 | Plutonium Facility |
| PIDAS | Perimeter Intrusion Detection and Assessment System |
| R&D | Research and Development |
| RDT&E | Research, Development, Test, and Evaluation |
| RTBF | Readiness in Technical Base and Facilities |
| SAR | Selected Acquisition Report |
| SGT | Safeguards Transporter |
| SNL | Sandia National Laboratories |
| SNM | Special Nuclear Material |
| SRS | Savannah River Site |
| SSMP | *Stockpile Stewardship and Management Plan* |
| SSP | Stockpile Stewardship Program |
| STA | Secure Transportation Asset |
| TA | Technical Area |
| TPBAR | Tritium-Producing Burnable Absorber Rod |
| TRIM | Tritium Responsive Infrastructure Modifications |
| U.S.C. | United States Code |
| U1a | U1a Complex |
| UAS | Unmanned Aerial Systems |
| WR | War Reserve |
| Y-12 | Y-12 National Security Complex |
| Z | Z facility |

# Legislative Language

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

> the NNSA 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, NNSA has submitted reports on the plan to Congress annually since 1998, with the exception of 2012.[2] Starting in 2013, full reports on the plan are to be submitted every odd-numbered year, with summaries of the plan provided in even-numbered years.

This *Fiscal Year 2017 Stockpile Stewardship and Management Plan – Biennial Plan Summary* (*FY 2017 SSMP*) is a summary of the 25-year strategic plan, including a discussion of updates to the *Fiscal Year 2016 Stockpile Stewardship and Management Plan* and newly added requirements from the *National Defense Authorization Act for Fiscal Year 2016*, Section 3112, to establish a stockpile responsiveness program in support of the Stockpile Stewardship and Stockpile Management Programs. The majority of this *FY 2017 SSMP* is captured in this single, unclassified document. A classified Annex to the *FY 2017 SSMP* is also provided. The Annex contains supporting details concerning the U.S. nuclear stockpile and stockpile management.

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

# Chapter 1
# Overview

## 1.1 Summary of the Strategic Environment for Nuclear Security

The United States and its allies and partners are confronted with a rapidly changing global security environment. Many sources of potential conflict persist, particularly in regions with an active and growing terrorist presence. State and non-state actors continue to pursue a diverse set of nuclear capabilities that threaten multiple strategic domains. Moreover, while the size of the Russian and U.S. nuclear arsenals has been significantly reduced since the end of the Cold War, thousands of nuclear weapons and large stockpiles of weapons-usable nuclear materials remain. Other countries, such as China and North Korea, are increasing the size of their nuclear arsenals. Preventing nuclear proliferation and nuclear terrorism remains one of the United States' highest nuclear policy priorities. Likewise, as long as nuclear deterrence remains a major element of U.S. national security, the United States must ensure that its nuclear weapon stockpile remains safe, secure, and effective.

Although the principal role of the stockpile is to undergird America's national security, the U.S. nuclear deterrent also contributes to the security of its allies and partners around the world. By extending deterrence to these states, the United States not only helps promote peace and stability, but also removes incentives to develop indigenous nuclear capabilities, thereby strengthening nonproliferation. These assurances remain vital to U.S. and allied security and play a critical role in maintaining stability in strategically vital regions across the globe. Tailoring strategies in response to U.S. and allied needs in the fast-moving global security environment will require periodic adjustments to the Department of Energy's (DOE's) National Nuclear Security Administration (NNSA) Stockpile Stewardship and Management Plan (SSMP). This 25-year plan of record, developed in conjunction with the Department of Defense (DOD) and other interagency partners, is designed to keep the stockpile safe, secure, and effective to ensure U.S. national security and honor America's commitments to its allies. As the United States continues to reduce the size of the operational and deployed strategic stockpile under the New Strategic Arms Reduction Treaty, an increasing premium is being placed on the safety, security, and reliability of the weapons it retains.

As detailed in the *Enterprise Strategic Vision* (DOE/NNSA August 2015), current and evolving strategic environmental challenges that influence the Stockpile Stewardship Program and nuclear weapons planning include the following:[1]

- Much of the United States arsenal has aged beyond its originally anticipated lifetime.
- United States nuclear infrastructure has, in part, aged beyond its originally anticipated service life. Recapitalization of key infrastructure capabilities must continue for a significant time period.

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[1] For further description of today's challenging environment and NNSA's approach to executing its mission within that environment, see *Enterprise Strategic Vision* (DOE/NNSA August 2015) at http://nnsa.energy.gov/content/strategic-vision.

- Global expansion of civil nuclear power production and the spread of civil nuclear materials challenge national and international capabilities to manage and secure these materials. Moreover, virtually all countries use radiological sources for industrial and medical purposes, creating the attendant risk of loss of regulatory control over radiological materials.
- The United States and its allies continue to face the risk of nuclear or radiological attack by a variety of terrorist groups or nation states. The expansion of global trade and the increasing sophistication of illicit trafficking networks could enhance opportunities for state and non-state actors to acquire nuclear and radiological materials, equipment, and technology.

## 1.2 Policy Framework Summary

The role of nuclear weapons as part of the nuclear security enterprise is established as a matter of national policy. DOE/NNSA draws its mission and authority from the *Atomic Energy Act* (42 United States Code [U.S.C.] § 2011 *et seq.*) and the *National Nuclear Security Administration Act* (50 U.S.C. § 2401*, et seq.*). The *National Nuclear Security Administration Act* directs DOE/NNSA "To maintain and enhance the safety, reliability, and performance of the United States nuclear weapons stockpile, including the ability to design, produce, and test, in order to meet national security requirements" (50 U.S.C. § 2401*, (b) (2)*).

This direction is supplemented by Presidential and DOE policy guidance documents that provide additional direction regarding how the nuclear weapons mission is accomplished. These documents include the February 2015 *National Security Strategy* (White House 2015), the *Nuclear Posture Review Report* (DOD 2010), and the 2013 Presidential Policy Directive, *Nuclear Weapons Employment Strategy of the United States* (PPD-24). These documents and the imperatives and limitations they impose are described in more detail in Chapter 1, Section 1.1, of the March 2015 *FY 2016 Stockpile Stewardship and Management Plan*.

The *National Defense Authorization Act for Fiscal Year 2016* requires DOE/NNSA to establish a stockpile responsiveness program **"**to identify, sustain, enhance, integrate, and continually exercise all capabilities required to conceptualize, study, design, develop, engineer, certify, produce, and deploy nuclear weapons." This legislation is intended to ensure the nuclear security enterprise workforce is sufficiently challenged through integrated warhead life cycle activities (design, develop, manufacture, prototype, build, and experiment) to ensure that mission needs can be met without new underground nuclear explosive testing. DOE/NNSA is already implementing a number of activities that meet the intent of this legislation and is in the process of analyzing current programs to ensure national security mission needs and proficiencies are met now and maintained into the future.

Achieving this goal requires the modernization of aging facilities, upgrading and exercising critical capabilities, and investing in the human capital necessary to ensure the nuclear security enterprise of the United States remains safe, secure, reliable, and effective. In order to achieve these goals, DOE/NNSA works in coordination with the Nuclear Weapons Council and interagency partners.

## 1.3 Summary of the Current Nuclear Weapons Stockpile

The size and composition of the nuclear weapon stockpile has evolved in response to changes in the global security environment and national security needs, as described in Section 1.1 and shown in **Figure 1–1**.

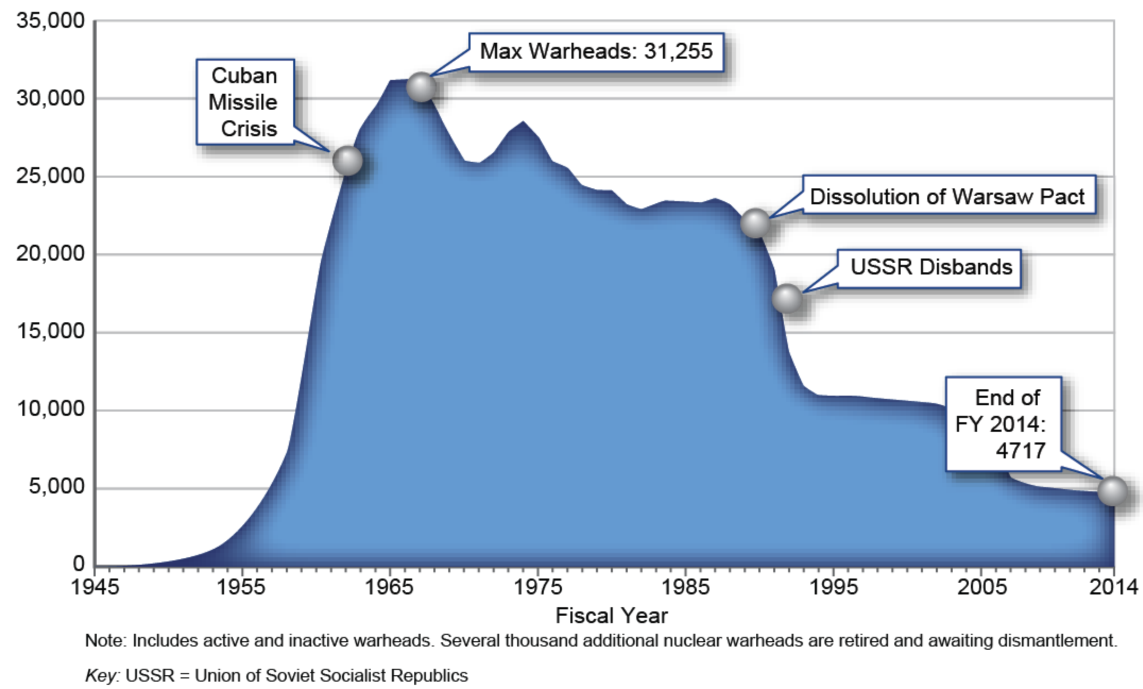


**Figure 1–1. Size of the U.S. nuclear weapons stockpile, 1945–2014**

**Table 1–1** reflects the major characteristics of the current stockpile, which is composed of two types of submarine-launched ballistic missile warheads, two types of intercontinental ballistic missile warheads, several types of bombs, and a cruise missile warhead delivered by aircraft.

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

| *Warheads—Strategic Ballistic Missile Platforms* | | | | | |
|---|---|---|---|---|---|
| ***Type*** [a] | ***Description*** | ***Delivery System*** | ***Laboratories*** | ***Mission*** | ***Military*** |
| W78 | Reentry vehicle warhead | Minuteman III intercontinental ballistic missile | LANL/SNL | Surface to surface | Air Force |
| W87 | Reentry vehicle warhead | Minuteman III intercontinental ballistic missile | LLNL/SNL | Surface to surface | Air Force |
| W76-0/1 | 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*** | | | | | |
| B61-3/4/10 | Non-strategic bomb | F-15, F-16, certified NATO aircraft | LANL/SNL | Air to surface | Air Force/Select NATO forces |
| B61-7 | Strategic bomb | B-52 and B-2 bombers | LANL/SNL | Air to surface | Air Force |
| B61-11 | Strategic bomb | B-2 bomber | LANL/SNL | Air to surface | Air Force |
| B83-1 | Strategic bomb | B-52 and B-2 bombers | 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” for the W76) represents the modification associated with the respective weapon.

The classified Annex to this document provides more specific technical detail on the stockpile by warhead type.

## 1.4 Summary of the Nuclear Security Enterprise

The mission is supported by three crosscutting capabilities: science, technology, and engineering; people and infrastructure; and management and operations. These capabilities are spread across the DOE/NNSA nuclear security enterprise at NNSA Headquarters (located in Washington, DC; Germantown, Maryland; and the Albuquerque Complex in Albuquerque, New Mexico); the NNSA field offices; four production facilities; three national security laboratories, two of which include production missions; and a national security site (see **Figure 1–2**). At these locations, a highly trained workforce consisting of Federal employees (more than 1,500), employees of our management and operating (M&O) partners (more than 35,000), and assigned members of the military ensure the success of the NNSA mission. NNSA Headquarters develops the strategy and oversees and coordinates activities to ensure they are accomplished in an efficient and fiscally responsible manner.

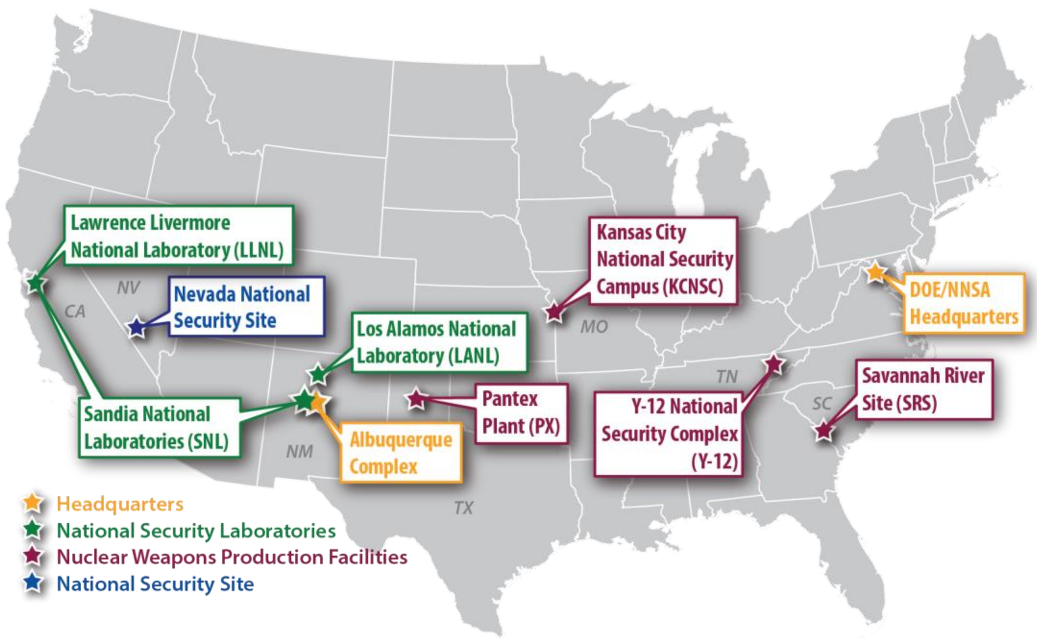


**Figure 1–2. The nuclear security enterprise**

### 1.4.1 National Security Laboratories

The national security laboratories are Lawrence Livermore National Laboratory (LLNL) in Livermore, California; Los Alamos National Laboratory (LANL) in Los Alamos, New Mexico; and Sandia National Laboratories (SNL) in Albuquerque, New Mexico and Livermore, California.[2] Their primary mission is to develop and sustain nuclear weapons design, simulation, modeling, and experimental capabilities and competencies to ensure confidence in the stockpile without nuclear explosive testing. Additional core missions include plutonium research and development (R&D); tritium R&D; high explosives (HE) and

[2] Some research and development capabilities also exist at DOE's Savannah River National Laboratory in Aiken, South Carolina, in support of the national security laboratories' gas transfer system design and certification activities.

energetic materials R&D; special nuclear material (SNM) accountability, storage, protection, handling, and disposition; pits, detonators, neutron generators, and other non-nuclear component production; research, development, test, and evaluation (RDT&E) efforts for stockpile stewardship; engineering, design, and technical systems integration for Secure Transportation Asset; and nonproliferation, counterterrorism and counterproliferation. In addition to the national security laboratories, NNSA also has ongoing work performed by other DOE national laboratories, supporting both Weapons Activity and the Defense Nuclear Nonproliferation programs.

### 1.4.2 Nuclear Weapons Production Facilities

The nuclear weapons production facilities include the Kansas City National Security Campus (KCNSC) in Kansas City, Missouri; Pantex Plant (Pantex) in Amarillo, Texas; Y-12 National Security Complex (Y-12) in Oak Ridge, Tennessee; and Savannah River Site (SRS) in Aiken, South Carolina.[3] These facilities conduct a range of activities that include assembling, disassembling, rebuilding, repairing, maintaining and surveilling stockpile weapons and weapon components; fabricating joint test assemblies; assembling and disassembling test beds; conducting interim staging and storing of nuclear components from dismantled weapons; performing pit requalification, surveillance, and packaging; producing and procuring non-nuclear weapons components; extracting and recycling tritium; loading tritium and deuterium into gas transfer system (GTS) reservoirs of nuclear weapons; performing surveillance of GTSs to support certification of the stockpile; manufacturing uranium components for nuclear weapons, cases, and other weapons components; evaluating and performing tests of these components for surveillance purposes; storing Category I/II quantities of highly enriched uranium (HEU); conducting dismantlement, storage, and disposition of HEU; and supplying HEU for use in naval reactors. In addition, the nuclear weapons production facilities process uranium and plutonium to meet DOE/NNSA's nonproliferation goals and counterterrorism activities.

### 1.4.3 National Security Site

The Nevada National Security Site in Nye County, Nevada, provides facilities, infrastructure, and personnel to the national security laboratories and other organizations to conduct nuclear and non-nuclear experiments. It is the primary location where experiments using radiological and other high-hazard materials are conducted and the primary location where HE-driven plutonium experiments can be conducted.

## 1.5 Challenges in Executing the Stockpile Stewardship and Management Plan

DOE/NNSA has made substantial progress on near-term priorities, including life extension programs (LEPs), to ensure the stockpile remains safe, secure, and effective as long as nuclear weapons exist. Efforts on the Navy's W76-1 and W88 warheads, the Air Force's B61-12 gravity bomb, and the accelerated schedule for the W80-4 warhead for the Air Force's Long-Range Stand Off cruise missile are under way. In addition, NNSA has continued the design phase for the Uranium Processing Facility at Y-12 and is beginning infrastructure and service activities at the site of the future facility. The Uranium Processing Facility will ensure the ability to produce uranium components for the stockpile and support nuclear propulsion for the Navy.

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

Despite these accomplishments, continued investment is required to modernize aging nuclear facilities and infrastructure that support the Nation's nuclear weapons policies and force structure, and to address the most pressing security challenges. Key considerations include the following:

- The nuclear weapons stockpile is aging and contains many obsolete technologies that must be replaced as the service lives of the warheads are extended. This requires significant investment in new technologies and tools to certify warheads.
- The trustworthiness of the nuclear weapon supply chain that provides necessary parts (*e.g.*, radiation-hardened electronics) must be sustained to deal with the potential for sabotage, malicious introduction of an unwanted function, or subversion of a function without detection.
- The DOE/NNSA mission depends on facilities, infrastructure, and equipment for success. Current demands of the LEPs, along with stewardship demands of the stockpile, have increased loads on an aging NNSA infrastructure. Without infrastructure recapitalization, the risk to nuclear weapon maintenance and LEPs will increase.
- At most sites, the number of employees eligible for retirement is increasing (see **Figure 1–3**) and aggressive programs to recruit and retain high-quality individuals and provide new personnel with opportunities to acquire the experience and expert judgment to sustain the stockpile are needed. Preservation and transfer of institutional and technical knowledge prior to the exodus of retirement-eligible members are critical to the continuity of nuclear weapons work.

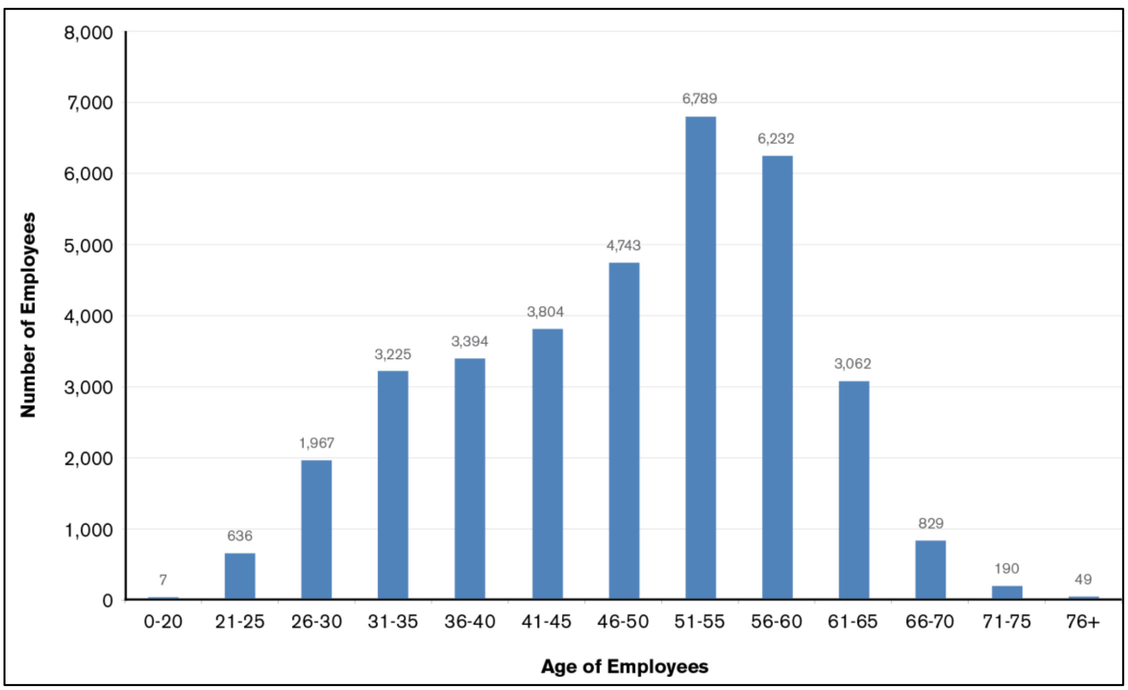



**Figure 1–3. Management and operating headcount distribution by age**

Although significant portions of the Nation's stockpile are aging and the nuclear security enterprise is even older, NNSA is sustaining the arsenal through LEPs and is beginning to modernize the infrastructure to ensure the nuclear arsenal remains safe, secure, reliable, and effective in the long term in the absence of underground nuclear explosive testing. Substantial progress has been made, but NNSA's workforce must continue to maintain the cutting-edge scientific expertise and facilities needed to ensure continued success into the future.

## 1.6 Overall Strategy, Objectives, Prioritization of Weapons Activities

DOE/NNSA and DOD play critical roles in implementing the Administration's agenda for maintaining strategic stability with other major nuclear powers, deterring potential adversaries, and reassuring the Nation's allies and partners as to the national security commitments of the United States. NNSA's role is to ensure that the nuclear weapons stockpile remains safe, secure, and effective, and DOD's role is to ensure the weapons can be delivered effectively. These respective efforts are coordinated through the congressionally-mandated Nuclear Weapons Council, which is made up of senior officials from both organizations who work together to determine the options and priorities that shape national strategies and budgets for developing, producing, and retiring nuclear weapons and weapon delivery platforms.

DOE/NNSA priorities are to sustain and maintain the stockpile while balancing the investments in both infrastructure and RDT&E to meet technical and national security challenges in both the near and long term.

The major strategies for sustaining and maintaining the stockpile are as follows:

- To extend the life of the stockpile, refresh obsolete technology, address security concerns, and meet nonproliferation obligations, NNSA will continue to pursue the "3+2" Strategy. This strategy transitions the stockpile to three interoperable ballistic missile warheads (each type would have a common nuclear explosive package and common or adaptable non-nuclear components) and two air-delivered warheads or bombs, as described in more detail in Section 2.2 of this document.
- To sustain the ability to assess and certify the stockpile, NNSA will continue science-based stockpile stewardship by conducting experimental research and incorporating new knowledge into models and advanced computer codes. This strategy has allowed the stockpile to be assessed as safe, secure, reliable, and effective for nearly two decades without underground nuclear explosive testing.

***Major goals of Weapons Activities***

- *Complete W76-1 production by 2019.*
- *Cease programmatic operations at the Chemistry and Metallurgy Research facility at Los Alamos National Laboratory by 2019.*
- *Complete B61-12 first production unit by March 2020.*
- *Complete W88 Alteration 370 first production unit (with refreshed conventional high explosive) by 2020.*
- *Complete W80-4 first production unit by 2025.*
- *Ensure the capability to produce 50 to 80 pits-per-year by 2030.*
- *Cease enriched uranium programmatic operations in Building 9212 at the Y-12 National Security Complex by 2025.*
- *Accelerate dismantlement of weapons retired prior to FY 2009.*
- *Provide experimental and computational capabilities to support stockpile assessment certification.*
- *Enhance predictive modeling capability to certify and assess via experimental data and implementation of advanced scientific tools.*

- To address infrastructure and equipment issues, DOE/NNSA will improve the data used to plan and prioritize investments within the current budget-constrained environment.
- To augment the first two strategies, the stockpile responsiveness program that is under development will provide a greater breadth of opportunities to exercise key capabilities and skills to ensure the readiness to respond to the needs of the stockpile and nuclear deterrence. Additionally, exercising these capabilities will provide a mechanism to preserve and transfer knowledge across the workforce.

Additional activities that exist to address other issues include:

- NNSA is making investments to determine the potential of additive manufacturing to reduce development and production costs, as well as recapitalization costs of production capabilities. Additive manufacturing may also allow greater in-house production of nuclear weapon parts.
- To address supply chain issues, NNSA has established a Nuclear Enterprise Assurance program to address threats to critical products and processes. The program will focus on the need to enhance and protect designs, establish robust and secure manufacturing processes, and augment supply chain management to ensure malicious hardware and software do not enter nuclear security enterprise products.
- NNSA and DOE's investment in exascale computing will advance the time frame over which these capabilities can be applied to stockpile stewardship and ensure that the computing needs of the nuclear security enterprise are addressed.

Implementation of these strategies will allow NNSA to perform its nuclear weapons mission and, in particular, accomplish the goals listed in NNSA's 2015 *Enterprise Strategic Vision* and the March 2015 *FY 2016 SSMP*.

# Chapter 2
# Status of the Stockpile and Life Extension Efforts and Key Tools and Methods

Stockpile management encompasses a range of activities to assess the current condition of the stockpile, perform routine maintenance to ensure weapon operability, and extend weapon lifetimes by 20 to 30 years. The status of the stockpile and the activities to keep it safe, secure, reliable, and effective are described in Sections 2.1 and 2.2. High-level descriptions of the tools and methods of the RDT&E programs for warhead assessment are provided in Section 2.3.

## 2.1 Status of the Stockpile

The stockpile is safe, secure, reliable, and effective. On an annual basis, the Directors of the national security laboratories (LANL, LLNL, and SNL) and the Commander of the U.S. Strategic Command submit letters to the Secretaries of Energy and Defense providing that the assessment of the stockpile. These Annual Assessment Reports provide relevant information on the safety, security, and reliability of each weapon type that could affect military utility. Core surveillance, non-nuclear hydrodynamic tests, subcritical experiments, materials evaluation, enhanced surveillance, and modeling and simulation contribute to the analysis. Much of this information is generated through the execution of the programs in the Directed Stockpile Work (DSW) and RDT&E budget categories.

> ***Annual Assessment Process***
>
> *The science-based Stockpile Stewardship Program has allowed the Secretaries of Energy and Defense to certify to the President for the twentieth time that the U.S. nuclear weapons stockpile remains safe, secure, and effective without the need for underground explosive nuclear testing.*

### 2.1.1 Surveillance of the Stockpile

Surveillance allows integration across test regimes to demonstrate performance requirements, such as laboratory and flight tests and component and material evaluations. The comparability of data over time provides the ability to predict, detect, assess, and resolve aging trends and anomalous changes in the stockpile, as well as develop and implement modernization programs to address or mitigate issues or concerns.

Specifically, the Surveillance Program addresses the (1) design integrity of refurbished warheads, (2) detection of the number of changes over time in aging warheads, and (3) safety of the inactive stockpile. Reductions in laboratory and flight tests and component evaluations create new challenges in the ability to make confident assessments of weapon safety, performance, and reliability. In response to these challenges, NNSA is furthering its efforts to leverage tools and data from different weapon and warhead types that have similar materials or components to understand the behavior in response to a variety of environments and conditions, while capitalizing on innovative enhanced surveillance techniques.

**Table 2–1** depicts the number of disassembled and inspected warheads for each warhead type and the number of flight and laboratory tests and major material and component evaluations conducted in FY 2015 and planned for FY 2016. **Table 2–2** shows surveillance requirements for the FY 2017 Future Years Nuclear Security Program (FYNSP) as compared to the actual FY 2015 and planned FY 2016 surveillance evaluations.

**Table 2–1. Fiscal year 2015 actual and fiscal year 2016 projected core Directed Stockpile Work Program stockpile evaluation activities (as of January 31, 2016)**

| | ***D&Is*** | | ***JTA Flights*** | | ***Test Bed Evals*** | | ***Pit NDE*** | | ***Pit D-Tests*** [a] | | ***CSA NDE*** | | ***CSA D-Tests*** | | ***GTS Tests*** | | ***HE D-Tests*** [b] | | ***DCA Tests*** | | ***Program Totals*** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ***Fiscal Year*** | | | | | | | | | | | | | | | | | | | | | |
| ***Warheads*** | ***15*** | ***16*** | ***15*** | ***16*** | ***15*** | ***16*** | ***15*** | ***16*** | ***15*** | ***16*** | ***15*** | ***16*** | ***15*** | ***16*** | ***15*** | ***16*** | ***15*** | ***16*** | ***15*** | ***16*** | ***15*** | ***16*** |
| B61 | 14 | 3 | 6 | 6 | 1 | 6 | 27 | 25 | 0 | 0 | 0 | 4 | 1 | 2 | 0 | 10 | 4 | 1 | 0 | 22 | 53 | 79 |
| W76-0 | 4 | 4 | 0 | 5 | 8 | 0 | 16 | 25 | 0 | 2 | 12 | 6 | 2 | 2 | 8 | 18 | 0 | 12 | 7 | 8 | 57 | 82 |
| W76-1 | 18 | 29 | 3 | 3 | 1 | 21 | 32 | 25 | 0 | 2 | 7 | 14 | 0 | 3 | 6 | 13 | 10 | 10 | 25 | 22 | 102 | 142 |
| W78 | 3 | 10 | 2 | 1 | 4 | 8 | 6 | 25 | 1 | 3 | 10 | 9 | 0 | 2 | 8 | 8 | 3 | 3 | 3 | 9 | 40 | 78 |
| W80-0/1 | 4 | 11 | 4 | 5 | 2 | 0 | 15 | 25 | 0 | 0 | 1 | 0 | 2 | 1 | 10 | 9 | 4 | 8 | 0 | 8 | 42 | 67 |
| B83 | 4 | 2 | 2 | 1 | 2 | 2 | 36 | 25 | 1 | 2 | 1 | 1 | 1 | 1 | 7 | 7 | 3 | 1 | 8 | 0 | 65 | 42 |
| W84 | 0 | 1 | | | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | | 0 | 0 | 0 | 1 |
| W87 | 11 | 9 | 2 | 3 | 9 | 6 | 17 | 25 | 0 | 0 | 0 | 0 | 1 | 1 | 16 | 8 | 0 | 1 | 4 | 4 | 60 | 57 |
| W88 | 5 | 8 | 7 | 4 | 7 | 0 | 13 | 25 | 0 | 3 | 2 | 19 | 1 | 2 | 12 | 17 | 4 | 4 | 14 | 14 | 65 | 96 |
| **Totals** | 63 | 77 | 26 | 28 | 34 | 43 | 162 | 200 | 2 | 12 | 33 | 53 | 8 | 14 | 67 | 90 | 28 | 40 | 61 | 87 | 484 | 644 |

CSA = canned subassembly
D&I = disassembly and inspection
DCA = detonator cable assembly
D-tests = destructive tests
GTS = gas transfer system
HE = high explosive
JTA = joint test assembly
NDE = nondestructive evaluation

[a] A pause in plutonium operations in the Plutonium Facility (PF-4) caused postponement of most FY 2015 pit D-test requirements.
[b] Beginning in FY 2015, HE D-Tests are being counted as a major activity.

**Table 2–2. Major surveillance evaluations completed in FY 2015 and planned for FY 2016 and the Future Years Nuclear Security Program (FY 2017 through 2021) (as of January 31, 2016)**

| ***Major Activity*** | ***FY 2015 Actual*** | ***FY 2016 Plan*** | ***FY 2017 Requirements*** | ***FY 2018 Requirements*** | ***FY 2019 Requirements*** | ***FY 2020 Requirements*** | ***FY 2021 Requirements*** | ***FYNSP Total*** [a] |
|---|---|---|---|---|---|---|---|---|
| **D&Is** | 63 | 77 | 70 | 68 | 68 | 89 | 86 | 458 |
| **JTA Flights** | 26 | 28 | 25 | 23 | 21 | 26 | 31 | 154 |
| **Test Bed Evaluations** | 34 | 43 | 87 | 41 | 58 | 56 | 73 | 358 |
| **Pit NDEs** | 162 | 200 | 200 | 200 | 200 | 200 | 200 | 1,200 |
| **Pit D-Tests** [b] | 2 | 12 | 13 | 5 | 16 | 8 | 8 | 62 |
| **CSA NDEs** | 33 | 53 | 57 | 54 | 56 | 37 | 36 | 293 |
| **CSA D-Tests** | 8 | 14 | 18 | 12 | 21 | 15 | 14 | 94 |
| **GTS Tests** | 67 | 90 | 86 | 87 | 78 | 69 | 72 | 482 |
| **HE D-Tests** [c] | 28 | 40 | 33 | 33 | 37 | 32 | 29 | 204 |
| **DCA Tests** | 61 | 87 | 73 | 87 | 65 | 61 | 55 | 428 |
| **TOTALS** | 484 | 644 | 662 | 610 | 620 | 593 | 604 | 3,733 |

CSA = canned subassembly
D&I = disassembly and inspection
DCA = detonator cable assembly
D-tests = destructive tests
GTS = gas transfer system
HE = high explosive
JTA = joint test assembly
NDE = nondestructive evaluation

[a] FYNSP-forecasted quantities do not reflect reductions that may result from the lowering of stockpile readiness proposed for certain weapons.
[b] A pause in plutonium operations in the Plutonium Facility (PF-4) caused postponement of most of the FY 2015 pit D-test operations.
[c] Beginning in FY 2015, HE D-Tests are being counted as a major activity.

LANL restarted pit surveillance activities in early 2016 after pausing in plutonium operations at the Plutonium Facility (PF-4) in 2013. Table 2–2 also reflects the recovery schedule for pit destructive tests across the FYNSP period. NNSA and the U.S. Navy agreed to conclude joint flight tests for the W76-0 in FY 2016, with the last production unit of the W76-1 scheduled for completion in FY 2019. Moreover, in anticipation of completion of the B61-12 LEP and gaining confidence in the B61-12, Nuclear Weapons Council members agreed on surveillance test reductions for the B83 and four the B61 variants that are to be replaced by the B61-12 (-3, -4, -7, and -10) to partially offset the added cost of conventional high explosive replacement in the W88.[4] The approximate 10 percent decrease in total tests between FY 2017 and FY 2018 is predominately the result of the pending decrease in weapon variants enabled by the B61-12. Weapon alterations (Alts) implemented across the FYNSP (*e.g.*, the W87 Alt 360 for the GTS and the W88 Alt 370 replacement of the arming, fuzing, and firing assembly and the conventional high explosive) will require additional surveillance tests during phase-in periods.

## 2.1.2 Significant Finding Investigations

The evaluation and investigation of anomalies identified through experiments, assessments, surveillance, DOD operations, and other activities are assessed under so called "significant finding investigations." The cause of an anomaly and the impact to weapon safety, security, performance, and reliability are determined through the significant finding investigation process. **Figure 2–1** below depicts the recent history of these investigations.

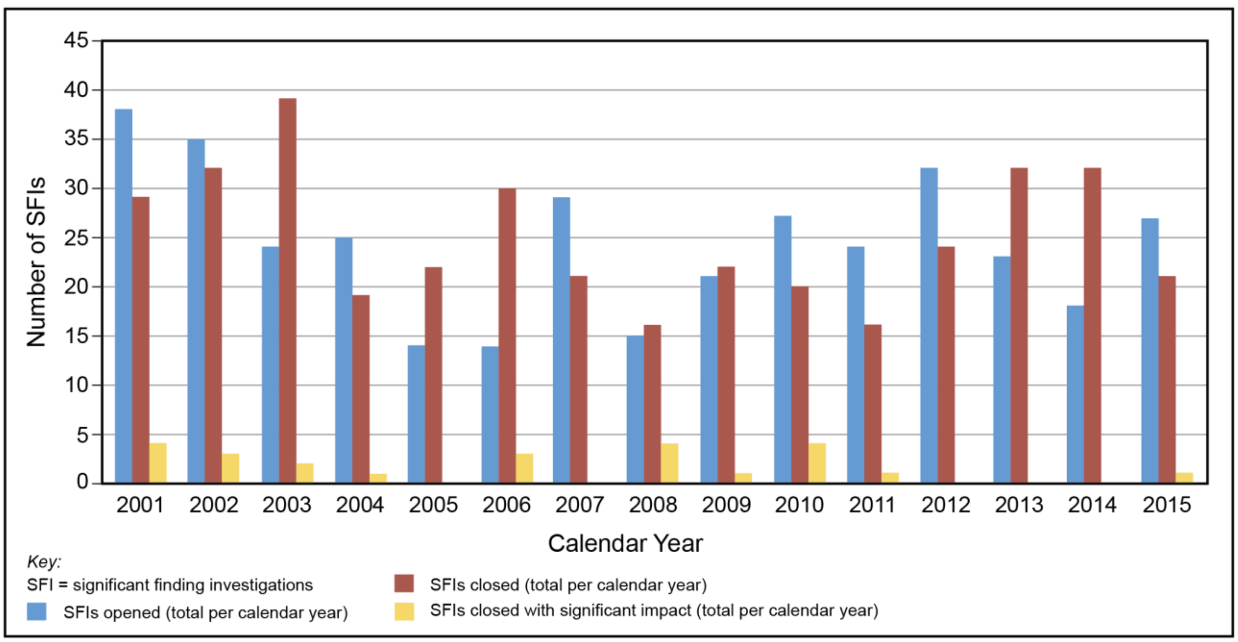



**Figure 2–1. Historical number of significant finding investigations opened and closed in calendar years 2001 to 2015 and the number that resulted in an impact to the stockpile**

[4] See Chapter 2, pp. 2-1, 2-7, 2-8, 2-21, and 2-22 of the *FY 2016 SSMP*.

### 2.1.3 Assessments of the Stockpile

The annual stockpile assessment process evaluates the safety, performance, and reliability of weapons based on physics and engineering analyses, experiments, and computer simulations. Assessments may also evaluate the effect of aging on performance and quantify performance thresholds, uncertainties, and margins. Available sources of information on each weapon type (including surveillance, non-nuclear hydrodynamic tests, subcritical experiments, materials evaluation, enhanced surveillance techniques, and modeling and simulation) contribute to these evaluations.

### 2.1.4 Maintenance of the Stockpile

Weapons contain limited life components (LLCs) such as GTSs, neutron generators, and power sources that require periodic replacement to sustain system functionality. LLCs are required for warhead performance, and NNSA and DOD jointly manage component delivery and installation.

### 2.1.5 Sustainment of the Stockpile

The Nation's stockpile is annually assessed for sustainability. As weapons systems age, or when issues arise through significant finding investigation or other assessments, sustainment activities may warrant LEPs, Alts, or modifications (Mods) to address the aging or performance issues, enhance safety features, and/or improve security. An Alt to a weapon is a change to a component that does not alter the weapon's operational capability. A Mod to a weapon alters the operational capabilities of a warhead; however, in accordance with current policy, the change is made in a way that does not alter the military capability (*e.g.*, improving security). In either case, the technologies used are typically more modern than the technologies they replace and are developed and matured as part of the RDT&E programs. An LEP comprehensively analyzes all components of a weapon and either reuses, refurbishes, or replaces components to purposefully extend the service life of the weapon. An LEP typically requires NNSA to certify the weapon's protected period (that is, its new lifetime) for 20 to 30 years. NNSA activities for LEPs and major Alts of specific weapon types are illustrated in **Figure 2–2**. Section 2.2 illustrates the 3+2 Strategy, under which LEPs and stockpile modernization are planned.

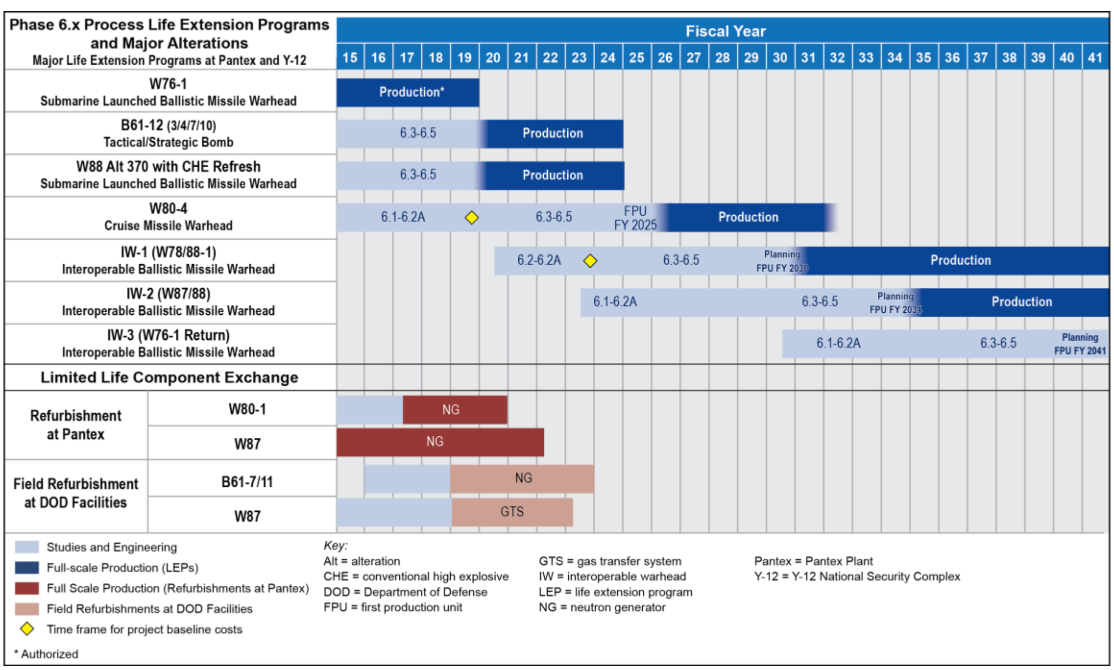



**Figure 2–2. National Nuclear Security Administration warhead activities**

### 2.1.6 Weapons Dismantlement and Disposition

> ***Dismantlement and Disposition***
>
> *The Weapons Dismantlement and Disposition program has developed plans to recover its schedule and has kept on pace to receive additional W76-0 retired units, reduced its component inventories, exceeded secondary dismantlement at the Y-12 National Security Complex, and begun efforts to support the W80-4 Life Extension Program.*

Weapons are retired as a result of changes to military requirements or surveillance evaluations, including disassembly and destructive tests of certain components. A retired weapon is no longer part of the stockpile. The Weapons Dismantlement and Disposition program is the process whereby major components are disassembled and the components are assigned for reuse, storage, recycling, surveillance, or disposal.[5] NNSA committed to dismantling nuclear weapons retired prior to FY 2009 by the end of FY 2022. In FY 2015, NNSA fell behind schedule because of safety reviews, unusually high lightning events, and a worker strike at Pantex. The FY 2017 SSMP classified Annex shows the shortfall in FY 2015 and NNSA's recovery schedule in FY 2016 and FY 2017. At the Nuclear Nonproliferation Treaty Review Conference on April 27, 2015, Secretary of State John Kerry announced that "President Obama has decided that the United States will seek to accelerate the dismantlement of retired nuclear warheads by 20%." To meet the accelerated rate, NNSA will hire, train, and certify additional weapons dismantlement technicians starting in FY 2017 and will increase weapons dismantlement by 20 percent starting in FY 2018. The accelerated rate will allow NNSA to complete the dismantlement commitment a year early, before the end of FY 2021.

## 2.2 Modernizing the Stockpile through the 3+2 Strategy

The 3+2 Strategy is the program of record that guides NNSA's life extension efforts and rightsizes the stockpile. As each of the 12 warheads or bomb variants within the seven deployed warhead families enters an LEP, the strategy will transition the stockpile to three interoperable nuclear explosive packages to be used in submarine-launched ballistic missiles and intercontinental ballistic missiles and. will also include two air-delivered weapons—one bomb and one cruise missile.

NNSA will evaluate options to improve safety and security and reuse, as well as refurbish or replace components and systems to extend the service life of weapons by an additional 20 to 30 years. LEPs represent prime opportunities to improve safety, security, and reliability. Critical and timely investments in areas such as technology maturation, RDT&E, Laboratory Directed Research and Development, and Plant Directed Research and Development will position NNSA to capitalize on innovative technological options.

Implementation of the 3+2 Strategy is a long-term investment in the U.S. nuclear deterrent. The strategy is driving investments in new technologies and execution of the LEPs. Sections 2.2.1 to 2.2.5 describe the FY 2015 accomplishments and the FYNSP schedule for LEPs and major Alts. See Chapter 2, Sections 2.4.1.1 to 2.4.1.5 in the *FY 2016 SSMP* for more extensive descriptions of these programmatic efforts. Funding requirements are detailed in Chapter 4 of this *FY 2017 SSMP*.

### 2.2.1 W76-1 LEP

The W76-1 LEP extends the original warhead service life from 20 years (as designed) to 60 years. Completion of production is scheduled for no later than the end of FY 2019. The W76-1 first production

[5] A detailed description of the Weapons Dismantlement and Disposition process is on the NNSA website at http://www.nnsa.energy.gov/ourmission/managingthestockpile/dismantlementanddisposition.

unit was completed in September 2008, and the first delivery of warheads to the U.S. Navy took place in FY 2009. The program is making all deliveries on schedule and under budget.

**FY 2015 Accomplishments**

In January 2015, the W76-1 LEP passed the halfway point in the total number of refurbished warheads scheduled for delivery to the U.S. Navy according to the current program of record.

In FY 2015, KCNSC resumed full-rate production and requalification of most W76-1 components, following relocation of activities from the Kansas City Plant to the new KCNSC. One remaining component is on schedule to complete requalification activities in FY 2016.

**Deliverables, Plans, Schedules, and Milestones**

The deliverables for the W76-1 LEP through the end of full production are as follows:

- Achieve or exceed annual refurbished warhead production rates at the Pantex Plant.
- Deliver the refurbished warheads on schedule to the U.S. Navy.
- Produce and deliver joint test assemblies for surveillance flight tests.
- Execute retrofit evaluation system test and stockpile surveillance activities to facilitate completion of Annual Assessment and Weapon Reliability activities.

### 2.2.2 W88 Alt 370

The W88 Alt 370 first production unit is scheduled for December 2019. The Alt 370 includes a new arming, fuzing, and firing system, lightning arrestor connector, trainers, flight test assemblies, and associated handling gear and spares. In November 2014, the scope of the W88 Alt 370 was changed to include replacement of the conventional high explosive main charges and associated components. Changes in initial cost estimates for the main-charge replacement have been reflected in this SSMP compared to the *FY 2016 SSMP* (see Chapter 4). The Alt 370 conversion is scheduled concurrently with LLC exchanges of the GTSs and neutron generators. The program is running on schedule and within budget.

**FY 2015 Accomplishments**

- Completed the third major flight test, the Follow-on Commanders Evaluation Test 51.
- Tested functional component prototypes in stockpile-to-target-sequence environments.
- Conducted additional radar fuzing ground tests.
- Maintained Interface Requirements Agreements with other programs to document the W88 Alt 370 dependencies on programmatic deliverables.
- Completed implementation of an EIA-748[6]-compliant earned value management system to improve the scope, cost, and integrated resource-loaded schedule management, and initiated an Integrated Baseline Review.
- Completed 11 of 14 major component Baseline Design Reviews and three Final Design Reviews.

[6] *Earned Value Management Systems ANSI/EIA-748-C Intent Guide*, National Defense Industrial Association, Integrated Program Management Division, April 2014.

**Deliverables, Plans, Schedules, and Milestones**

The deliverables for the W88 Alt 370 Program are as follows:

- Obtain Phase 6.4 (Production Engineering) approval in FY 2017.
- Conduct the system-level Final Design Review in FY 2018.
- Conduct the final flight test qualification (demonstration and shakedown operation tests) in FY 2019.
- Complete the first production unit by December 2019.
- Conduct the Final Design Review and Acceptance Group Review in FY 2020.
- Obtain Phase 6.6 (Full-Rate Production) approval in FY 2020.

## 2.2.3 B61-12 LEP

The B61-12 LEP will consolidate and replace the B61-3, -4, -7, and -10 to reduce the number of gravity bombs in the stockpile, consistent with *Nuclear Posture Review Report* (DOD 2010) objectives. The first production unit is planned for FY 2020. The program is running on schedule and within budget.

**FY 2015 Accomplishments**

- Executed vibration fly-around and instrumented measurement vehicle flight to validate flight environments on three additional platforms, including the F-35 and the B-2.
- Completed the first system-level Flight Test Development Unit tests for ballistic and guided flight at the Tonopah Test Range. Completed a system-guided flight test in the "All-up-Around" configuration in October 2015 at Tonopah.
- Completed first hydrodynamics experiment to support certification of the B61-12 LEP.
- Implemented EIA-748-compliant earned value management system to improve the scope, cost, and integrated resource-loaded schedule management.
- Maintained Interface Requirements Agreements with other programs to document the B61-12 dependencies on programmatic deliverables.

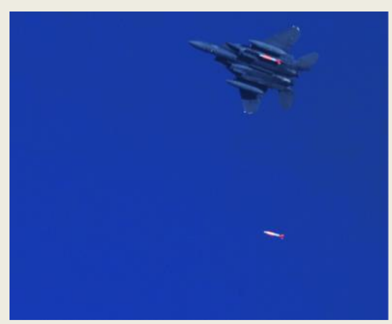
**Deliverables, Plans, Schedules, and Milestones**

The following are deliverables and planned milestones through the end of the program:

- Baseline the system design in FY 2016.
- Participate in the FY 2016 Air Force Design Review and Acceptance Group Review to assess design and qualification against military requirements.

***B61-12 Flight Test***

*NNSA and the U.S. Air Force completed the third development flight test of a B61-12 nuclear gravity bomb at Tonopah Test Range, Nevada, on October 20, 2015. The test used representative non-nuclear components, but no highly enriched uranium or plutonium. The bomb hardware was designed and manufactured by the nuclear security enterprise and mated to the tail-kit assembly section provided by the Air Force Nuclear Weapons Center. This B61-12 LEP test provides additional confidence in the weapon system and instrumentation designs prior to authorizing Phase 6.4 (Production Engineering) in 2016.*



- Obtain Phase 6.4 (Production Engineering) approval in FY 2016.
- Conduct first system qualification drop test in FY 2017.
- Complete the first production unit in FY 2020.
- Conduct the Final Design Review and Acceptance Group Review in FY 2020.
- Obtain Phase 6.6 (Full Rate Production) approval in FY 2020.

### 2.2.4 W80-4 LEP

This LEP will consider W80-based reuse, refurbishment, and replacement options for nuclear and non-nuclear components for the cruise missile to replace the Air Force's aging air-launched cruise missile (ALCM). Key design requirements include use of the existing insensitive high explosive design; incorporation of modern components and safety features; maximum use of non-nuclear components developed for other LEPs; and exploration of enhanced surety options. The first production unit is scheduled for FY 2025.

**FY 2015 Accomplishments**

- Completed Phase 6.1 (Concept Study) and received Nuclear Weapons Council approval to enter Phase 6.2 (Feasibility Study).
- Delivered Phase 6.1 Report and the draft military characteristics and stockpile-to-target-sequence to the Nuclear Weapons Council.

**Deliverables, Plans, Schedules, and Milestones**

The following are some of the deliverables for the W80-4 LEP during the FY 2017 FYNSP:

- Provide Phase 6.2 Report identifying preferred design options to Nuclear Weapons Council Standing and Safety Committee in FY 2017.
- Obtain Phase 6.2a approval in FY 2018 and present a Weapon Design and Cost Report outlining the program baseline, development plans, and design down-select recommendation.
- Obtain Phase 6.3 (Development Engineering) approval at the start of FY 2019.
  - Develop a Baseline Cost Report and a Selected Acquisition Report (SAR) and complete a detailed design with regard to safety, performance, and production.
  - Produce the final draft of military characteristics and stockpile-to-target-sequence and a draft addendum to the Final Weapon Development Report for review by the Design Review and Acceptance Group.

### 2.2.5 W78/88-1 LEP (Interoperable Warhead-1)

The LEP objective is to deploy an interoperable nuclear explosive package for use in the Mk21 intercontinental ballistic missile and the Mk5 submarine-launched ballistic missile aeroshells, with adaptable non-nuclear components. This LEP is referred to as the first interoperable warhead option, the Interoperable Warhead (IW-1).

**Deliverables, Plans, Schedules, and Milestones**

IW-1 LEP specific activities are scheduled to recommence in FY 2020 to achieve a first production unit in FY 2030.

# 2.3 Methods and Information for Assessment and Certification

## 2.3.1 Annual Stockpile Assessment and Weapon Certification

Certification is 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 any noted exceptions, the military characteristics within the environments defined by the system's stockpile-to-target-sequence. In contrast, the annual stockpile assessment is the process whereby the current status of each weapon system is evaluated on the basis of everything known about that system; the annual assessment *does not* replace or repeat the certification of the weapon system.

Both processes rely on assembling a body of evidence—based on experiments, physical and environmental tests, destructive and nondestructive evaluations, and modeling and simulation—and then making an assessment at the part, component, subsystem, and system levels to determine whether all the required performance characteristics are met. Both assessment and certification are quantitative processes that combine data and theory with simulations of nuclear weapons and arrive at a conclusion based on the judgment of experts that the body of evidence is sufficient.

## 2.3.2 Predicting Weapon Performance in a Zero Yield Environment

Today, NNSA relies on a combination of experiments and integrated design codes (IDCs) running on high performance computers to predict weapon performance. To provide a predictive capability, NNSA must know how accurately the code simulations can describe a real weapon—that is, knowing the error in the simulation predictions is critical. To determine that error, scientists at LANL and LLNL compare the simulation results with data generated from small-scale laboratory experiments; large-scale experiments at facilities such as the Dual-Axis Radiographic Hydrodynamic Test (DARHT) and LANL, the National Ignition Facility (NIF) at LLNL, and the Z facility (Z) at SNL; subcritical (*i.e.*, zero yield) experiments underground at the Nevada Nuclear Security Site; as well as data from nearly 40 years of U.S. underground nuclear explosive testing. Even in the era of underground nuclear explosive testing, theory and modeling were necessary for assessment because weapons could not be tested at all relevant scales in all relevant environments, and diagnostics could not provide data on all performance metrics of interest. Predictive capabilities are important because they allow weapon designers to extrapolate from the data obtained from legacy nuclear explosive testing and modern non-nuclear experiments to regimes that cannot be probed experimentally.

The results of modern simulations conducted with the new IDCs, while of lower fidelity than the experimental data, can capture the physics of interest and provide information that contributes to the body of positive evidence that a weapon will perform as required. These complex, multi-dimensional IDCs are progressively eliminating phenomenological models that have used ”knobs” to adjust the models to match the available data. To accomplish this, stockpile stewardship scientists have broken down the operation of a weapon into a sequence of individual steps, analyzed those steps through computational models and experiments, and then reintegrated the steps through large-scale weapon simulation codes and computational tools. The process has required the development of new experimental facilities that can approach the densities, pressures, velocities, temperatures, and timescales relevant in a nuclear detonation; the development of high-fidelity weapon simulation codes; the development and acquisition of high performance computers; and the acquisition of detailed data to validate and calibrate the models. New approaches have also become necessary to qualify the nuclear and non-nuclear components against hostile nuclear attack using new or improved experimental tools and simulation codes. Although NNSA has made significant progress in eliminating these knobs, much research and experimentation remains to be performed.

### 2.3.3 Developing Accurate Models of Weapon Systems and Components

Understanding the full-system behavior of a weapon from the knowledge of its component subsystems is one of the most difficult aspects of modeling such a complex system. The physical processes that a nuclear weapon undergoes extend from the microscale to the macroscale in both time and length. The processes that must be modeled at these widely disparate scales include material damage, mixing of fluids, and detonation of HE. Moreover, a full-system numerical simulation of the weapon depends upon accurate, reliable models for material equations of state, material motion, interaction of neutrons with materials, radiation flow, *etc*. These models are based on data from experiments that represent some, but not all, of the regimes experienced by a nuclear weapon. As a specific example, to inform decisions on developing replacements for particular materials and components and on when LEPs, Mods, and Alts ought to occur, NNSA is improving models for the long-term aging behavior of materials and components by deploying advanced diagnostics and technologies and applying new evaluation techniques as part of Enhanced Surveillance.

### 2.3.4 Quantification of Margins and Uncertainties

Using predictive capabilities to assess and certify the performance of a weapon is a tremendous challenge. This RDT&E challenge is addressed through the quantification of margins and uncertainties methodology, which evaluates the confidence of a prediction in terms of the degree to which the operation of a weapon is judged to lie safely within the bounds of judiciously chosen operating characteristics. Confidence is numerically represented as a confidence factor—that is, as the ratio of margin over uncertainty. The *margin* (M) is measured based on how much "room" is available between the predicted value of a metric and the boundary where that metric becomes unacceptable. *Uncertainty* (U) is a measure of the ability to predict the metric based on both the values that are measured (*via* experiments) and the values that are calculated (*via* databases for physical quantities, physical models, and numerical simulations). An analogy can be drawn between the quantification of margins and uncertainties methodology and the process to approve a new drug by the Food and Drug Administration (see text box).

> ***Analogy between "Quantification of Margins and Uncertainties" Methodology and the Process to Approve a New Drug***
>
> *The Food and Drug Administration requires that a drug's efficacy be demonstrated before it can be approved. NNSA requires positive evidence that a nuclear weapon will work; the absence of evidence that the weapon does not perform safely, securely, and reliably is not sufficient. The Food and Drug Administration requires documentation of contraindications and possible side effects of the drug. Similarly, NNSA requires documentation of the effects of aging and obsolescence of components on the behavior of a weapon and of how that weapon performs under specific conditions.*

A value of the confidence factor significantly greater than 1.0 is desirable. A value at or less than 1.0 motivates actions to increase the confidence factor by increasing the margin. These actions might include shortening the interval between LLC replacements. Another way to increase the confidence factor would be to reduce the uncertainty. This could be done by focusing R&D resources on areas of physical uncertainty, such as the specific characteristics of strategic materials to which weapon performance is sensitive, or by improving the fidelity of models used to simulate the operation of the warhead. Both of these approaches are being pursued by the RDT&E programs.

# Chapter 3
# Capabilities that Support the Nuclear Security Enterprise

In this summary SSMP, DOE/NNSA is using an updated approach to describe how the stockpile is supported and maintained. Specifically, NNSA is focusing on a set of key capabilities necessary to execute the mission and maintain deterrence. Many, if not most, of these capabilities are unique to the nuclear security enterprise, such as the production of uranium and plutonium components and the design and certification of nuclear warheads. The planning described herein reflects consideration of the sustainment and, where necessary, the improvement and/or recapitalization of these capabilities, consistent with the anticipated needs of the stockpile and in response to unforeseen geopolitical and technological challenges.

Continued investment in these critical capabilities is necessary to improve the understanding of nuclear weapons performance, provide confidence in the aging and evolving stockpile, and maintain and develop scientific and engineering capabilities. Sophisticated tools and methods are used to assess the challenges of technology maturation and, in particular, to certify the W88 Alt 370, the B61-12, and the down-selection and development of W80-4 technical design options. In the long term, unique capabilities remain crucial to annual assessments of weapons, future LEPs and Alts, and other activities related to NNSA's stewardship of nuclear weapons without nuclear explosive testing.

Congress recently directed DOE/NNSA to initiate a Stockpile Responsiveness Program to augment activities that have routinely been part of the Stockpile Stewardship and Management Program. NNSA has implemented several activities within its current Stockpile Stewardship Program and Stockpile Management Program portfolios to address Section 3112 of the *FY 2016 National Defense Authorization Act*, and "carry out a Stockpile Responsiveness Program . . . to identify, sustain, enhance, integrate, and continually exercise all capabilities required to conceptualize, study, design, develop, engineer, certify, produce, and deploy nuclear weapons." Activities that support a responsive nuclear security enterprise include the following:

- The Joint Technology Demonstrator (a United States and United Kingdom collaboration) exercises the workforce throughout the design, develop, manufacture, and prototype life cycle.
- NNSA intends to increase operational efficiencies to ensure that the rate of hydrodynamic experiments (including subcritical experiments conducted at the Nevada National Security Site) is sufficient to train and exercise the workforce of designers, engineers, experimentalists, and fabrication and assembly personnel.
- The rate of experiments is increasing at other facilities, most notably at the National Ignition Facility, that exercise designers, engineers, fabricators, and assembly personnel.
- Defense Programs began pre-Phase 6.1 Certification Readiness Exercises to examine potential LEP options early in order to identify and reduce the technical LEP risks and support LEP certification processes. These include hydrodynamic experiments to provide a technical assessment of proposed LEP options.

- The Capabilities for Nuclear Intelligence portfolio provides training and development activities for designers, engineers, and experimentalists. Capabilities for Nuclear Intelligence is principally funded in the Primary Assessment sub-program of the Science program. Foreign weapons assessments are funded from outside Weapon Activities in collaboration with the intelligence community.
- Defense Programs conducted 120-day studies of interoperable warhead concepts.
- A continuous cycle of manufacturing technology development and maturation activities ensures that modern, well understood, and sustainable manufacturing capabilities are ready for future stockpile sustainment needs.

Critical capabilities listed in **Table 3–1** allow DOE/NNSA to execute the Stockpile Stewardship and Management Program and are also applicable to NNSA's nuclear threat reduction mission [see *Prevent, Counter, and Respond – A Strategic Plan to Reduce Global Nuclear Threats (FY 2017 – FY 2021),* NNSA 2016]. NNSA will more fully develop a comprehensive list of the essential capabilities as part of the *FY 2018 Stockpile Stewardship and Management Plan*. Sections 3.1 – 3.7 summarize the status of current capabilities, the challenges the workforce faces in applying them, and the strategies to address those challenges in order to enhance the capabilities. The general purpose infrastructure of the nuclear security enterprise and the highly skilled workforce that exercises these capabilities were described in Chapters 4 and 7 and Appendix D of the *FY 2016 SSMP*. Except where updated here, the conclusions about the infrastructure and workforce remain valid.

**Table 3–1. Critical capabilities that support the mission of the nuclear security enterprise**

| *Sections* | *Critical Capabilities* |
|---|---|
| 3.1 Exascale Computing and the National Strategic Computing Initiative | Exascale computing, computational science, component design |
| 3.2 Experiments and Tests | Hydrodynamic tests, subcritical experiments, assessments, high energy density physics, environmental tests, small-scale experiments |
| 3.3 Strategic Materials and Core Components | |
| 3.3.1 Plutonium | Pit production, storage, R&D |
| 3.3.2 Uranium | HEU component production, storage, LEU production, R&D |
| 3.3.3 Tritium | Recycle and supply, reservoir loading, storage, R&D |
| 3.3.4 Lithium | Production, storage, R&D |
| 3.3.5 High Explosives | HE component production, storage, R&D |
| 3.3.6 Nonnuclear Components | Gas transfer systems, power sources, neutron generators, radiation-hardened microelectronics, production, R&D |
| 3.4 Weapons Assembly and Disassembly | Cell and bay operations, weapon and component storage, NDE, surveillance |
| 3.5 General Purpose Infrastructure | Utilities, roads, HVAC, fire, radioactive waste storage and disposal |
| 3.6 Security | Physical security, cyber security |
| 3.7 Secure Transportation | Transport of weapons, components, and strategic materials |

HE = high explosive
HEU = highly enriched uranium
HVAC = heating, ventilating, and air conditioning
LEU = low-enriched uranium
NDE = nondestructive evaluation
R&D = research and development

## 3.1 Exascale Computing and the National Strategic Computing Initiative

The President signed an Executive Order on July 29, 2015 establishing the National Strategic Computing Initiative. Among other goals, the Executive Order directed the NNSA and DOE Office of Science to execute a joint program focused on advanced simulation through a capable exascale computing program that emphasizes sustained performance on mission relevant applications. Mission-relevant applications in the NNSA are its integrated design codes (IDCs) and supporting modeling and simulation capabilities. These capabilities enable NNSA to evaluate and address the performance, safety, effectiveness, and security of the nuclear weapons stockpile; determine the effects of manufacturing imperfections; predict the impact of future manufacturing techniques, to include additive manufacturing; quantify margins and uncertainties; and resolve the effects of asymmetric features, which require three-dimensional simulations. Modeling and simulation capabilities rely on IDCs, science codes, and high performance computing systems, together with the necessary hardware and software.

### 3.1.1 Current Status

The first phase of the Trinity system at LANL has at least seven times more processing capability than NNSA's current supercomputer, Cielo (also at LANL). When fully built out by the end of FY 2016, Trinity will have more than 40 petaflops of processing power. In 2015, NNSA also continued its CORAL collaboration with LLNL; the DOE Office of Science national laboratories at Oak Ridge, Tennessee, and Argonne, Illinois; and IBM and other vendors. CORAL will help develop next-generation computing platforms to dramatically improve the ability to run increasingly complex codes and will represent a significant step on the path to exascale computing. In addition, NNSA's Advanced Simulation and Computing (ASC) Program is maturing the predictive and three-dimensional simulation capabilities of its IDCs and expanding its computational resources to address the evolving needs of the Stockpile Stewardship Program.

The first phase of Trinity is operational and two vendor-staffed Centers of Excellence have been established to work with staff at the national security laboratories. This will ensure the codes are compatible and performing well on the Trinity and upcoming Sierra advanced technology systems.

**_20 Years of Science-Based Stockpile Stewardship_**

*In October 2015, NNSA commemorated the twentieth anniversary of the Stockpile Stewardship Program. The efforts of some of the world's best scientists and engineers using extraordinary tools at NNSA's sites have allowed the Nation to maintain confidence in the nuclear deterrent without nuclear explosive testing. Many were skeptical in 1995 that this would be possible. The investment in the Stockpile Stewardship Program has enabled resolution of many stockpile issues and provided more detailed knowledge than had been attained through nuclear explosive testing. With this history and a commitment to revitalize the infrastructure, NNSA is actively ensuring its capabilities to deliver another 20 years and beyond of Stockpile Stewardship Program success.*

### 3.1.2 Challenges

Today, NNSA is seeing a significant degradation in time-to-solution as its IDCs are transferred (or "ported") to run on its current "fastest" capability-class platform, Sequoia at LLNL. Performance degradation of weapon codes is expected to increase unless active measures are taken, as the architectures that industry will provide become increasingly taxing on the ASC code base. Vendors are reacting to disruptions that result from the breakdown of historical scaling laws (Moore's Law and Dennard scaling) that worked well at larger feature (transistor) sizes. As a consequence, technologies that DOE and NNSA must address include multi-levels of memory on a node; a variety of processors, including graphical processing units, low power cores (as in Sequoia), and reduced instruction set computer processors, with these often combined in complex formations on a node; new interconnects; intrusive power management software; and hierarchical models for secondary storage, like file systems.

The next generation of advanced computing hardware presents significant challenges to current IDCs and Science Codes. The existing IDCs will require extensive modifications or may be replaced by entirely new codes to run efficiently on the emerging computer architectures. Because of the reliance of the Stockpile Stewardship Program on simulations for assessment and certification, DOE/NNSA must continue to provide and improve simulation capability during the transition to new architectures. This requirement places additional demands on the scientists and engineers at the national security laboratories as they strive to satisfy current Stockpile Stewardship Program demands while preparing codes for more advanced computer technologies.

The simulation challenges of the Stockpile Stewardship Program require enormous computing capability when applied to the physics of nuclear weapons. Historical test anomalies have proven that small, seemingly insignificant features in a weapon design can have a profound impact on its performance, driving a continued need for deeper understanding. Better surveillance capabilities are uncovering the evolution of features as a result of aging that are inherently three-dimensional in nature and require high resolution to model. Because of the heavy reliance on simulations in these areas, multiple codes with different algorithmic approaches increase confidence in the overall assessment.

In addition to the large capability-class problems that push the limits of computing resources with one or a handful of simulations, assessing the impact of a feature that may have a random aspect to its nature requires large ensembles of simulations to bound the effects. One cannot assume that the specific representation of a feature uncovered in surveillance represents the worst case. Variations must be performed to bound the overall impact, which might require hundreds of thousands of simulations.

The vast amount of data produced by new experiments, experimental capabilities, and diagnostics (*e.g.*, at NIF, DARHT, and subcritical experiments at the U1a Complex [U1a]) provide both an opportunity and a challenge. The data allow detailed validation of IDCs and their material databases; however, improved data analysis techniques are also required.

Improving the physics fidelity of IDCs by removing various approximations will decrease the uncertainty in the confidence factor used in the quantification of margins and uncertainties process, as well as make the IDCs more predictive when applied to regimes outside of what was tested; however, this will come at the expense of increased computational resources, which have been the limiting factor. In addition, a correlation frequently exists between the fidelity needed in a Science Code to generate physical data and the ease with which that data can be obtained experimentally. The more extreme the phase space, and thus the harder the experiment, the greater the fidelity needed in the Science Code simulations.

The nationwide demand for computer scientists means that programs at the NNSA national security laboratories must compete with other industries and Government departments to recruit and retain qualified personnel. One advantage the three NNSA laboratories still have in recruiting is the challenge of cutting-edge technology and computer hardware. This is still a draw for top talent and is one more reason why NNSA needs to remain at the forefront of technology. However, private sector compensation and benefits are often higher. Additionally, some sites have difficulty attracting computer scientists due to their remote locations. These realities present the NNSA laboratories with a very difficult challenge in staffing critical skills to support ongoing and future stockpile stewardship missions.

### 3.1.3 Approach and Strategies

Historically, industry has delivered new leading-edge systems every four to five years. Exascale systems will require more than incremental technology improvements. An exascale system will be much more difficult to achieve than previous systems; however, these barriers can be overcome, in part by relaxing constraints and in part by adapting and augmenting the existing ASC and DOE's ASCR Programs, to include research activities at universities, vendor-laboratory partnerships, development of prototype systems, and strategic acquisitions. Because of the complexity of exascale computing, these approaches are being augmented by substantial new efforts.

Given the challenges of achieving exascale computing, code developers must recognize the trends and opportunities of architecture and technologies, and the platform developers must understand the intended applications. Through ASC and DOE Office of Science investments, exploratory research has begun on the hardware and architecture, software stacks, and numerical methods and algorithms for mission applications, as well as determining tradeoffs in the design of exascale hardware, system software, and application codes.

The realization of an exascale system involves complex tradeoffs among algorithms; hardware (*e.g.,* processors, memory, energy efficiency, reliability, and interconnectivity); and software (programming models, scalability, data management, productivity, *etc.*). Applications software must be redesigned and restructured to meet challenges that hardware and software research cannot resolve fully.

The strategy to address these challenges will focus in four areas:

- **Application Development:** developing next-generation codes to address extreme parallelism, reliability and resiliency, memory hierarchies, and other performance issues caused by next-generation computing hardware.
- **Software Technology:** developing an expanded, vertically integrated software stack to support applications on next-generation hardware.
- **Hardware Technology:** supporting vendor R&D activities to deploy next-generation systems suitable for DOE/NNSA applications.
- **Exascale Systems:** supporting non-recurring engineering activities by vendors; reducing the costs of system expansion and site preparation; providing the associated power and cooling needed to run the next-generation supercomputers; and enhancing acquisition and support of prototypes and testbeds for application, software, and hardware evaluation activities.

The goal of this strategy is to field a usable exascale system for stockpile applications by the mid-2020s.

## 3.2 Experiments and Subsystem Tests

Unique experimental facilities are required to exercise the capability to conduct hydrodynamic experiments, which provide essential data in support of the Annual Assessment process, resolution of significant finding investigations, assessment of LEP options, and advancement of a simulation-based predictive capability. These facilities include U1a, DARHT, the Contained Firing Facility, the High Explosives Applications Facility, and the Los Alamos Neutron Science Center (LANSCE) proton radiography capability. Surrogate experiments provide information on the behavior and interaction of non-nuclear components, scaling, physical integrity, surety, *etc*.

Subcritical experiments at U1a involve high explosives and plutonium in configurations and quantities such that no self-sustaining nuclear fission chain reaction can result. The data allow inference regarding the performance of a full-scale device and build confidence in stockpile assessments to validate models in weapon simulation codes and enhance the ability to predict the behavior of life-extended weapons. Focused subcritical experiments at U1a investigate specific physics and material properties that are important to the dynamic behavior of plutonium in weapons design and systems. Integral subcritical experiments that capture the behavior of imploding systems using plutonium (under conditions that ensure it remains subcritical) can be designed to constrain parameters and, when coupled with historical nuclear testing data, can explore confidence in predictive codes. This capability serves as a valuable training ground for next-generation weapon designers to challenge their ability to couple theory, modeling, simulation, experimentation, and analysis.

Facilities to test non-nuclear-explosive-package components are critical to developing new LEP options and eventual certification. Facilities such as HERMES, Saturn, the Annular Core Research Reactor, the Ion Beam Laboratory, NIF, and Z are all necessary to test and validate codes for neutron and radiation effects on weapon components. Furthermore, environmental test facilities are vitally important to weapon certification and include a number of capabilities such as centrifuges, wind tunnels, drop tests, thermal facilities, electromagnetic test chambers, and sled tracks.

***National Ignition Facility***

*During 2015, researchers conducted an unprecedented number of experiments at NIF, with 356 laser shots in support of the Stockpile Stewardship Program. This level of effort represents an 85 percent increase over FY 2014 and an 18 percent increase over the goal for FY 2015. The experiments included code and model validation to assess the safety and reliability of the nuclear weapons stockpile. Four were first-of-a-kind shock physics experiments to explore dynamic properties of plutonium that have never been investigated, further improving the understanding of the stockpile.*

***Joint Actinide Shock Physics Experimental Research Experiments***

*The two-stage gas gun platform at this facility executed ten dynamic materials properties experiments in FY 2015, seven of which used actinide materials (plutonium and other materials) of interest to both stockpile stewardship and nuclear counterterrorism.*

## 3.2.1 Current Status

The major experimental facilities have been operating effectively over the past year, and improvements in shot rate and the ability to conduct plutonium experiments have been introduced at NIF. Proposals for additional capabilities to understand the behavior of materials (Matter-Radiation Interactions in Extreme [MaRIE]) and improve understanding of the hydrodynamic behavior of plutonium in subcritical experiments (Enhanced Capabilities for Subcritical Experiments [ECSE]) have reached Critical Decision (CD)-0 (approve mission need) since the *FY 2016 SSMP* was published. With the restructuring of the NIF effort to balance high energy density (HED) stockpile stewardship experiments with experiments to understand ignition, NIF's contribution to stewardship has increased. The capability to conduct experiments with plutonium at HED conditions at NIF was demonstrated in FY 2015; in FY 2016, the NIF experimental throughput will continue to increase. Additionally, researchers at NIF conducted first-of-a-kind shock physics experiments exploring dynamic properties of plutonium that have never been investigated, further improving our understanding of the stockpile.

The mission need for the U1a Complex Enhancements Project (part of an ECSE initiative) has been submitted as a line-item project to provide infrastructure at U1a for studies of late-time hydrodynamic behavior with more energetic radiographic sources, as well as to explore the reactivity of imploding systems within the early 2020s time frame.

### 3.2.2 Challenges

One challenge of the experiments and tests program is to increase the pace of acquiring, at the required precision, data relevant to weapons physics to provide insight into underlying physical processes and phenomena and validate the codes and models needed to develop predictive capabilities for stockpile applications. Additional challenges include increasing the resolution and penetrating power of radiographic diagnostics for subcritical hydrodynamic experiments and measuring the nuclear properties of imploding subcritical assemblies, which lead to the need for ECSE. Simultaneously measuring the microstructure and properties of materials under extreme conditions is required to develop and certify new and newly manufactured materials in a responsive manner without nuclear explosive testing.

Another challenge involves the need for a trusted supply of strategically radiation-hardened (rad-hard) microsystems, including microelectronics, sensors, and other critical components. As microfabrication facilities and expertise continue to move off-shore, production options for custom components are increasingly limited, and the current NNSA production infrastructure has reached its design end of life. Accordingly, NNSA is working to ensure a supply of trusted rad-hard components.

### 3.2.3 Strategies

In FY 2015, NNSA's HED community delivered an integrated 10-year HED Strategy that outlined the experimental plans and objectives that are focused on acquisition of weapons-physics-relevant data in the HED physics regime. In addition, the community delivered a long-term national HED Diagnostics Plan to develop and deliver transformational capabilities to acquire data at the precision needed for model validation. The HED effort provides a critical national resource to investigate crucial weapons physics issues, as well as opportunities to train the next generation of weapons stewards.

Initiatives are under way to provide the enhanced capabilities to improve subcritical hydrodynamic experiments. ECSE will provide radiography at the resolution and penetrating power required to see what is occurring within a plutonium pit as it implodes. A neutron-diagnosed subcritical experiment capability will allow measurements of the nuclear properties of an imploding subcritical mass. Both of these initiatives will fill important gaps in NNSA's experimental capability for certifying modernized weapons.

MaRIE, a facility concept currently under development, would combine several different types of diagnostic probes (protons, photons, neutrons) for *in situ*, real-time characterization of the state of materials under extreme conditions of temperature, pressure, and radiation. MaRIE would, for the first time, allow rapid, thorough characterization of microstructure, physical properties, and material in a single facility. These capabilities are essential to achieve the goals of rapidly developing new materials from conception to fabrication, characterization, and application, while avoiding the indirect methodologies of the past and present. MaRIE is currently at the CD-0 phase of planning, with an Analysis of Alternatives scheduled to begin in spring 2016.

Defense Programs is also studying options for the future supply of trusted strategic rad-hard microelectronics because the current NNSA production facility, Microsystems and Engineering Sciences Applications (MESA) at SNL, has reached its design end of life and increased performance requirements for interoperable nuclear explosive packages will require a new capability. The Analysis of Alternatives, which is currently in progress to explore trusted microsystems capabilities, will provide valuable information concerning the present state of Government and commercial options judged against capability requirements, risk, and cost.

## 3.3 Strategic Materials and Core Components

Strategic materials are key to ensuring safety, security, and effectiveness of the Nation's nuclear deterrent, as well as addressing national security concerns such as nuclear proliferation and terrorism. These materials require a highly skilled workforce and significant programmatic infrastructure. Weapons components created with these strategic materials cannot be produced outside the United States. NNSA has long-term strategies to maintain the facilities, scientific equipment, and manpower to sustain the strategic materials. A common obstacle is the need to refurbish or replace the aging and obsolete facilities in which these materials are handled. The strategies below outline solutions to such challenges or offer bridging strategies to manage implementation of capability investments. Also highlighted are specific aspects of the plutonium, uranium, tritium, lithium, and HE material strategies, as well as the infrastructure requirements for weapons assembly and disassembly and unique non-nuclear components.

### 3.3.1 Plutonium

The use of plutonium requires proper storage facilities, safe and secure disposal pathways, unique equipment and facilities for R&D activities, and modern plutonium pit production capabilities. Almost all plutonium processing for the nuclear weapons program (*i.e.*, recovery, characterization, component fabrication, nondestructive analysis, and surveillance), as well as basic applied research on plutonium, is conducted in LANL's Technical Area 55 (TA-55).

> ***Z facility***
>
> *In 2015, Sandia National Laboratories researchers at Z conducted the seventeenth dynamic compression experiment using plutonium. The data generated by this and previous experiments will improve understanding of the material properties of plutonium under extreme pressures and temperatures to inform decisions on pit reuse in warhead LEPs.*
>
> ***U1a Subcritical Experiments***
>
> *The Orpheus experiment in the Lyra series of subcritical experiments at the Nevada National Security Site was executed in 2015. The experiment provided rich data on the early-time hydrodynamic performance of surrogates for plutonium using several newly developed diagnostics.*

#### 3.3.1.1 Recent Challenges and Strategies

**Aged Plutonium Processing Facilities**

NNSA is addressing the aging infrastructure at LANL and modernizing the waste processing and treatment facilities through recapitalization and line-item projects, including the TA-55 Reinvestment Project, Chemistry and Metallurgy Research Replacement Project, Radiological Liquid Waste Treatment Facility Project, and Transuranic Waste Facility Project.

**Expanded Storage Capacity for Plutonium from Retired Weapons**

The largest portion of the U.S. weapons-usable plutonium inventory is in the form of thousands of retired pits. As more weapons are dismantled, the staging capacity at Pantex is projected to become inadequate within the next decade. In the near term, NNSA will execute a strategy to stage the pits in nuclear material bays until a long-term staging facility is available. A potential long-term solution is a new facility at Pantex, the Material Staging Facility, which completed CD-0 Mission Need in FY 2015.

**Resuming Plutonium Operations at PF-4**

Since pit production paused in 2013, LANL has worked to restart all operations safely. In early FY 2016, LANL resumed machining operations for pit surveillance activities and plans to manufacture a development pit by the end of FY 2016. Full operations at PF-4 are scheduled in late 2016. The Plutonium Sustainment Program at KCNSC provides manufacturing capabilities for shells and other non-nuclear pit components. These interdependent efforts are critical to support a pit manufacturing capacity of 10 War Reserve (WR) pits in 2024, 20 WR pits in 2025, and 30 WR pits in 2026, followed by 50 to 80 pits per year by 2030.

**Resuming Operations at the Waste Isolation Pilot Plant**

The radiological release at the Waste Isolation Pilot Plant in February 2014 stopped transuranic waste shipments and imposed an operational constraint on plutonium programs at TA-55 and throughout the nuclear security enterprise. Phase I of the Waste Isolation Pilot Plant Recovery Plan has been completed. Phase II involves initial resumption of waste disposal operations by December 2016, followed by installation and operation of a new ventilation system.

#### 3.3.1.2 Long-term Plutonium Sustainment Strategy

**Modernization of Plutonium Capabilities**

To meet weapon-grade plutonium requirements for the stockpile, in January 2014, NNSA adopted a three-step strategy, as detailed below.

- The first two steps optimize the use of LANL's existing facilities for analytical chemistry and material characterization capabilities to end program operation in the early Cold War-era Chemistry and Metallurgy Research facility (scheduled for FY 2019):
  - Some laboratory space in the Radiological Laboratory Utility Office Building, completed in 2012, is being reconfigured and equipped for analytical chemistry and material characterization operations to maximize use of existing facilities.
  - LANL is repurposing space for new glove boxes and analytical chemistry and material characterization operations in PF-4 at TA-55 to ensure these capabilities will support pit production and other activities at LANL.
- The third step, the Plutonium Modular Approach, is currently envisioned to construct two separate laboratory modules to conduct operations over the long term and extend the lifetime of PF-4. CD-0 Mission Need for the Plutonium Modular Approach Project was approved in November 2015, and an Analysis of Alternatives is under way to prepare for CD-1.

> ***Plutonium Strategy***
>
> *To meet pit production requirements and address the need for a responsive infrastructure, NNSA is investing in plutonium infrastructure through line-item construction projects, as well as pit production equipment and resources. NNSA and DOD remain committed to achieving a 50 to 80 pits-per-year capability as part of a responsive infrastructure. NNSA is currently evaluating how best to begin demonstrating higher levels of pit manufacturing capacity in 2027.*

### 3.3.2 Uranium

Uranium is a strategic national defense asset with different assays and enrichments (depleted uranium, low-enriched uranium [LEU], and HEU)[7] being used in a wide variety of applications, including weapon components, naval reactors, and fuel in commercial power reactors for the production of tritium. The infrastructure to store and process uranium is mostly at Y-12, with some R&D capabilities located at LANL and Oak Ridge National Laboratory.

[7] Depleted uranium is primarily $U^{238}$; LEU is 3-5 percent $U^{235}$; and HEU is primarily $U^{235}$.

### 3.3.2.1 Challenges

- Provide a new Uranium Processing Facility at Y-12 by 2025 to replace some uranium processing capabilities in the Manhattan Project era facility, Building 9212, and relocate other capabilities to existing Y-12 buildings.
- Reduce inventory of in-process enriched uranium materials at Y-12 to improve safety.
- Maintain the LEU capability for the nuclear security enterprise.

### 3.3.2.2 Long-term Sustainment Strategy

NNSA approved the long-term strategy to produce, process, recycle, and store uranium. The strategy is as follows:

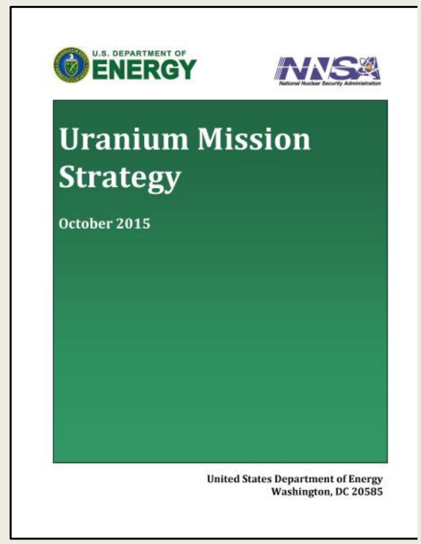
- End enriched uranium programmatic operations in Building 9212 by 2025.
- Sustain and modernize the manufacturing capabilities for casting, machining technology, and purified metal production.
- Upgrade the electrical and heating, ventilating, and air conditioning (HVAC) systems of enduring facilities.
- Transfer classified components and enriched uranium material inventories to the Highly Enriched Uranium Materials Facility for secure storage.

The strategy to maintain the LEU capability for the nuclear security enterprise is as follows:

- Secure existing sources of unobligated[8] LEU using obligation exchanges[9] and downblending the HEU from the current inventory to provide unobligated LEU to extend the tritium fuel need date to the 2038 to 2041 timeframe. Downblending must begin in FY 2019 to preserve the downblending capability and ensure extension of the need date.
- Continue research on centrifuge technology including the AC100 and a smaller centrifuge design. Develop a detailed acquisition strategy with industry to deploy an LEU capability for tritium production and identify options to supply enriched uranium for all national security and nonproliferation mission requirements for some yet-to-be-determined time in the future.

***Uranium Strategy***

*The Uranium Processing Facility provides critical capabilities to the Nation's nuclear weapons program, Naval Reactors, and nonproliferation missions. NNSA is committed to ending enriched uranium programmatic operations in Y-12's Building 9212 and delivering the Uranium Processing Facility by 2025 for no more than $6.5 billion. NNSA is reducing sources of mission and safety risk in the existing buildings to ensure that long-term enriched uranium operations continue safely.*


U.S. DEPARTMENT OF ENERGY
NNSA
Uranium Mission Strategy
October 2015
United States Department of Energy
Washington, DC 20585

[8] Unobligated materials are not encumbered or "obligated" by international treaties or agreements such as peaceful nuclear cooperation agreements.

[9] Unobligated LEU is owned within the U.S. commercial reactor industry. "Trading" or exchanging U.S.-owned, but obligated, LEU with commercial owners will preserve nuclear security enterprise access to the unobligated materials.

## 3.3.3 Tritium

Because of its short half-life, tritium must be periodically replenished in nuclear weapons. Tritium is recovered from gas transfer system reservoirs at SRS. The recovery process provides the majority of SRS's inventory to fill the reservoirs. The Material Recycle and Recovery program is responsible for that mission. Producing new tritium[10] to maintain the SRS inventories is the responsibility of the Tritium Sustainment program. Maintaining the infrastructure associated with the production, purification, storage, and recycling of tritium is vital to meet national security needs. R&D is also required to understand and advance tritium technologies to support the limited life gas transfer system components and the production and gas handling infrastructure. In 2015, NNSA appointed a Tritium Strategic Material Manager as a single point of contract for issues involving the GTS tritium supply chain.

### 3.3.3.1 Challenges

- Tritium gas processing and support equipment in the aged SRS H-Area New Manufacturing facility will require replacement within the FYNSP period. While production outages are carefully planned to avoid impacting mission schedules, in some instances, NNSA and SRS will likely have to work with DOD to adjust schedules to accommodate this work.
- SRS must restore full Tritium Extraction Facility staffing by the end of FY 2016 to allow time for training and qualification and to establish the proficiency needed when full-time operations begin in FY 2019.
- Production of tritium must ramp up to 2800 grams over two 18-month reactor cycles by 2025. Appropriate license amendment requests and a step-wise increase of tritium-producing burnable absorber rod (TPBAR) irradiation at the Watts Bar Reactor are the near-term actions to meet this requirement.
- SRS must replace H-Area New Manufacturing chillers to be in compliance with U.S. Environmental Protection Agency regulations. SRS has developed a mission strategy that replaces the chillers by the late 2020s.

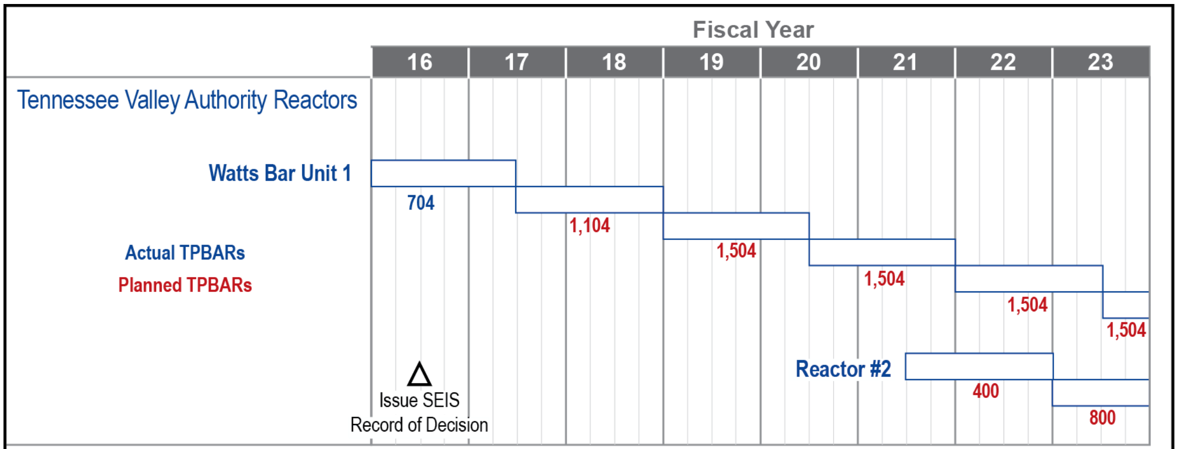
***Tritium Supply Chain Management***

*NNSA strengthened the management of the tritium supply chain by appointing a Strategic Material Manager for Tritium. An enterprise-wide team conducted a supply and demand analysis that defined the requirements validated by the Nuclear Weapons Council. NNSA updated its tritium production planning to address the current requirements.*

### 3.3.3.2 Long-term Sustainment Strategy

DOD and NNSA have requirements to improve performance margins and to reduce the frequency of gas reservoir exchanges, which translates into increased demand for tritium. NNSA updated its tritium production plan accordingly, as illustrated in **Figure 3–1**. Each horizontal bar in Figure 3–1 represents an 18-month irradiation cycle at Tennessee Valley Authority commercial nuclear reactor sites. Beginning with the 2017 irradiation cycle and subsequent cycles, the number of TPBARs must be increased, and eventually two reactors will be required. The tritium to be recovered through stockpile returns and dismantlement of weapons has been factored into the assessment of production needs.

[10] Tritium is produced by irradiating lithium-aluminate pellets with neutrons in a commercial nuclear power reactor. TPBARs are similar in dimension to reactor fuel rods and, with irradiation, tritium is produced and captured on getters. When the TPBARs are processed, the tritium is extracted, purified, and stockpiled.




*Key:*
SEIS = Supplemental Environmental Impact Statement
TPBARs = tritium-producing burnable absorber rods

**Figure 3–1. Schedule for irradiating TPBARs in two reactors at the Tennessee Valley Authority**

## 3.3.4 Lithium

Lithium is used in the manufacturing of nuclear weapons components for NNSA and lithium materials are provided to the Department of Homeland Security and the DOE Office of Science. The infrastructure to produce lithium components is at Y-12. NNSA will appoint a Lithium Strategic Material Manager in 2016.

### 3.3.4.1 Challenges

Building 9204-2, the main facility for lithium production at Y-12, is over 70 years old and is one of the oldest operating facilities in the nuclear security enterprise. NNSA will continue to use 9204-2 and its process equipment to meet near-term stockpile needs while developing a plan for the Lithium Production Capability to address long-term capability requirements.

### 3.3.4.2 Long-term Sustainment Strategy

The strategy for lithium is as follows:

- A few processes will be restarted in Building 9204-2 in the near term to provide additional feedstock material. In lieu of full purification capabilities, material recycle is the only source of lithium for weapon systems.
- To address long-term requirements, an Analysis of Alternatives is under way and is expected to finish by the third quarter of FY 2016.
- A bridging strategy is being executed to ensure safe operations in the current production facility and sustain capabilities and material supplies at Y-12 until the new lithium production capability is in place around 2028.
- Nuclear weapons production planning has identified a number of retired weapons systems and canned subassembly inventories that could be a source for lithium salt recycling to augment the currently certified sources. LANL and LLNL must certify these additional sources before they can be used for LEP components.

## 3.3.5 High Explosives

High explosives (HE) are used in the nuclear explosive package and non-nuclear support systems. A broad range of activities in synthesis, formulation, processing, characterization, and dynamic tests of energetic materials, components, and subassemblies are conducted to support the mission. The infrastructure to support these efforts includes unique experimental facilities, characterization laboratories, contained firing sites, an outdoor test area, isostatic pressing, and the synthesis plant.

> ***High Explosives***
>
> *The Pantex Plant is currently the only national supplier of several War Reserve-quality high explosives (HE), including hexanitrostilbene, pentaerythritol tetranitrate, and plastic bonded explosive (PBX)-9012. The HE pressing operations are being conducted in a World War II-era facility until the High Explosive Pressing Facility is commissioned and startup activities commence in 2016.*

**Challenges and Strategies**

- Risk to HE operations has been reduced through the construction of the High Explosive Pressing Facility, which consolidates operations from numerous buildings and greatly reduces movement of HE within Pantex. Operations at the new facility are scheduled to begin in September 2016.
- HE storage at LANL and LLNL is currently adequate, however many of the Pantex facilities are World War II-era buildings that have been identified for replacement. When built, these facilities were not constructed to meet modern safety design criteria for HE.
- Additionally, other HE facilities (including buildings and structures associated with HE research, development, test, and evaluation at LANL and LLNL) require recapitalization to support LEP activities, improve efficiencies, and reduce downtime. NNSA will continue to meet its near-term mission commitments and strengthen core capabilities, while planning and making capital investments in projects that include new facilities, modernizing other facilities, consolidating like activities, returning several capabilities to their intended purpose, and demolishing several facilities that are not economically feasible or are no longer needed.
- HE and other energetic materials are used in more than 50 non-nuclear components within the nuclear stockpile (*e.g.*, explosive detonators, timers and drivers for neutron generators, initiators for spin-rocket motors and explosive firing sets). These non-nuclear components developed at SNL span a wide range of functions, designs, and chemistries that make it difficult for commercial vendors to meet all nuclear weapon requirements. The stringent specifications and diversity of the energetic materials do not provide the economic incentives necessary for commercial vendors to improve their existing processes. A new capability is under development to reprocess available energetic materials by engineering their purity and morphology for existing and future applications.

> ***Insensitive High Explosive (IHE) Research and Development***
>
> *These explosives are more resistant to shock and fire than conventional high explosives. The IHE in the present stockpile were developed in the 1970s. The new generations of IHE under development are lighter and take up less volume than the first-generation IHE.*

### 3.3.6 Non-nuclear Components

#### 3.3.6.1 Gas Transfer Systems

NNSA delivers tritium-filled GTSs, an LLC, to DOD as part of the nuclear weapon stockpile. GTSs are designed, produced, filled, and delivered for existing and future weapon systems. SNL and LANL are responsible for the design of the GTSs to meet performance characteristics of the weapon systems. Savannah River National Laboratory partners with these national security laboratories to conduct GTS R&D. The Savannah River National Laboratory works closely with SNL and LANL, in particular, to evaluate new GTS designs produced at KCNSC and conducts tests to qualify the new designs. In response to this expanding role, Savannah River National Laboratory is enhancing its tritium processing infrastructure, separate from its tritium production facilities, to accommodate these R&D needs.

**Recent Challenges and Strategies**

- Formal risk analyses continue to show deteriorating infrastructure as a primary risk to the continuity of SRS' stockpile missions. The Tritium Responsive Infrastructure Modifications (TRIM) Program is NNSA's primary strategy for mitigating infrastructure risks at SRS. In FY 2015, NNSA approved CD-0 for the TRIM Program's Tritium Production Capability line-item project based on the Acquisition Advisory Board's validation of mission need. NNSA will execute this project after a preferred alternative is identified *via* the formal Analysis of Alternatives process.
- Limited capacity for GTS function tests at SRS are forcing trade-offs between surveillance and R&D needs at the national security laboratories. With the need for GTS function tests forecasted to grow, SRS will study options, including multi-shift operations on existing equipment.
- Because of complex system designs and concurrent production of multiple weapon systems, GTS loading capacity at SRS will be insufficient unless modifications are made. As a result, NNSA will modify process equipment in multiple SRS facilities by FY 2020 to establish the additional loading capacity to support mission requirements.
- Production welding equipment and precision turning equipment at KCNSC should be replaced to maintain the programmatic schedule. The existing equipment was transferred from Rocky Flats in the early 1990s. Upgrades to production welding and precision turning equipment are in KCNSC plans.

#### 3.3.6.2 Power Sources

**Challenges and Strategies**

Facility conditions at SNL are becoming inadequate for power source production, placing battery deliveries to support stockpile modernization schedules at risk. The current facility was not designed to contain the power source capability, and the associated infrastructure has exceeded its design life and is becoming unreliable. To meet the mission needs for the power source capability, the new Weapons Engineering Facility is on the NNSA Construction Resource Planning List in Figure 4–35 of Chapter 4 in this *FY 2017 SSMP*.

#### 3.3.6.3 Neutron Generators

No updates in the *FY 2017 SSMP*.

#### 3.3.6.4 Radiation-Hardened Microelectronics

NNSA requires a trusted supply of radiation-hardened advanced microsystems, including R&D capabilities to maintain the safety, security, and effectiveness of the Nation's nuclear deterrent in an increasing geopolitical threat environment. The MESA fabrication facilities at SNL are the only source of custom, strategic, radiation-hardened microelectronics for nuclear weapons.

**Challenges and Strategies**

- A clear path forward is needed to sustain an adequate supply of trusted, strategic, radiation-hardened advanced microsystems. Through the CD process, NNSA is evaluating the mission need and program requirements.
- The silicon fabrication infrastructure continues to deteriorate and is at risk for a major failure. The silicon fabrication facility at MESA that delivers custom integrated circuits reached the end of its design life in 2013 and relies on fabrication tools that are no longer supported by manufacturers. NNSA is determining how to qualify new processes associated with converting from 6-inch to 8-inch wafer tooling at SNL's MESA facilities.

## 3.4 Weapons Assembly and Disassembly

As part of maintenance and surveillance, weapons are selected for disassembly and inspection. Weapons sampled from production lines or returned from DOD are inspected during disassembly. Necessary maintenance is performed, as well as some surveillance activities, including component and material inspections and evaluations. Reassembly is then performed. Most assembly and disassembly activities are done at Pantex, with some evaluation and reacceptance activities performed at SNL, LLNL, LANL, and KCNSC. The activities within the assembly and disassembly capability are cell and bay operations, weapon and component storage, and nondestructive evaluation and surveillance.

### 3.4.1 Challenges and Strategies

- Cell and bay operations, weapon and component storage, and nondestructive evaluation and surveillance are inadequate at Pantex because of infrastructure deficiencies (*e.g.*, fire suppression systems and radiological alarm monitoring systems that limit performance and for which refurbishment is required to return the key assets to adequate conditions). The infrastructure decline at Pantex is being arrested through reinvestments that will mitigate the effects on cell and bay operations and nondestructive evaluation and surveillance. For weapon and component staging, the proposed Material Staging Facility would offset the decline and operational challenges.
- Explosive facilities for hydrodynamics assembly are inadequate to substandard at LLNL. Small investments are in place at LLNL and the equipment status is trending toward an adequate rating within the FYNSP. Weapons test assembly fabrication will require some major building system recapitalization.

## 3.5 General Purpose Infrastructure and Programs

General purpose infrastructure includes all nuclear security enterprise infrastructure (such as roads, fire suppression systems, site utilities, and equipment) that is not specifically program-focused, but supports mission execution. Also included in this category are the building envelopes (*e.g.*, roofs, walls) that house the programmatic infrastructure,[11] as well as surveillance and maintenance of excess (that is,

[11] Programmatic infrastructure includes the scientific devices and diagnostic equipment, core capabilities, and processes housed within the buildings of the general purpose infrastructure. The programmatic infrastructure allows NNSA to conduct research, tests, production, sustainment, and disposition related to the entire range of its national security commitments.

unused) general purpose and programmatic infrastructure. A variety of new tools, techniques, and approaches have been designed and deployed to enhance NNSA's ability to manage an exceedingly diverse and complex suite of infrastructure assets. In addition, NNSA has focused on ways to operate more efficiently and prioritize its investments better across the nuclear security enterprise. These new approaches have already yielded some success, but many challenges remain, and NNSA must sustain these efforts over the next 25 years to ensure the ability to support its mission needs fully.

For information on NNSA's programmatic infrastructure, refer to the Experiments and Tests capabilities discussion in Section 3.2 and the strategic material and core component capabilities discussions in Section 3.3.

### 3.5.1 Current State

NNSA's ability to meet national security mission needs depends on a safe and reliable general purpose infrastructure. The condition and age of this infrastructure poses increasing risk for NNSA in meeting its mission. This challenge is made more difficult since that infrastructure is failing at an increasing frequency because of its age and condition. As shown in **Figure 3–2**, more than half of NNSA's facilities are more than 40 years old, nearly 30 percent date to the Manhattan Project era, and 12 percent are excess. The state of NNSA's general purpose infrastructure is in decline and, in some instances, cannot fully support mission activities in terms of availability, capacity, or reliability. Increased investment is required to avoid unacceptable risk to capabilities, the workforce, the public, and the environment.

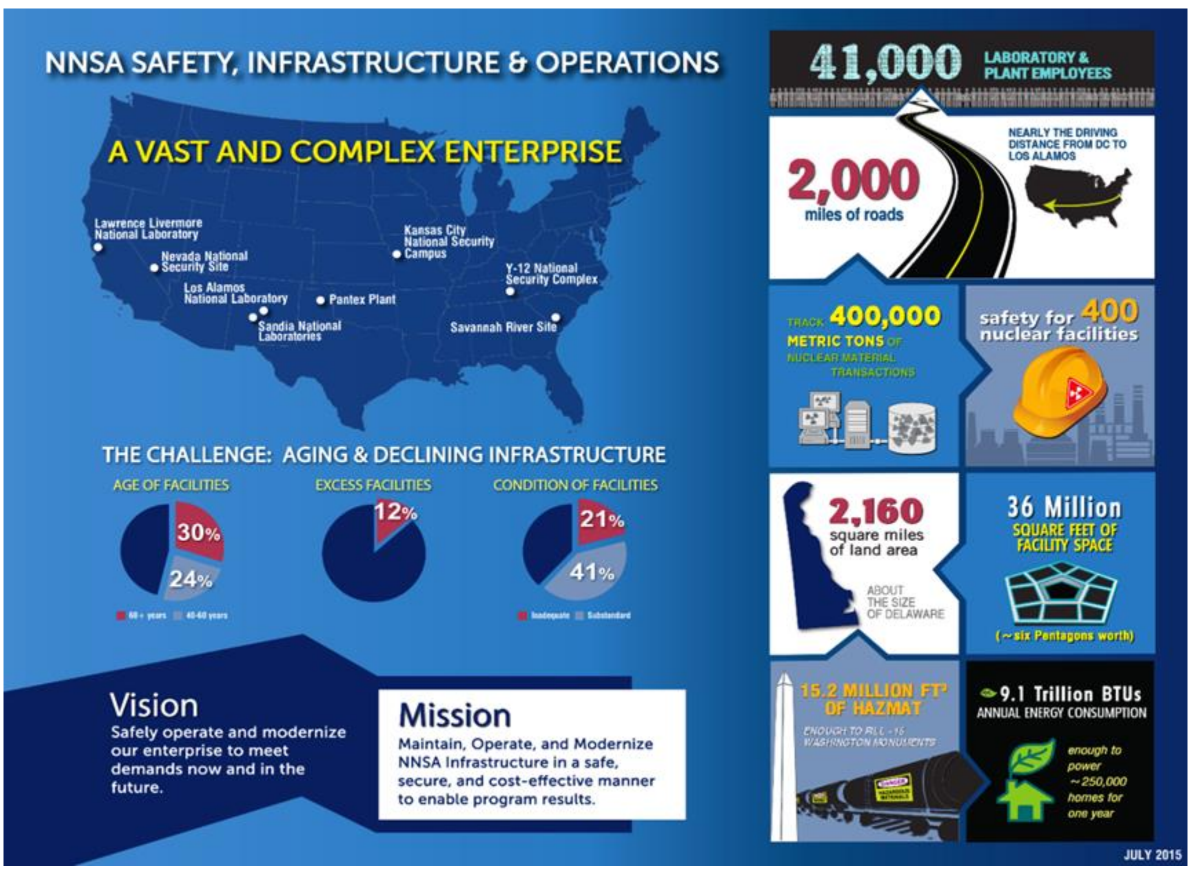



**Figure 3–2. NNSA general purpose infrastructure scope**

NNSA is taking steps to arrest the declining state of its general purpose infrastructure by making better use of existing resources and working to enhance these resources. To do so, NNSA is deploying innovative management tools to facilitate a data-driven planning process that will lead to risk-informed investment decisions.

### 3.5.2 Challenges

The main challenges facing NNSA with respect to sustainment, modernization, and operation of its general purpose infrastructure are:

- the growing need for refurbishment or modernization of key infrastructure assets,
- the allocation of limited capital construction resources to replace these assets,
- halting the growth of deferred maintenance (DM), especially that associated with mission-essential assets, and
- the backlog of excess assets awaiting decontamination and decommissioning, which results in ongoing costs to manage risks in unoccupied space.

These interrelated challenges must be considered as a whole to develop an integrated approach to investment planning to ensure resources are prioritized to address the greatest risks. NNSA must also become more efficient and resourceful in prioritizing the funding it receives.

### 3.5.3 Program Management Tools and Processes

This section summarizes the cutting-edge management tools and processes NNSA is deploying to make data-driven, risk-informed investment decisions to address its general purpose infrastructure challenges.

**BUILDER** is a web-based software tool that enables decisions concerning when, where, and how to best maintain, repair, and recapitalize infrastructure. Developed by the U.S. Army Corps of Engineers, the BUILDER Sustainment Management System has been recognized[12] by the National Academies of Sciences, Engineering, and Medicine as a best-in-class practice for infrastructure management. BUILDER uses pre-existing engineering data to predict facility and component conditions, prioritize maintenance work, and support analysis of different spending scenarios.

NNSA's ultimate goal is to collect all condition assessment data in BUILDER and use it as the auditable, consistent single source of information on the condition of all NNSA general purpose infrastructure. BUILDER implementation is under way and will be completed by early 2018. When this implementation is complete, NNSA will use BUILDER to calculate a more consistent and accurate DM picture of the nuclear security enterprise.

**Enterprise Risk Management (ERM)** is a risk-based methodology that measures "consequence to mission" and the "likelihood of the consequence occurring." ERM provides a framework to evaluate the potential impact of investment efforts and opportunities for future investment. This ERM strategy represents a fundamental shift in the methods and tools that NNSA has used over the past 15 years and will require lower-priority (hedge) assets to be repurposed or dispositioned.

**Enterprise Management Information System Generation 2 (G2)** empowers the M&O partners to manage infrastructure at the project level with appropriate transparency and provides NNSA senior management with a common, transparent picture of the allocation and execution of general purpose

[12] See *Predicting Outcomes of Investments in Maintenance and Repair of Federal Facilities*, The National Academies Press, 2012.

infrastructure spending. G2's flexibility[13] provides this transparency without burdening M&O partners with unnecessary additional data tracking and reporting requirements in the following manner:

- Tracks scope, schedule, cost, risk, and prioritization data.
- Automates change control, business rules, and notifications.
- Maintains geospatial data for maps, diagrams, photos, inventories, and condition.
- Uses ERM questions and formulas to prioritize projects.

**Mission Dependency Index** measures the consequence to the mission by combining the impact if the asset were lost, the difficulty to replace the asset, and the interdependency of assets. The Mission Dependency Index also shows the interconnectivity of facilities. Combining this with BUILDER condition and functionality data will allow NNSA to understand the risks associated with the condition and functionality of its assets and the potential impacts to its mission.

**New DOE Laboratory Operations Board Assessment Tools**. In 2013, the Secretary of Energy formed the National Laboratory Operations Board to provide a nuclear security enterprise-wide forum to engage DOE's national laboratories and programs in a joint effort to identify opportunities for improving effectiveness and efficiency of operations. The Laboratory Operations Board established an integrated plan to conduct the Department's first assessment of its general purpose infrastructure across all 17 DOE laboratories, as well as its NNSA sites, nuclear weapons production plants, and the Nevada National Security Site, using common standards and a DOE-wide approach. This assessment influenced the infrastructure portions of NNSA's FY 2017 Budget Request, which will allow NNSA to prevent the growth in the DM backlog above the FY 2015 end-of-year levels.

### 3.5.4 Strategies and Path Forward

This section summarizes the strategies NNSA is developing and deploying to address its general purpose infrastructure challenges, including those being used for long-term strategic planning.

**Core Infrastructure Risk-Informed Strategic Planning**

NNSA will implement the planning process *via* the Core infrastructure, Risk-Informed Strategic Planning (CRISP) Team. CRISP is a multi-organization, nuclear security enterprise-wide team that includes representatives from all NNSA field offices and M&O partners. The CRISP mission is to develop data-driven, risk-informed strategic planning processes to improve general purpose infrastructure investment decision-making. CRISP will identify high-priority, nuclear security enterprise-wide actions that put NNSA on the path to achieving its vision.

**NNSA Master Asset Plan**

The Master Asset Plan serves as the roadmap to meet NNSA's general purpose infrastructure needs; it provides a prioritized sequencing of major capital investments over a minimum of 25 years to meet NNSA mission requirements. The new NNSA Master Asset Plan process draws on the DOE Office of Science's proven infrastructure strategic planning process and includes three major process elements:

- Mission Strategic Planning,
- Infrastructure Analysis, and
- Infrastructure Roadmap.

[13] See *FY 2015 SSMP*, Chapter 8, Section 8.10.12, p. 8-23.

### Asset Management Program

The Asset Management Program funds prioritized repair and replacement of major building systems that are common across the nuclear security enterprise. Asset Management Program funds were first applied to roofs.[14] In 2015, the program was expanded to include HVAC equipment. The Asset Management Program uses systems engineering and supply chain management strategies to increase purchasing power and improve the timeliness of procurements in order to improve the condition of these systems faster and more economically than decentralized approaches.

### Decontamination and Decommissioning

NNSA's strategy for tackling the decontamination and decommissioning backlog is driven by the principles of enterprise risk management, *i.e.*, applying funding to tasks that will eliminate the most risk for the least investment. To measure these risks, NNSA is developing a Mission Risk Index, which factors in surveillance and maintenance, operating costs and missions, and safety of the workforce and public. NNSA's highest disposition funding priorities are to stabilize degraded process-contaminated buildings, characterize their hazards and conditions, remove hazardous materials, and place these buildings in the lowest risk condition possible. While process-contaminated buildings pose the greatest hazards, non-process-contaminated buildings also pose risks to the workforce, the public, and the environment as a result of structural degradation, industrial contamination, and increased vulnerability to fire or other accidental events.

### Capital Construction Projects

NNSA's general purpose infrastructure capital investments balance the need to modernize the aging nuclear security enterprise with the risk management of maintaining existing facilities and capabilities beyond their intended lifetimes. The projects listed below, as well as other planned capital improvements, are necessary to sustain existing infrastructure needs and provide the capabilities to meet future mission demands.

- Emergency Operations Centers at Y-12, LLNL, and SNL are being planned to improve emergency management response and survive high-consequence natural phenomena.
- The electrical distribution system projects at LANL, LLNL, and the Nevada National Security Site will improve the capability, capacity, and reliability to support mission-essential activities.
- The new fire station at Y-12 will improve emergency response capabilities.
- The new High Pressure Fire Loop for Zone 11 at Pantex will provide a reliable fire protection system to support HE production and development operations.

### Public Private Partnerships

NNSA is committed to satisfying its programmatic needs through a rigorous acquisition and project management process. Consistent with DOE's recently instituted policies, NNSA conducts an Analysis of Alternatives—independent from the contractor organization that would benefit from the project—for all projects greater than $10 million prior to selecting an alternative at CD-1. As part of the Analysis of Alternatives process, NNSA evaluates all options, including capital construction, use of public-private partnerships, and other alternatives. This evaluation includes life-cycle cost analysis that takes into account all relevant cost drivers, including whether third-party financing may be cost-feasible based on

[14] See the *FY 2011 SSMP*, Annex A, pp. 147 and 149 and Figure A-11-2 on p. 148. The Roof Asset Management Program component of NNSA's Facilities and Infrastructure Recapitalization Program received the first prize for Real Property Innovation in the 2008 General Services Administration's annual competition.

application of the criteria in Office of Management and Budget (OMB) Circular A-11.[15] If NNSA chooses to pursue a public-private partnership, additional considerations will need to be addressed and the proposal will have to be submitted through the normal channels.

In April 2015, the NNSA Administrator approved leasing as the preferred alternative to recapitalize aging infrastructure for administrative services at Pantex and directed the use of a "Sources Sought" process as the first step toward developing a specific proposal, which has been submitted to OMB for review and approval. As with any proposed public-private partnership, this proposal must be compliant with OMB Circulars A-11 and A-94.[16]

**Halting the Growth of Deferred Maintenance**

Many NNSA buildings vital to mission success are being used well past their intended lifetimes and have substantial maintenance backlogs. NNSA's total DM at the end of FY 2015 was $3.67 billion.

NNSA's strategy for reducing DM has two main elements. The first, centered on the Secretary of Energy's initiative to avoid increased DM, entails revising NNSA's approach to managing its infrastructure to ensure that senior decision-makers understand the funding required for current maintenance needs while also reducing DM to an acceptable level of risk. The second, equally important element involves to making DM estimates auditable and comparable across all sites and improving how required maintenance is identified.

The reduction in DM will be accomplished by prioritizing NNSA's routine investments in general purpose infrastructure. This approach will allow NNSA to make risk-informed strategic choices that address the DM backlog, dispose of unneeded facilities, and revitalize the general purpose infrastructure. NNSA recognizes that these goals will not be met quickly and that arresting the declining state of the general purpose infrastructure will require steady commitment over many years. The tools and processes being implemented, along with sustained investment in that infrastructure, will set NNSA on the right path to ensuring a viable, safe, and effective nuclear security enterprise well into the future.

# 3.6 Security

## 3.6.1 Physical Security

Defense Nuclear Security (DNS) provides the physical security for the Nation's nuclear materials and infrastructure assets, as well as the personnel security of the workforce at NNSA Headquarters, field offices, and the eight M&O partner sites. DNS works in coordination with complementary programs, such as Counterintelligence and Insider Threat, to protect NNSA 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. The physical security mission is carried out at each field location by dedicated cadres of highly trained security professionals, employing an array of weapons and technologies deployed to address general and site-specific threats.

[15] OMB Circular No. A-11 "Preparation, Submission, and Execution of the Budget"
[16] OMB Circular No. A-94, "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs."

The following sections describe the current status for deploying systems to protect the general purpose and programmatic infrastructure, nuclear materials, and workforce by addressing near-term challenges and developing long-term strategies to ensure future security capabilities.

#### 3.6.1.1 Current Status for Deployment of Physical Security Tools and Processes

NNSA deploys technologies at its sites for alarm management and control, intrusion detection and assessment, access controls, barriers and locks, secure storage, communications, materials accountability, technical surveillance countermeasures, and protective forces. **Table 3–2** shows which NNSA M&O partner sites deploy each type of technology. These tools and processes are then briefly described.

**Table 3–2. FY 2015 NNSA physical security technology deployment**

| *Technology Description* | *LANL* | *NNSS* | *Pantex* | *Y-12* | *KCNSC* | *LLNL* | *SNL* | *SRS* |
|---|---|---|---|---|---|---|---|---|
| **Alarm Management** | | | | | | | | |
| Argus | X | | X | X | | X | | |
| Other | | X | | | X | | X | X |
| **Intrusion Detection** | | | | | | | | |
| PIDAS | X | X | X | X | | | | |
| Intrusion Detection System | X | X | X | X | X | X | X | X |
| **Access Controls** | | | | | | | | |
| Badge Readers | X | X | X | X | X | X | X | X |
| **Barriers and Locks** | | | | | | | | |
| Vehicle Gates | X | X | X | X | | X | X | X |
| Vehicle Barriers | X | X | X | X | X | X | X | |
| Entry Booths | X | X | X | X | | X | | X |
| Pedestrian Gates and Turnstiles | X | X | X | X | X | X | X | X |
| Security Doors | X | X | X | X | X | X | X | X |
| Locking Mechanisms | X | X | X | X | X | X | X | X |
| **Materials Control and Accounting** | X | X | X | X | (a) | X | X | X |
| **Technical Surveillance and Countermeasures** | X | X | X | X | X | X | X | X |
| **Contraband Detection and Tactical Systems** | | | | | | | | |
| Metal Detection | Please refer to the version of this chart included in the classified Annex for specific locations where these systems are deployed. | | | | | | | |
| Explosives Detection | | | | | | | | |
| K-9 Explosives Detection | | | | | | | | |
| Package X-Ray | | | | | | | | |
| SNM Detection | | | | | | | | |
| Ground Radar | | | | | | | | |
| Blue Force Tracker | | | | | | | | |
| Sniper Detection | | | | | | | | |
| Wireless Communications | | | | | | | | |
| Tactical Surveillance | | | | | | | | |
| Remotely Operated Weapons Systems | | | | | | | | |

KCNSC = Kansas City National Security Campus
LANL = Los Alamos National Laboratory
LLNL = Lawrence Livermore National Laboratory
NNSS = Nevada National Security Site
Pantex = Pantex Plant
PIDAS = Perimeter Intrusion Detection and Assessment System
SNL = Sandia National Laboratories
SNM = special nuclear material
SRS = Savannah River Site
Y-12 = Y-12 National Security Complex

[a] KCNSC does not have SNM and therefore does not have a Materials Control and Accounting program.

**Alarm Management and Control Systems.** NNSA sites that possess Category I or II quantities of special nuclear materials are expected to use the Argus system developed by LLNL. This proprietary system meets all DOE requirements for protecting these materials. LANL, Y-12, Pantex, and LLNL (although no longer a Category I/II site) have fully implemented Argus. The Nevada National Security Site and the SRS Tritium Facility are on schedule to replace their legacy systems with Argus as high-priority security projects. SNL and KCNSC use other commercial systems.

**Intrusion Detection Systems.** An integrated, multilayered suite of barriers, sensors, and assessment systems protects NNSA assets, including the Perimeter Intrusion Detection and Assessment System (PIDAS) for Category I or II quantities of SNM. For exterior applications within a PIDAS, most sites have deployed a combination of passive and active sensors (*e.g.*, bi-static microwave sensors, infrared sensors, fence detection systems, buried-line sensors, unattended ground sensors, long-range radar systems, and electromagnetic field detection systems). For interior applications, all sites use balanced magnetic switches on doors and dual-technology interior sensors on vaults and vault-type rooms.

**Access Control Systems.** Access control systems use a combination of entry control and contraband detection for authorized entry and exit. NNSA is in various stages of fully implementing the Identity, Credential, and Access Management program according to the Federal Identity, Credential, and Access Management Roadmap.

**Barriers and Lock Systems.** State-of-the-art barrier technologies are used at some NNSA facilities, along with low-technology barriers (such as concrete blocks or razor wire).

**Secure Storage Systems.** These systems provide additional barriers when practical for specific material.

**Materials Control and Accounting.** NNSA has deployed specific technologies (*e.g.*, accounting software, tamper-indicating devices and dispensers, measurement devices, and barcode readers).

**Package Inspection Systems.** Several sites have deployed x-ray inspection equipment at shipping and receiving facilities to prevent the introduction of contraband into protected or material access areas.

**Communication Systems.** These systems allow members of NNSA's Protective Force to communicate with each other securely and with system redundancy.

**Protective Force Tactical Systems.** NNSA tactical systems increase protective force lethality and survivability. These systems include hardened vehicles and fighting positions, protective force tracking systems, friend or foe identification systems, Boomerang Sniper Detection System, non-explosive mechanical and thermal breaching equipment, Multiple Integrated Laser Engagement System gear, and remotely operated weapons systems.

#### 3.6.1.2 Challenges

- Identify emerging threats and ensure capabilities are developed and implemented to counter them.
- Fill Protective Force vacancies across the nuclear security enterprise.
- Develop time-phased maintenance programs and master schedule for upgrades and replacements across the nuclear security enterprise.
- Integrate and standardize safeguards and security policies and procedures across the nuclear security enterprise.
- Ensure security is considered in the planning for all new construction and for all adjustments to the layouts of the national security laboratories and nuclear weapons production facilities.
- Assess and address the full range of threats, from protestor incursions to active/violent insiders.

Among the challenges we confront, the emerging threat posed by Unmanned Aerial Systems (UASs) is among the most pressing. UAS technical capabilities and availability are rapidly expanding and their ability to carry substantial payloads is likewise increasing. Along with the technical capability to counter the UAS threat we are also working to develop the policy and the means to determine hostile intent, essential to selecting an appropriate and effective response. The NNSA, like other government agencies, has encountered actual incursions, a circumstance that adds a degree of urgency to our efforts to field a C-UAS capability along with the policy for its use.

#### 3.6.1.3 Strategies

NNSA is addressing the challenges of managing security risks for nuclear weapons and related programs described below.

**Ten-Year Plan.** Historically, DOE's implementation of physical security technology has been site-centric, with no corporate direction on how to select, install, operate, and maintain technologies at all the sites. This approach has led to individual site solutions that have increased the funding requirements to manage multiple systems that perform similar functions. NNSA is aware of these issues and has been working actively to address them and, in FY 2015, NNSA established baseline data for tracking security infrastructure and technology.

**Roadmap.** In 2015, DNS developed and began implementing a Security Roadmap to guide the efforts to address shortcomings identified in a series of security reviews by congressional and other Governmental panels. (See *GAO Report to Congressional Requesters – Nuclear Security: NNSA Should Establish a Clear Vision and Path Forward for Its Security Program*, May 2014, GAO-14-208.)

**Strategic Plan for DNS.** The priorities outlined in the DNS Strategic Plan include sustaining the security enhancements implemented at the sites since September 11, 2001; continuing to reduce physical security vulnerabilities; leading efforts to integrate security initiatives with DOE program offices, government agencies, and international partners; and assisting NNSA sites in applying risk management principles and processes to achieve cost-effective physical security.

**Layered Protection Area.** NNSA is continuing to apply its physical security technology capabilities using a 'layered protection strategy' at the boundaries of designated protected areas and within material access areas around what is referred to as a 'property protection area.' Barriers of various types are being used within these areas, along with personnel identification and verification procedures.

**Collaboration with Other Parts of Defense Programs.** DNS is participating in the Construction Working Group and the Management Council to ensure a proper interface is achieved to maintain close collaboration with other parts of Defense Programs and all other parts of NNSA.

**Center for Security Technology, Analysis, Response, and Testing (CSTART).** In an effort to enhance standardization, integration and cost effectiveness across the nuclear security enterprise, Public Law 113-66, 50 United States Code 2515 created CSTART to leverage national laboratory expertise to provide objective expertise on the full range of security program needs. CSTART is located at SNL in Albuquerque, New Mexico and operated by a dedicated program management office. While SNL manages CSTART, the initiative employs a very collaborative approach which includes working with other national laboratories, DOD, and the Nuclear Regulatory Commission to achieve enterprise solutions for security challenges. We are leveraging CSTART to address a number of strategic challenges, to include development of Counter-UAS capabilities.

## 3.6.2 Cyber Security

NNSA is pursuing an information technology and cyber security transformation strategy to lower costs, improve security, and enable collaborative solutions. The strategy is driven by Government-wide mandates, including the Office of Management and Budget's *25-Point Implementation Plan to Reform Federal Information Technology Management* (White House 2010) and Executive Order 13576, *Delivering an Efficient, Effective, and Accountable Government* (White House 2011). NNSA's Cyber Security Program is responsible for fostering a culture to ensure that information technology systems and projects are coordinated across NNSA, have the necessary cyber security protection, and are aligned with DOE requirements and objectives. These are mandated by the *Federal Information Security Modernization Act* (FISMA) and the *Federal Information Technology Acquisition Reform Act* (FITARA).

Because of the highly complex and global nature of the stockpile stewardship and stockpile management missions, electronic information and information assets must be managed and protected using a risk management approach. All information collected, created, processed, transmitted, stored, or disseminated by or on behalf of NNSA on automated information systems requires a level of protection commensurate with the risk to that information and associated information-processing systems. Moreover, because of the geographically diverse nature of the nuclear security enterprise, the risk management approach must be flexible, comprehensive, coordinated, and cost-effective to ensure that security considerations are fully integrated into the architecture of the nuclear security enterprise and NNSA business processes.

### 3.6.2.1 Program Goals

The overarching goal of NNSA's Cyber Security Program is to implement a flexible, comprehensive information technology and cyber security system to ensure the protection of NNSA's classified and sensitive information assets related to the nuclear weapons stockpile *via* the following approaches:

- improving cyber security protections for NNSA mission data,
- maintaining a relevant NNSA Cyber Security Program,
- solidifying NNSA's evolving incident management capabilities, and
- realizing the management and resource benefits of implementing the 2015 *Federal Information Technology Acquisition Reform Act.*

NNSA's Cyber Security Program is also aligned with the Office of Management and Budget's 2012 *Digital Government Strategy*, the 2012 *Federal Information Technology Shared Services Strategy*, the 2011 *Federal Cloud Computing Strategy*, the 1995 *Paperwork Reduction Act*, the 1996 *Clinger-Cohen Act*, the 2002 *e-Government Act*, the 2013 *Federal Enterprise Architecture Model*, FITARA, FISMA, and other information technology and cyber initiatives within the Federal Government.

### 3.6.2.2 Threat Identification and Prioritization

The national and economic security of the United States depends on the reliable functioning of critical infrastructure. To strengthen the resilience of this infrastructure, President Obama issued Executive Order 13636, "Improving Critical Infrastructure Cybersecurity," on February 12, 2013. The Executive Order directed the National Institute of Standards and Technology to work with stakeholders to develop a voluntary framework. Version 1.0 of the Framework for Improving Critical Infrastructure Cybersecurity was published in February of 2014. In addition to being aligned with the National Institute of Standards and Technology framework, FISMA requires agencies to develop and implement an organization-wide information security program to address the identification and prioritization of threats as they apply to an agency's information security. NNSA's Cyber Security Program meets the FISMA threat-based requirements with a range of mechanisms designed to match the cyber program investment to the observed, perceived, and anticipated threats to NNSA. These mechanisms include site assessment visits, nuclear security enterprise and site-specific risk management boards, security controls assessment, and the cyber security threat statement. *The NNSA Threat and Risk Statement* identifies risks facing NNSA, focuses efforts on those with the highest residual risk, and provides resource guidance to prioritize resources to protect the most valuable information and systems. Current prioritized programming decisions are documented in the upcoming annual budget request and embedded in the annually issued NNSA Cyber Program Execution Guidance.

Combined, NNSA's threat identification and prioritization mechanisms provide a robust and evolving framework that leverages the joint knowledge and capabilities of the entire cyber security workforce.

#### 3.6.2.3 Technologies

**Table 3–3** provides a summary listing of deployed cyber security technologies. The security tools that are currently deployed throughout the NNSA nuclear security enterprise are then briefly described.

**Table 3–3. NNSA cyber security technologies**

| *Cyber Security Technology* | *Security Focus* | *Site(s)* |
|---|---|---|
| Intrusion Detection System | Inspects all inbound and outbound network activity and identifies suspicious patterns. | All Sites |
| Vulnerability Scanning | Identifies vulnerabilities that can be exploited or threaten computing systems in a network. | All Sites |
| Firewalls | Prevents unauthorized access to or from a private network. | All Sites |
| Antivirus Program | Searches a hard disk or other media for known viruses and removes them. | All Sites |
| Encryption | Protects sensitive information during storage and transmission and reduces the risk of intentional and accidental compromise or alteration of data. | All Sites |
| Data Loss Prevention | Protects the confidentiality and integrity of mission essential data on classified networks. | All Sites [a] |
| Data at Rest | Prevents unauthorized access to sensitive data on portable devices carried outside of site installations using encryption. | All Sites |
| Network Monitoring | Discerns the security posture of the environment at that given instant, collects the various alerts, assigns a standardized criticality level, logs all of the information to a centralized database, and concurrently displays network traffic in a summarized view. | All Sites |
| Enterprise Forensics | Provides real-time, remote or client-side inspections at the binary level of all data on a given system. | Information Assurance Response Center, SNL, LLNL, LANL [b] |
| Automated Security Control Assessment | Provides guidance and outreach to promote a higher level of understanding and acceptance of requirements and assists senior NNSA management in program implementation. | All Sites |

[a] SNL has implemented digital rights management software which will be implemented at all sites in upcoming years based on maturity of the product.

[b] All sites have some version of forensics and the Information Assurance Response Center provides this service for all locations. The locations identified in the table have additional capabilities that are leveraged for the enterprise as a whole.

**Intrusion Detection Systems (IDS).** NNSA's host-based IDS and network-based IDS enhance data protection through sustained availability and reliable integrity in both classified and unclassified environments. All inbound and outbound network activity is inspected and screened, and alerts are based on predefined rules of suspicious patterns that may indicate an attempt to break in or compromise a system. When triggered, the network-based IDS begin capturing network traffic related to the event in question, and data are made available to security analysts. A notification is also sent to the Security Information and Event Management tool, and the next phase of defense-in-depth protection begins.

A new high-bandwidth solution complements IDS to provide intelligent traffic visibility networking that improves the ability to see into the network infrastructure from both the nuclear security enterprise and local site perspective. The ability to share the same data stream across multiple monitoring tools allows NNSA to be more agile, secure, and cost-effective. The network infrastructure upgrade implementation provides flexibility to test new tools by sharing data from a single point, integrate new technology as it is developed, and improve network monitoring.

**Vulnerability Scanning.** Vulnerability scanning across the nuclear security enterprise employs software that seeks out security flaws based on a database of known flaws, tests systems for the occurrence of these flaws, and generates a report of the findings that can be used to tighten the network's security.

**Firewalls.** Firewalls prevent unauthorized access to or from private networks connected to the Internet. Firewalls can be implemented in both hardware and software or a combination thereof.

**Antivirus Program.** This commercial software searches a hard disk or other media for known viruses and removes any that are found. Most antivirus programs include an auto-update feature that allows the program to download profiles of new viruses as soon as they are discovered.

**Encryption.** Encryption and protocols work as technical controls to protect information as it passes throughout a network and resides on computers. These methods protect sensitive information during storage and transmission and provide important functionality to reduce the risk of intentional and accidental data compromise and alteration.

**Data Loss Prevention.** Digital rights management software and encryption may complement both classified and unclassified network data loss prevention solutions. The software prevents data from being copied from unauthorized access points and offers technical controls to mitigate data spillage. NNSA's implementation of the technology has progressed to functional requirements refinement, tool investigation, and initial implementation.

**Data at Rest.** This technology prevents unauthorized access to sensitive data through both technical and procedural security controls. Data at Rest implements passwords to inhibit a hard drive from spinning while the drive contents are encrypted. If a machine is stolen, these safeguards prevent data from being mined from the device. NNSA portable devices employ Data at Rest technologies to provide data confidentiality for equipment carried outside of site installations, with continuous monitoring mechanisms that can be implemented to prevent theft.

**Network Monitoring and Security Information and Event Management.** This technology facilitates gathering, analyzing, and presenting information from network and security devices and identifying and accessing management applications. Security Information and Event Management provides vulnerability management and policy compliance tools; operating system, database, and application logs; and external threat data. A key focus of Security Information and Event Management is monitoring and managing user and service privileges, directory services, and other system configuration changes and providing log auditing and review of incident responses.

**Enterprise Forensics.** Enterprise forensics is the ability to perform real-time, remote inspections at the binary level of all data on a given system. The inspections include operating memory, physical storage devices, and virtualized mechanisms in use on any machine at a given time. All authentications for this system are centrally controlled and maintained in accordance with existing Federal policy.

**Automated Security Control Assessment.** The NNSA Cyber Security Program will continue to provide agency-wide cyber security guidance and outreach to promote a higher level of understanding and acceptance of requirements and assist senior NNSA management in program implementation. This guidance and outreach provides a comprehensive set of cyber security performance metrics across the agency that enables program offices and contractor-run facilities to improve their FISMA reporting, increase oversight and monitoring of FISMA compliance requirements within NNSA, standardize cyber security performance requirements that incorporate Government requirements and industry best practices, and institute an improved review cycle to ensure continual update to plans of action and milestones.

## 3.7 Secure Transportation

The Secure Transportation Asset (STA) Program provides safe, secure transport of the Nation's nuclear weapons, weapons components, and SNM. The STA Program supports LEPs, LLC exchanges, surveillance, dismantlement, nonproliferation initiatives, and experimental programs for the NNSA mission. The STA Program also provides secure transport for DOD and other Government agencies on a reimbursable basis. The program modernizes mission assets and infrastructure, strengthens mission support systems, and improves its workforce capability and performance. The pillars of the STA security concept are specialized vehicles, secure trailers, highly trained Federal agents, and robust communication systems.

### 3.7.1 Current State

The STA Program operates a number of specialized vehicles and aircraft for the safe and secure transportation of cargo using highly trained Federal agents. DOE/NNSA continues to recruit and retain Federal agents to meet security postures and workload requirements.

STA is stabilizing and balancing vehicle production to replace aging vehicles to meet convoy security configurations. The Escort Vehicle Light Chassis production is nearing completion, and the Replacement Armored Tractors will be completed in FY 2018.

The STA Program completed an Analysis of Alternatives for the replacement of the Safeguards Transporter (SGT) and started SGT risk-reduction initiatives to extend the life of the SGT. The Mobile Guardian Transporter (MGT) will be the next-generation specialized trailer. The STA Program has completed the SGT replacement look-ahead studies, estimates, and concept-development tasks associated with the MGT. The MGT will use a modern transportation industry design approach and provide a sustainable platform for long-term viability.

STA has retrofitted four of five Federal agent units' mission support vehicles with the Advanced Radio Enterprise System (ARES), and the new Support Vehicle 2 will also include ARES.

When the ARES implementation is complete, the Federal agents will have an overarching command and control communication capability during normal and emergency situations.

Strategic upgrades will be made to the trailer communication system. These upgrades will ensure a reliable communication architecture is in place during convoy operations. The upgrade will apply to the existing SGT fleet and to the MGT.

The Transportation Command and Control System will be enhanced with the implementation of the Mission Management System's common operating system. NNSA plans to streamline and consolidate ARES and the Transportation and Emergency Control Center systems.

### 3.7.2 Challenges and Strategies

**Facilities**. The STA Program manages facilities and infrastructure to maintain long-term viability to support mission requirements identified in the Ten-Year Site Plan. Funds are allocated for minor construction projects, life-cycle replacements, repairs, and reduction of the DM backlog to ensure resources are managed in a cost-effective manner.

Industry best practices are implemented to maintain facilities in a safe and operable condition and to meet all security requirements. The STA's Facility Board prioritizes and matches mission needs to existing funding. The STA Program established a new Alternate Operations Facility as a backup location for mission support communications.

**Human Capital Base**. The people of the STA Program constitute an invaluable resource. Federal agents must be capable of responding to unpredictable situations across the full spectrum of threat scenarios. The STA Program is focused on recruiting, stabilizing, and retaining the Federal agent workforce. The objective is 370 Federal agents, and the STA Program's strategic initiative is to recruit and hire Federal agents to restore strength levels to support the required security postures and workload requirements and to keep pace with normal attrition and retirements.

Additional detailed information about the STA Program's accomplishments, objectives, and changes from the *FY 2016 SSMP* may be found in Chapter 4, Section 4.5 (Secure Transportation Budget).

# Chapter 4
# Budget and Changes to Programs

Chapter 4 provides an overview of the key programmatic elements in the Weapons Activities budget for the FY 2017 FYNSP and includes figures that display budgetary information for specific activities associated with these key elements, based on current plans and the best available data. The current program and schedules are the current program of record as approved by the joint DOD and DOE Nuclear Weapons Council and the two Department Secretaries. It is important to recognize that, for the FYNSP years beyond the budget year, maturation in planning may necessitate adjustment of funding levels in these years. These adjustments will be accomplished as part of future budget processes.

Each programmatic section also includes a summary of the major FY 2015 accomplishments, updates to the strategic plans and long-term budget trends since the *FY 2016 SSMP*, and a milestones and objectives chart that projects future plans. Section 4.8 describes resource requirements for the 20 years beyond the FYNSP and includes detailed information about the estimated costs for LEPs, major Alts, and major construction projects.

## 4.1 Future Years Nuclear Security Program Budget

**Table 4–1** shows the FYNSP budget for Weapons Activities. The budget structure reflects changes from the FY 2016 structure used in the *FY 2016 SSMP* to align with the way in which Congress appropriated monies for FY 2016. The new Infrastructure and Operations line consolidates almost all of what had been in the Readiness in Technical Base and Facilities (RTBF) Program and the new (in FY 2015) Infrastructure and Safety line in the *FY 2016 SSMP*, except for a few materials-related activities that have been moved to a renamed Strategic Materials line (formerly named Nuclear Material Commodities) in DSW. Additional changes to the budget structure below the level of detail in Table 4–1 are described in the pertinent sections below.

**Figure 4–1** shows how the level of funding in the FY 2017 President's budget request over the FYNSP compares with the Weapons Activities purchasing power in prior years (in 2010 dollars, a nadir year for Weapons Activities). The figure also displays how the composition of this funding has varied over time. Program funding totals have been adjusted to better reflect an "apples-to-apples" comparison of year-to-year funding or funding among programs. One adjustment has removed the Nuclear Counterterrorism Incident Response funding because, as of the FY 2016 budget, this program was moved from Weapons Activities to the Defense Nuclear Nonproliferation account. In addition, all programmatic construction has been moved to Infrastructure – Construction. In the early years of Weapons Activities, programmatic construction was funded by the sponsoring programs.

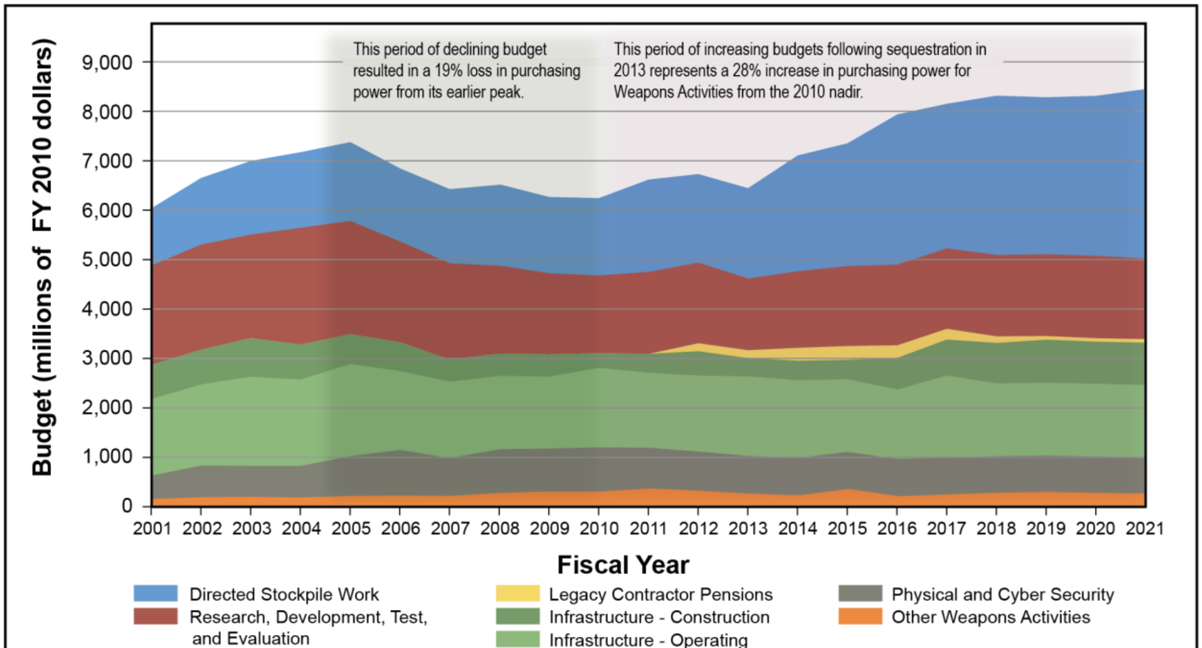
The most significant change over the period displayed in Figure 4–1 is the increase in funding for DSW, which, by FY 2021, is expected to triple compared with its FY 2001 value. Some amount of this increase is more apparent than real because of a number of changes to the budget structure over the intervening years. For example, pit production activities, originally funded as a campaign, were moved into DSW as Plutonium Sustainment in FY 2008. In addition, as described in the *FY 2016 SSMP*, Tritium Sustainment Program funding, some Uranium Sustainment funding, and Domestic Uranium Enrichment funding were added to DSW in the FY 2016 FYNSP. However, a significant amount of this increase can be explained by the increased funding for multiple LEPs and the DSW efforts that support those LEPs.

Pie charts for the FY 2017 budget and tables of the FY 2017 FYNSP breakdown, with comparisons to the FY 2016 reference year, are in the following sections.

**Table 4–1. Overview of Future Years Nuclear Security Program budget for Weapons Activities in fiscal years 2016 through 2021[a]**

| Activity | Fiscal Year (dollars in millions) | | | | | |
|---|---|---|---|---|---|---|
| | 2016 Enacted | 2017 Request | 2018 Request | 2019 Request | 2020 Request | 2021 Request |
| Directed Stockpile Work | 3,387.8 | 3,330.5 | 3,752.0 | 3,781.9 | 3,938.6 | 4,268.2 |
| Science Program | 423.1 | 442.0 | 489.7 | 514.7 | 526.5 | 506.1 |
| Engineering Program | 131.4 | 139.5 | 143.8 | 146.0 | 146.6 | 147.4 |
| Inertial Confinement Fusion Ignition and High Yield Program | 511.1 | 523.0 | 544.9 | 556.9 | 569.6 | 568.8 |
| Advanced Simulation and Computing Program | 623.0 | 663.2 | 668.2 | 685.5 | 707.7 | 720.3 |
| Advanced Manufacturing Development | 130.1 | 87.1 | 69.8 | 66.5 | 77.7 | 87.9 |
| Secure Transportation Asset | 237.1 | 282.7 | 330.1 | 355.1 | 341.0 | 331.8 |
| Infrastructure and Operations | 2,279.1 | 2,722.0 | 2,645.9 | 2,792.9 | 2,829.1 | 2,885.8 |
| Defense Nuclear Security | 682.9 | 670.1 | 681.0 | 692.1 | 704.9 | 721.9 |
| Information Technology and Cyber Security | 157.6 | 176.6 | 178.7 | 184.3 | 188.7 | 192.5 |
| Legacy Contractor Pensions | 283.9 | 248.5 | 157.1 | 87.4 | 87.4 | 87.4 |
| Adjustments [b] | 0.0 | (42.0) | 0.0 | 0.0 | 0.0 | 0.0 |
| ***Weapons Activities Total*** | ***8,846.9*** | ***9,243.1*** | ***9,661.3*** | ***9,863.3*** | ***10,117.9*** | ***10,518.2*** |

[a] Totals may not add because of rounding.
[b] Adjustments include rescissions and use of prior-year balances.




Note: Nuclear Counterterrorism Incident Response and Counterterrorism/Counterproliferation funding has been backed out of the Other Weapons Activities totals for the FY 2001-2015 period to make those years comparable to the FY 2016 FYNSP funding levels, which no longer include these programs as part of Weapons Activities.
For the purpose of this figure only, Secure Transportation Asset is part of Other Weapons Activities.

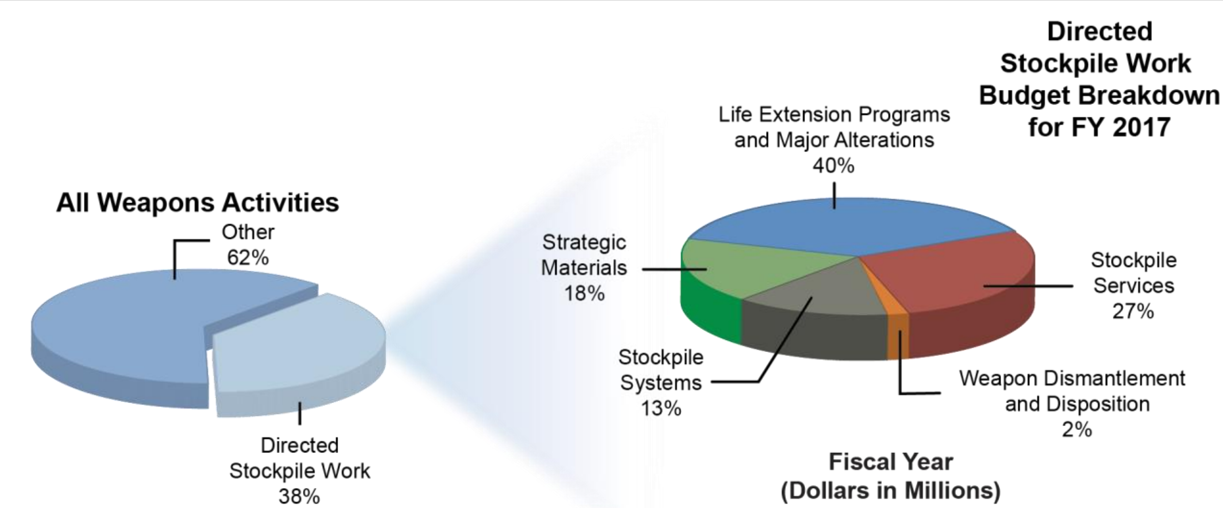
**Figure 4–1. Weapons Activities historical purchasing power – fiscal years 2001 through 2021**

# 4.2 Directed Stockpile Work Budget

## 4.2.1 Budget

As noted in Section 4.1, Nuclear Material Commodities has been renamed Strategic Materials. This category includes (in addition to Uranium Sustainment, Plutonium Sustainment, Tritium Sustainment, and Domestic Uranium Enrichment) Strategic Materials Sustainment, which funds recycling, recovery, and storage of strategic materials (previously funded by Material Recycle and Recovery, and Storage, respectively, in RTBF) along with support for materials other than those mentioned above, such as lithium. The Strategic Materials line also includes the Nuclear Materials Integration funding that was previously part of Site Stewardship. These changes are consistent with the way Congress appropriated funds for FY 2016.

The Stockpile Systems and Stockpile Services lines in **Figure 4–2** include the Surveillance Program funding shown in **Table 4–2** below with prior years shown for historical comparison.




**Fiscal Year (Dollars in Millions)**

| | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|---|---|
| Life Extension Programs and Major Alterations | 1,302.5 | 1,340.3 | 1,606.1 | 1,555.4 | 1,638.5 | 1,919.3 |
| Stockpile Systems | 482.4 | 443.7 | 497.8 | 503.1 | 496.3 | 492.1 |
| Weapon Dismantlement and Disposition | 52.0 | 69.0 | 71.6 | 73.4 | 73.8 | 75.4 |
| Stockpile Services | 938.6 | 899.7 | 979.3 | 1,063.8 | 1,066.0 | 1,101.1 |
| Strategic Materials | 612.3 | 577.8 | 597.3 | 586.2 | 664.0 | 680.4 |
| Total Directed Stockpile Work | 3,387.8 | 3,330.5 | 3,752.0 | 3,781.9 | 3,938.6 | 4,268.2 |

Note: Numbers may not add due to rounding

**Figure 4–2. Directed Stockpile Work funding schedule for fiscal years 2016 through 2021**

**Table 4–2. Surveillance Program funding for fiscal years 2010 through 2021**

| | *Fiscal Year (dollars in millions)* | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *2010* | *2011* | *2012* | *2013* | *2014* | *2015* | *2016* | *2017* | *2018* | *2019* | *2020* | *2021* |
| Surveillance Program Funding | 181 | 239 | 239 | 217 | 225 | 236 | 217 | 213 | 231 | 241 | 251 | 239 |

### 4.2.2 FY 2015 Accomplishments

#### 4.2.2.1 FY 2015 Directed Stockpile Work Accomplishments

Major DSW accomplishments since the *FY 2016 SSMP*, in addition to the Annual Assessment Reports, generation of the Laboratory Director Letters to the President, and scheduled replacements of LLCs, include the following:

**W76-1 LEP, W88 Alt 370, B61-12 LEP, and W80-4 LEP**

- See Section 2.2 for LEP and Alt accomplishments.

**Stockpile Systems**

- Conducted surveillance activities for all weapon systems using data collection from flight tests, laboratory tests, and component evaluations to assess stockpile reliability without nuclear explosive tests.
- Completed the first production unit of the new B61 Joint Test Assembly configuration.
- Completed close-out activities for the B83 Alt 353 gas transfer system and initiated the life storage program.
- Completed closeout activities for Joint Test Assembly Sustainment of the B83.
- Met DOD requirements for the W87 Small Ferroelectric Neutron Generator retrofits.
- Executed the first extended-range flight tests for the W78 and W87 instrumented Joint Test Assemblies.

**Weapons Dismantlement and Disposition**

- Continued to make progress toward NNSA's goal of dismantling weapons retired prior to FY 2009 by the end of FY 2022. Developed plans to accelerate weapon dismantlement so this goal could be accomplished one year sooner.
- Exceeded planned canned subassembly dismantlement at Y-12.
- Supported the Navy request to return W76-0 warheads early, avoiding several million dollars in future staging costs.

**Stockpile Services**

- Developed a more accurate method to ensure nuclear explosives are initiated uniformly.
- Performed analyses, with DOD, for key surety decisions, and added new capabilities to accommodate cyber and insider threats.
- Exceeded goal for High Resolution Computed Tomography surveillance by 10 percent.
- Demonstrated a GTS design that meets DOD requirements and initiated pre-production activities ahead of schedule.
- Conducted a hydrodynamic test at LANL's DARHT for W88 legacy and Alt 370 qualification effort.
- Archived past weapons data and converted sunset technology files to state-of-the-art data storage and security systems.
- Conducted seven Joint Actinide Shock Physics Experimental Research plutonium shots, five Phoenix experiments, and one weapon system hydrodynamic experiment.

- Supported development of a new HE for flight test diagnostics and qualification activities.
- Continued technology maturation of the integrated system architecture multi-application transportation device for all air-delivered weapons to support a Full-Scale Engineering Development start in FY 2018.

#### 4.2.2.2 FY 2015 Strategic Materials Accomplishments

Major Accomplishments in strategic materials since the *FY 2016 SSMP* include the following:

**Tritium**

- Completed Cycle 13 irradiation with 704 TPBARs.
- Submitted license amendment request for the Tennessee Valley Authority on March 31 to the Nuclear Regulatory Commission to increase production above 704 TPBARs to 1,792 maximum.

**Plutonium**

- Completed assembly and test of live power supply unit.
- Initiated Phase II equipment installation in the Radiological Laboratory Utility Office Building and decontamination and decommissioning and equipment installation in PF-4.
- NNSA authorized restart of several PF-4 readiness activities, including the T-Base II lathe, machining operations, and the Isotope Facility Impact Tester in FY 2015.

**Lithium**

- Finalized a revised lithium bridging strategy that, *via* a new nuclear weapon dismantlement plan, will provide a future supply of lithium materials for the stockpile beyond 2028.
- Obtained approval for the new dismantlement plan with issuance of the Production and Planning Directive 2016-0.

**Domestic Uranium Enrichment**

- Identified available uranium inventory to extend the need date for unobligated fuel for tritium production by about 10 years. This saves $1.3 billion through FY 2021 by deferring the need to reestablish a domestic uranium enrichment capability.

**Uranium**

- Published, for the first time, a Uranium Mission Strategy and Uranium Mission Requirements document that outline NNSA's long-term strategy to sustain and modernize uranium capabilities.
- Shipped 12.3 metric tons of enriched uranium metal from Area 5 to the Highly Enriched Uranium Materials Facility at Y-12 for secure storage, exceeding the FY 2015 goal by 50 percent.
- Achieved critical decision to install a rotary calciner in Building 9212 and an electro-refiner in Building 9215. The calciner provides the capability to convert low-equity solutions into a safe, storable oxide and the electro-refiner provides the capability to purify enriched uranium metal.
- Completed Site Readiness for the Uranium Processing Facility at Y-12 on schedule and $20 million under budget.

## 4.2.3 Changes from the *FY 2016 SSMP*

### 4.2.3.1 LEPs and Major Alterations

Funding for the W88 Alt 370 increased in the FYNSP based on an updated estimate to add some additional scope needed for the conventional high explosive refresh. However, NNSA is still in the process of completing a Baseline Cost Report for the entire W88 Alt 370 (with conventional high explosive refresh included) by September 2016.

### 4.2.3.2 Stockpile Systems

No substantive changes from the *FY 2016 SSMP*.

### 4.2.3.3 Weapons Dismantlement and Disposition

The increase in funds over the FYNSP is related to the strategy to mitigate requirements for selected LEP materials, the W84 project scope, and continued effort and progress toward meeting the President's intent to accelerate dismantlement of retired U.S. nuclear warheads by 20 percent. The latter goal was made official policy during the U.S. announcement at the Review Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons on April 27, 2015.

### 4.2.3.4 Stockpile Services

**Production Support**

- While generally at the same level of funding as in the *FY 2016 SSMP*, this subprogram now includes activities, formerly in RTBF, to maintain workforce critical skills at enterprise sites.

**Research and Development**

- The funding decrease over the FYNSP reflects a narrowing of technology development efforts to allow for increased investment in critical infrastructure.

**R&D Certification and Safety**

- The funding decrease over the FYNSP reflects a reprioritization within NNSA to support infrastructure investments. This includes a reduction in early technology development and advanced engineering efforts required to support the stockpile and future LEPs.

**Management Technology and Production**

- The funding decrease over the FYNSP reflects reductions in multi-system activities that support assembly and disassembly operations, assessment and studies, and multi-weapon management support.

### 4.2.3.5 Strategic Materials

**Uranium Sustainment**

- The decrease in funding over the FYNSP represents a reduction in support for acceleration of activities to replace uranium capabilities supported by Process Technology Development within Advanced Manufacturing.

**Plutonium Sustainment**

No substantive change from the *FY 2016 SSMP*.

**Tritium Sustainment**

No substantive change from the *FY 2016 SSMP*.

**Domestic Uranium Enrichment**

In FY 2015, the Domestic Uranium Enrichment program worked across DOE to conduct several congressionally directed analyses that contributed to development of DOE's Tritium and Enriched Uranium Management Plan through 2060. As a result of those analyses, the Domestic Uranium Enrichment program developed a three-pronged strategy that will be implemented beginning in FY 2016 and includes using existing uranium inventory to extend the need date for LEU for tritium production until 2038 to 2041, preserving and advancing centrifuge technology in the near term, and developing an acquisition strategy to re-establish a domestic uranium enrichment capability to meet national security requirements at some point in the future.

**Strategic Materials Sustainment**

The re-establishment of a purified depleted uranium supply has been deferred until evaluation of existing supplies and future demand is completed. Support to lithium direct material manufacturing associated with other DSW activities has been increased, as has funding for inactive actinide processing at Y-12, recovery of spent californium sources, and processing of sodium-bonded fuel experiment assemblies.

## 4.2.4 Milestones and Objectives

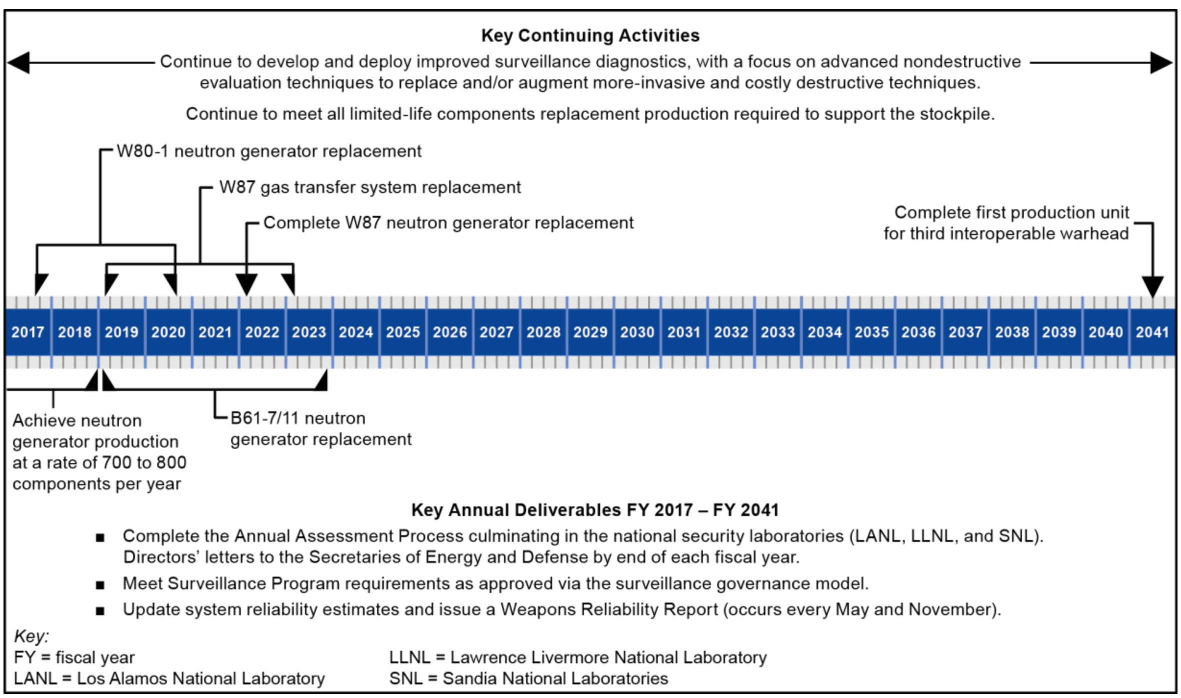



**Figure 4–3. Goals, milestones, and key annual activities for weapon assessment, surveillance, and maintenance**

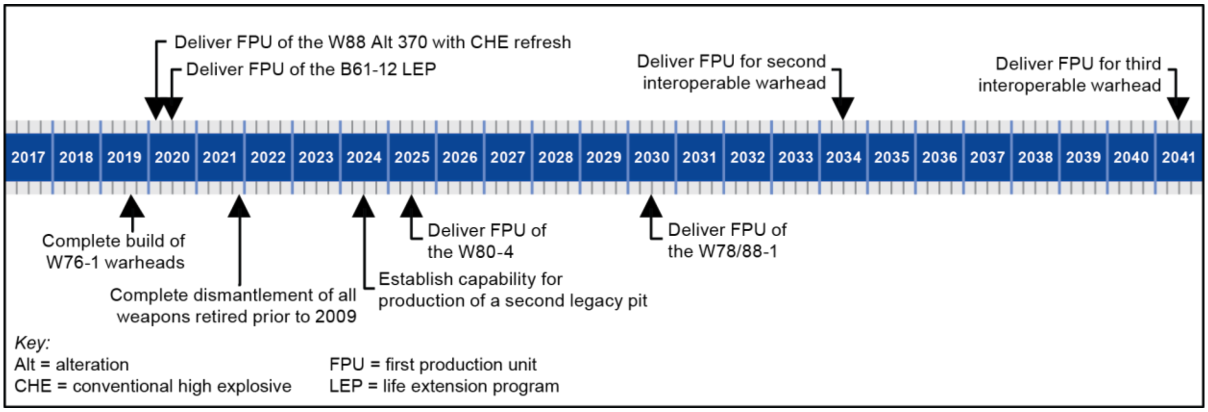


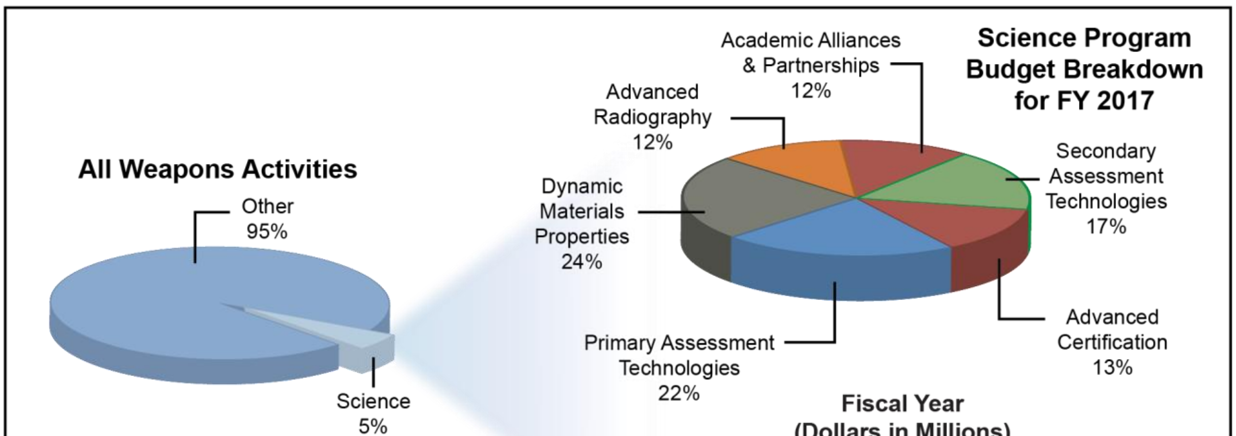

**Figure 4–4. Milestones for life extension programs, major weapons component production, and weapons alteration and dismantlement**

# 4.3 Research, Development, Test, and Evaluation Budget

## 4.3.1 Science Program

### 4.3.1.1 Budget

The Science Program now includes a funding line for Academic Alliances and Partnerships to consolidate funding that was originally found in the other subprograms that make up this program. That funding line also includes the Minority Serving Institution Partnership Program funding that was previously in Site Stewardship.




Fiscal Year (Dollars in Millions)

| | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|---|---|
| Advanced Certification | 58.7 | 58.0 | 59.0 | 60.2 | 61.4 | 62.7 |
| Primary Assessment Technologies | 95.5 | 99.0 | 100.8 | 102.8 | 104.9 | 107.0 |
| Dynamic Materials Properties | 100.4 | 106.0 | 122.3 | 141.0 | 146.2 | 139.8 |
| Advanced Radiography | 45.7 | 50.5 | 77.2 | 77.8 | 78.5 | 58.5 |
| Secondary Assessment Technologies | 72.9 | 76.0 | 77.4 | 78.9 | 80.5 | 82.1 |
| Academic Alliances & Partnerships | 49.8 | 52.5 | 53.0 | 54.0 | 55.0 | 56.1 |
| Total Science | 423.1 | 442.0 | 489.7 | 514.7 | 526.5 | 506.1 |

Note: Numbers may not add due to rounding

**Figure 4–5. Science Program funding schedule for fiscal years 2016 through 2021**

#### 4.3.1.2 FY 2015 Accomplishments

Major accomplishments in the Science Program since the *FY 2016 SSMP* include the following:

**Advanced Certification**

- Executed experiments to complete analysis of the use of advanced materials and manufactured components for potential stockpile applications.
- Assessed uncertainty of a critical performance characteristic for two systems, using a common method for modeling an underground nuclear explosive test and a proposed modern uncertainty quantification methodology.

**Primary Assessment Technologies**

- Developed new concepts for subcritical experiments, including neutron diagnosed subcritical experiments to assess late-time nuclear reactivity.
- Completed HED experiments on the behavior of materials and plasmas in regimes relevant to stockpile primaries to improve the understanding of boost.

**Dynamic Materials Properties**

- Characterized insensitive high explosive to support improved safety and pit reuse options.
- Delivered experimental data on plutonium, uranium, surrogate, and non-nuclear component materials for Annual Assessments and the closure of significant finding investigations.
- Executed experiments for future LEPs to evaluate the dynamic response of components and materials made with advanced manufacturing techniques.

**Advanced Radiography**

- Provided input to CD-1 for a line-item construction project to enhance experimental and diagnostic capabilities to certify a Long-Range Standoff pit and future LEPs.
- Implemented the capability to demonstrate a Dense Plasma Focus prototype to meet neutron diagnosed subcritical experiments source requirements for late-time nuclear reactivity measurements.

**Secondary Assessment Technologies**

- Executed plan for achieving the Secondary LEP Capability Level-1 milestone.
- Advanced the radiation effects science mission for weapons outputs and effects (including impulse and systems-generated electromagnetic pulse) to support Annual Assessments and LEPs.
- Conducted opacity experiments on the Z and NIF and modeled radiochemistry nuclear cross-section networks.

#### 4.3.1.3 Changes from the *FY 2016 SSMP*

No substantive changes from the *FY 2016 SSMP*.

#### 4.3.1.4 Milestones and Objectives

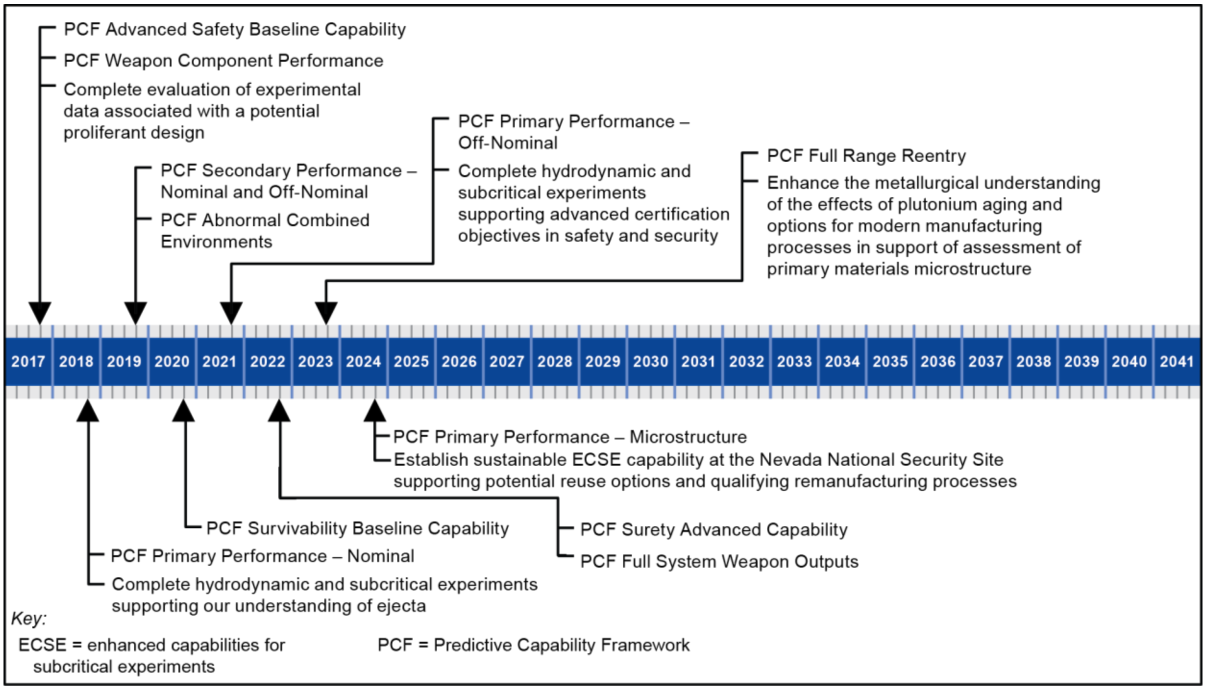
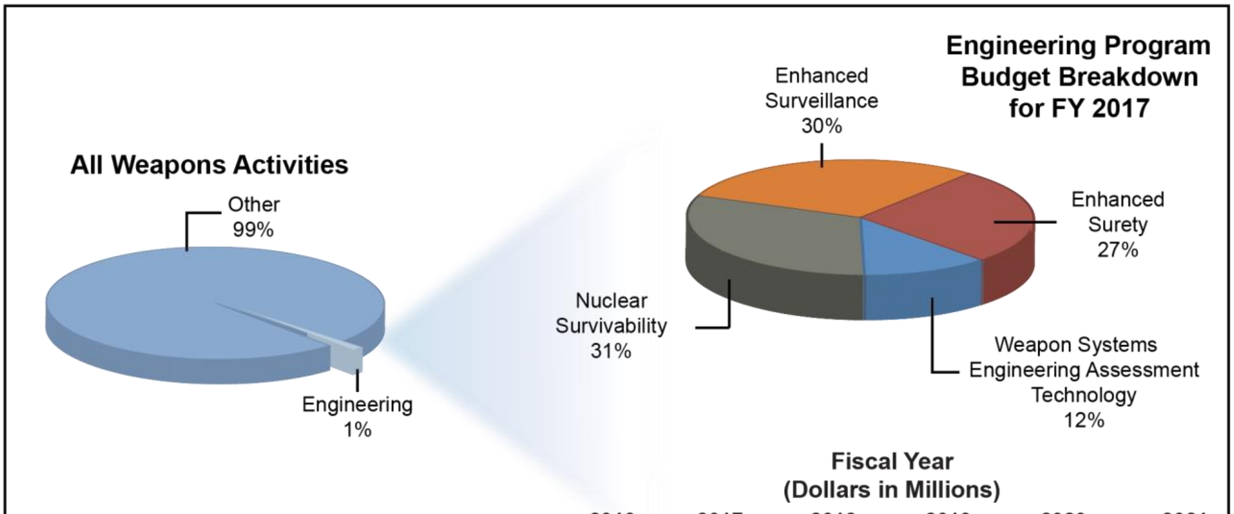



**Figure 4–6. Experimental and analysis milestones and objectives led by the Science Program**

### 4.3.2 Engineering Program

#### 4.3.2.1 Budget




**Fiscal Year (Dollars in Millions)**

| | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|---|---|
| Enhanced Surety | 50.8 | 37.2 | 44.4 | 45.8 | 44.1 | 44.2 |
| Weapon Systems Engineering Assessment Technology | 17.4 | 17.0 | 23.0 | 21.8 | 22.2 | 22.4 |
| Nuclear Survivability | 24.5 | 43.1 | 31.2 | 32.3 | 33.1 | 33.4 |
| Enhanced Surveillance | 38.7 | 42.2 | 45.1 | 46.2 | 47.2 | 47.4 |
| Total Engineering | 131.4 | 139.5 | 143.8 | 146.0 | 146.6 | 147.4 |

Note: Numbers may not add due to rounding

**Figure 4–7. Engineering Program funding schedule for fiscal years 2016 through 2021**

### 4.3.2.2 FY 2015 Accomplishments

**Engineering Accomplishments**

- Performed Concepts Comparison for a W88-0/Mk5 Integrated Surety Architectures solution for two proposed designs, with evaluations focused on several keys areas, including technical effectiveness and suitability, technical and manufacturing readiness, cost, and risk. The Alt 940 design was chosen for implementation with W88-0/Mk5 and could serve as point of departure for future applications.
- Continued advancement in a neutron imaging capability demonstrating the next advanced nondestructive evaluation technique for the W80-4 LEP. The work included neutron imaging studies at LANSCE, along with system design and component purchases.
- Provided necessary experimental data supporting the W88 Alt 370, observing neutron and radiation effects on III-V heterojunction bipolar transistors. Tests included detailed linear accelerator experiments at the Little Mountain Test Facility, shedding light on the response of III-V substrate to ionizing radiation.
- Conducted a record number of hostile environment x-ray experiments at NIF and Z, involving LLNL, LANL, SNL and the Atomic Weapons Establishment, to provide validation data and insights into coupling effects such as high-flux, warm x-ray system generated electromagnetic pulse.
- Completed computational simulations of the F-35 weapons bay that has provided valuable data for the harsh aeroacoustics environment that can impart structural damage to a captive B-61 prior to release. These simulations revealed the effects of geometric complexities subsequently measured in a model weapons bay with flight representative features.

### 4.3.2.3 Changes from the *FY 2016 SSMP*

Shifted the priority emphasis of the program in FY 2016 to the immediate needs of DSW.

### 4.3.2.4 Milestones and Objectives

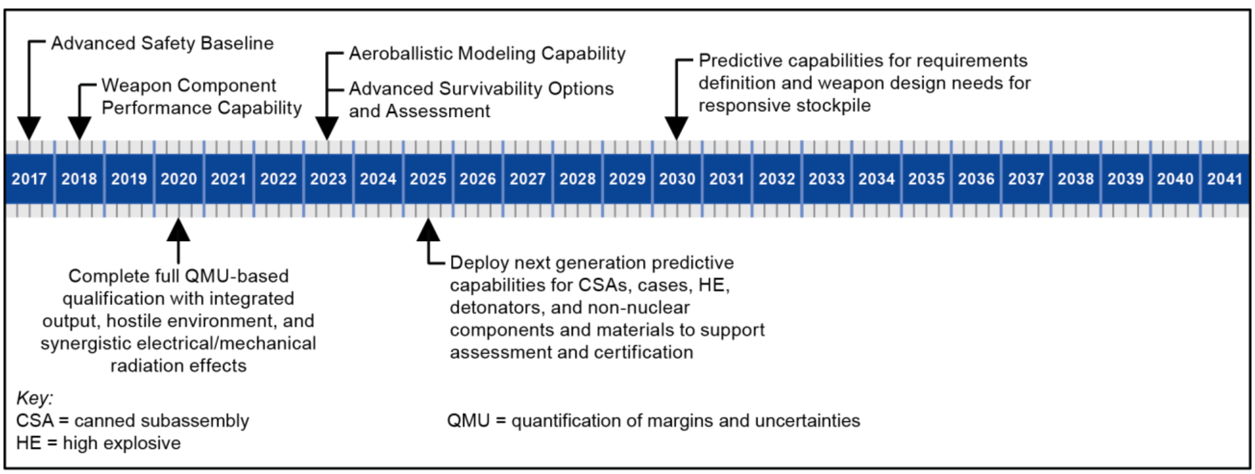
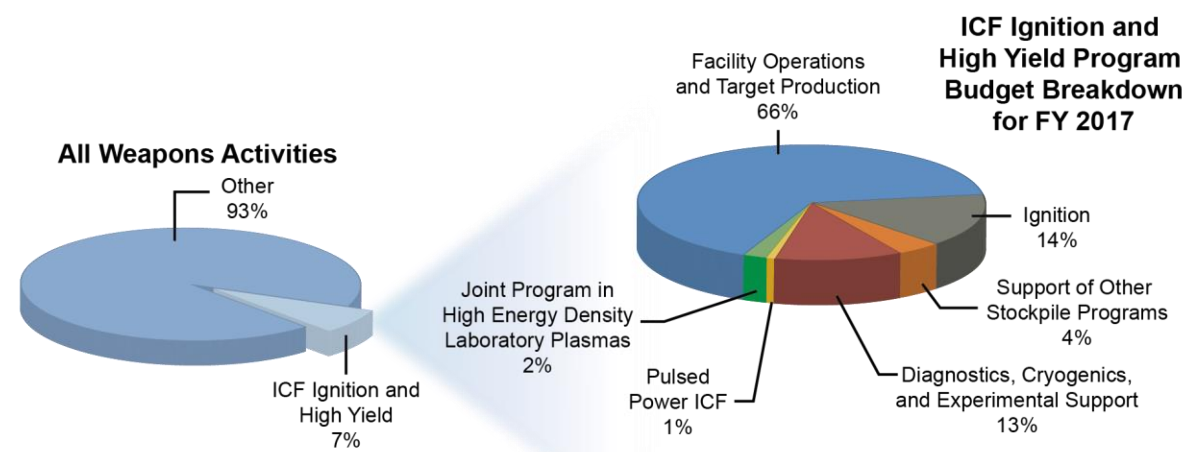



**Figure 4–8. Engineering and technological milestones and objectives led by the Engineering Program**

## 4.3.3 Inertial Confinement Fusion Ignition and High Yield Program

### 4.3.3.1 Budget




| Fiscal Year (Dollars in Millions) | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|---|---|
| Diagnostics, Cryogenics, and Experimental Support | 58.6 | 68.7 | 77.9 | 82.7 | 84.0 | 83.1 |
| Pulsed Power ICF | 5.0 | 5.6 | 7.6 | 8.4 | 9.1 | 9.1 |
| Joint Program in High Energy Density Laboratory Plasmas | 8.9 | 9.5 | 9.5 | 9.5 | 9.5 | 9.5 |
| Facility Operations and Target Production | 339.4 | 340.4 | 346.8 | 349.3 | 352.8 | 352.8 |
| Ignition | 76.3 | 75.4 | 79.6 | 83.4 | 86.4 | 86.4 |
| Support of Other Stockpile Programs | 22.8 | 23.4 | 23.6 | 23.6 | 27.8 | 27.8 |
| Total ICF Ignition and High Yield | 511.1 | 523.0 | 544.9 | 556.9 | 569.6 | 568.8 |

*Key:*
ICF = Inertial Confinement Fusion

Note: Numbers may not add due to rounding

**Figure 4–9. Inertial Confinement Fusion Ignition and High Yield Program funding schedule for fiscal years 2016 through 2021**

### 4.3.3.2 FY 2015 Accomplishments

**Inertial Confinement Fusion Ignition and High Yield Accomplishments**

- Surpassed the goal to conduct 300 data-acquiring shots on NIF; increased the number of such shots by 85 percent compared to FY 2014.
- Achieved groundbreaking pressures at LLNL and SNL for high-Z materials (*e.g.*, plutonium, uranium) and obtained weapons-relevant data that were previously inaccessible.
- Increased hot-spot pressures by 200 percent compared to the FY 2014 record *via* laser-driven direct-drive cryogenic targets at Omega.
- Achieved record neutron yields using the magnetized liner inertial fusion approach at SNL's Z.
- Obtained data relevant to critical nonproliferation mission needs from material science.
- The Omega laser facility has conducted 25,000 target shots, achieving a significant milestone after 45 years of operation.

### 4.3.3.3 Changes from the *FY 2016 SSMP*

**Inertial Confinement Fusion Ignition and High Yield Changes**

No substantive changes from the *FY 2016 SSMP*.

### 4.3.3.4 Milestones and Objectives

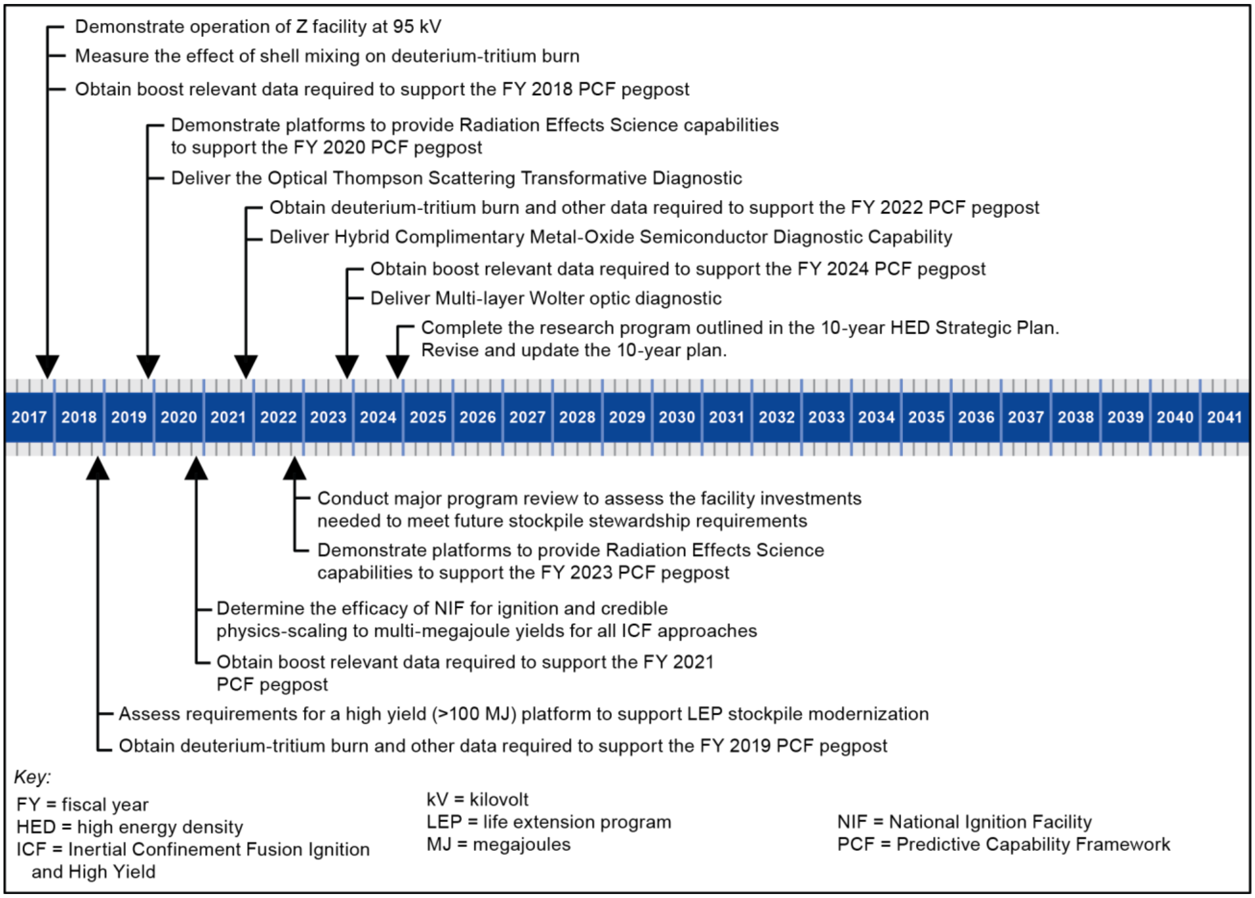
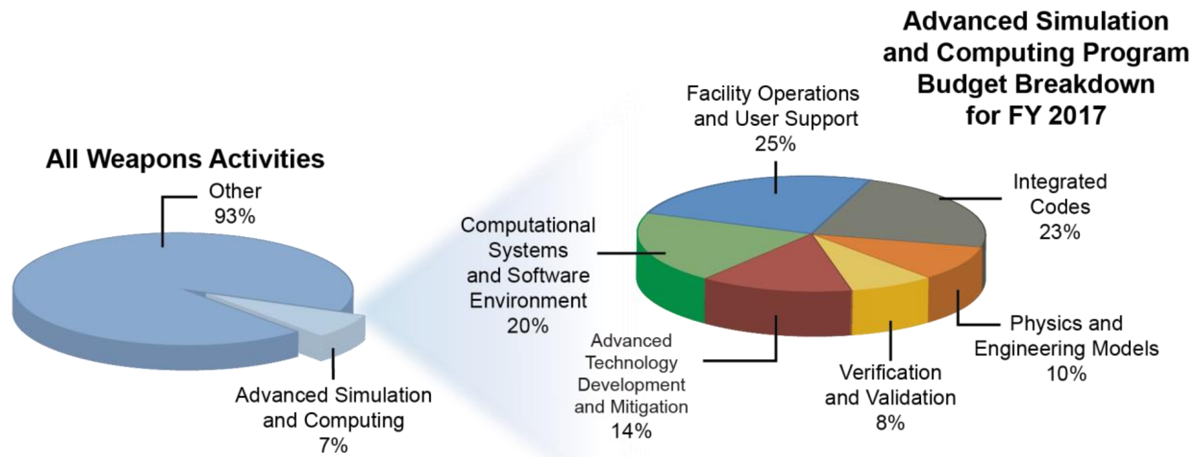



**Figure 4–10. Milestones and objectives based on experiments on NNSA's high energy density facilities led by the Inertial Confinement Fusion Ignition and High Yield Program**

## 4.3.4 Advanced Simulation and Computing Program

### 4.3.4.1 Budget




**Fiscal Year (Dollars in Millions)**

| | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|---|---|
| Integrated Codes | 149.2 | 149.6 | 155.1 | 158.2 | 159.8 | 163.0 |
| Physics and Engineering Models | 67.8 | 67.1 | 69.2 | 72.7 | 74.7 | 77.2 |
| Verification and Validation | 52.9 | 52.0 | 53.9 | 56.6 | 58.1 | 60.1 |
| Computational Systems and Software Environment | 120.8 | 130.6 | 120.0 | 128.0 | 140.0 | 145.0 |
| Facility Operations and User Support | 168.3 | 168.8 | 175.0 | 175.0 | 180.0 | 180.0 |
| Advanced Technology Development and Mitigation | 64.0 | 95.0 | 95.0 | 95.0 | 95.0 | 95.0 |
| Total Advanced Simulation and Computing | 623.0 | 663.2 | 668.2 | 685.5 | 707.7 | 720.3 |

Note: Numbers may not add due to rounding

**Figure 4–11. Advanced Simulation funding schedule for fiscal years 2016 through 2021**

### 4.3.4.2 FY 2015 Accomplishments

**Advanced Simulation and Computing Accomplishments**

- Created W80-4 program pilot development plan and implemented system-scale electrical simulation tools for DSW applications.
- Completed a key deliverable for modeling, validation, and uncertainty quantification of random vibration on reentry, including models for driving component vibration of the Mk5/W88 system.
- Procured and installed Phase I cabinets for the new Trinity supercomputer at LANL.
- Developed a unified creep plasticity damage model to assess the structural response of the B61-12 system in normal and abnormal mechanical environments.
- Determined material strength parameters to improve models for plutonium in DSW simulations.

### 4.3.4.3 Changes from the *FY 2016 SSMP*

No substantive changes from the *FY 2016 SSMP*.

#### 4.3.4.4 Milestones and Objectives

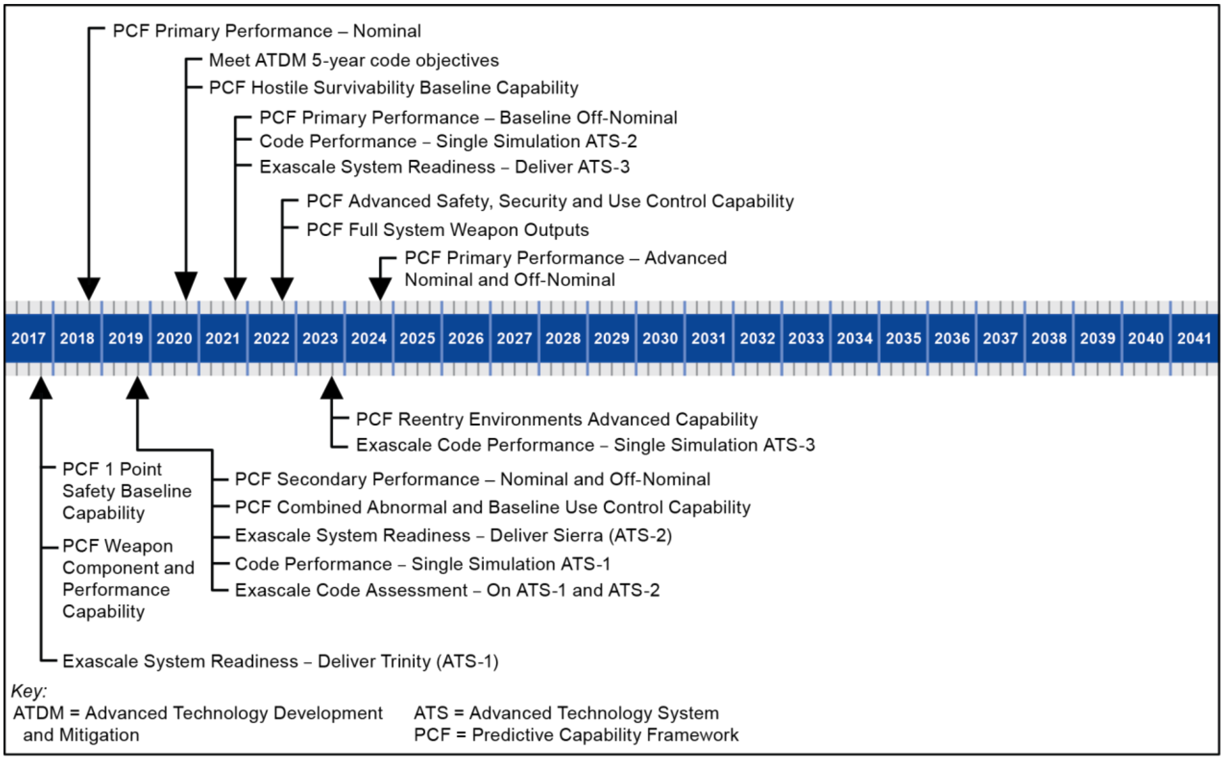



**Figure 4–12. Milestones and objectives of the Advanced Simulation and Computing Program**

### 4.3.5 Advanced Manufacturing Development

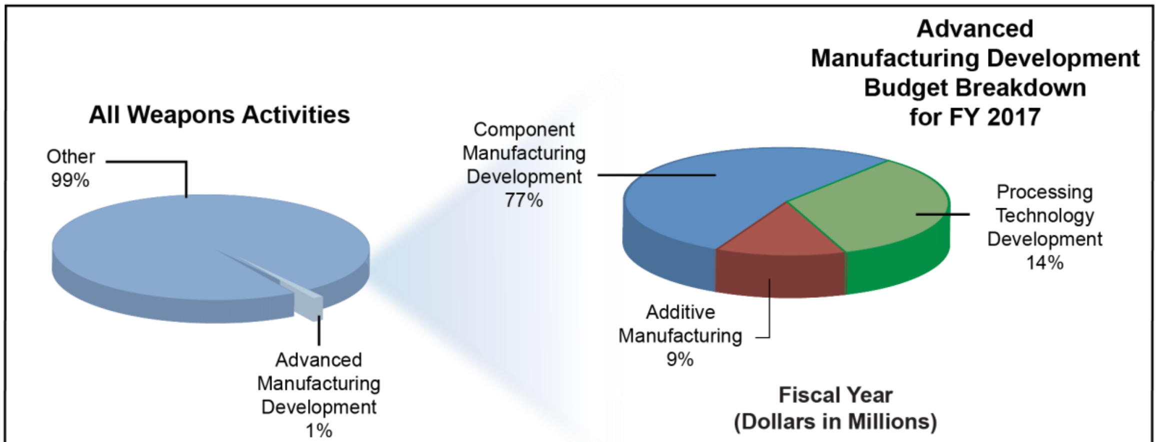
Advanced Manufacturing Development focuses on strategies to develop next-generation production processes and manufacturing tools so that future weapons systems are affordable, agile, and assured. Digital Manufacturing, which combines additive metal and polymer manufacturing with model-based designs and optical inspection, is impacting the NNSA stockpile stewardship and management mission and could effectively shorten the design iterations and increase production agility while minimizing costs and providing fast, efficient, end-to-end manufacturing. In addition, developing production tools through augmented reality eliminates the opportunities for manufacturing defects, improves production throughput and efficiencies, and limits the ergonomic strains of production operators.

The strategic developments anticipated include:

- deploying advances in production technology to allow demonstration of novel design concepts and shorter time to prototype manufacturing builds, thereby reducing costs;
- designing trustworthiness into the basic weapon architecture and enhanced techniques to validate product and supply chain integrity and assurance;
- developing new, faster methods to qualify and certify non-nuclear processes and components; and
- deploying new advanced design architectures and layered surety into systems.

Strategic partnerships with universities and industry consortia ensure the nuclear security enterprise will leverage the results from private industry and academia. These partnerships also expose students and professionals to the challenging work within the nuclear security enterprise and help to develop a pipeline of talent for the future workforce.

### 4.3.5.1 Budget




| Fiscal Year (Dollars in Millions) | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|---|---|
| Additive Manufacturing | 12.6 | 12.0 | 12.0 | 12.0 | 12.0 | 12.0 |
| Component Manufacturing Development | 99.7 | 46.6 | 27.8 | 23.3 | 37.0 | 46.7 |
| Processing Technology Development | 17.8 | 28.5 | 30.1 | 31.2 | 28.7 | 29.2 |
| Total Advanced Manufacturing Development | 130.1 | 87.1 | 69.8 | 66.5 | 77.7 | 87.9 |

Note: Numbers may not add due to rounding

**Figure 4–13. Advanced Manufacturing Development funding schedule for fiscal years 2016 through 2021**

### 4.3.5.2 FY 2015 Accomplishments

- Established partnership agreements with universities to perform additive manufacturing and material characterization research.
- Demonstrated use of additive manufacturing in tools, fixtures, and molds to reduce flow time, decrease costs, and accelerate development times.
- Delivered the first lot of development compression pads for the W88 arming, fuzing, and firing system using Direct Ink Write technology.

### 4.3.5.3 Changes from the *FY 2016 SSMP*

Priorities were realigned from technology development efforts to address higher NNSA priorities.

### 4.3.5.4 Milestones and Objectives

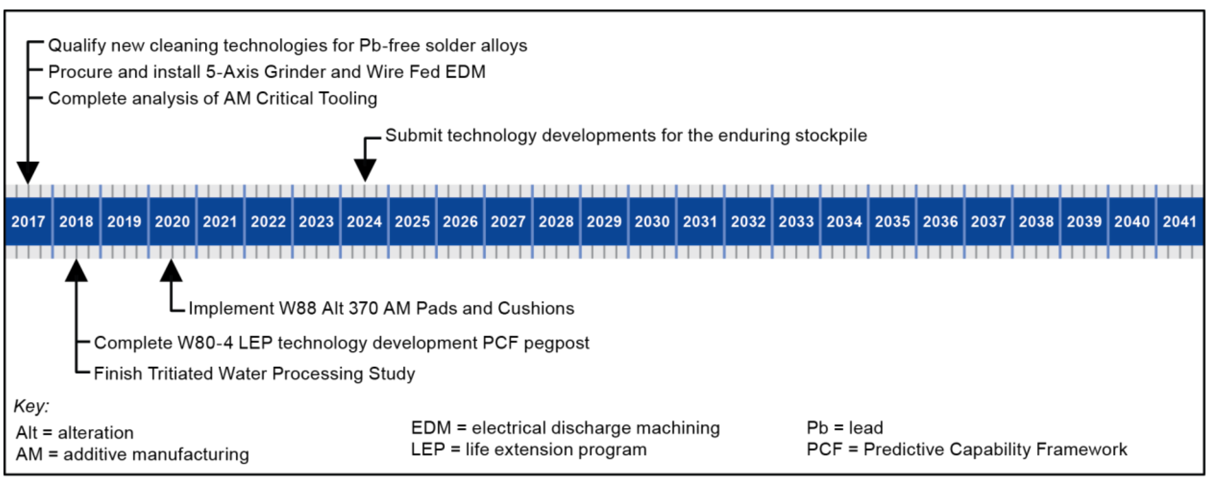



**Figure 4–14. Milestones and objectives for Advanced Manufacturing Development**

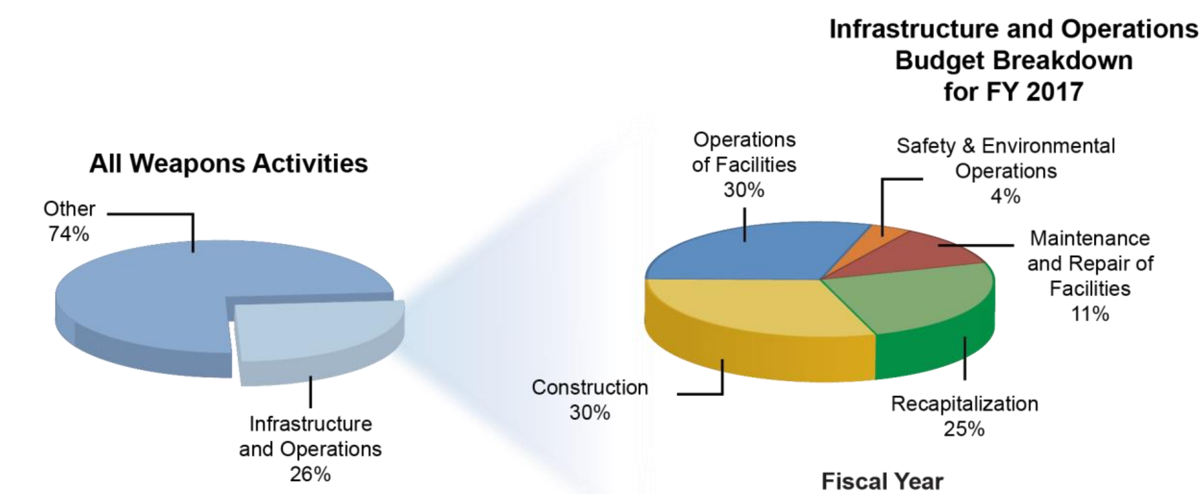
# 4.4 Infrastructure and Operations Budget

NNSA has made significant progress in improving its infrastructure planning and management tools. These efforts include implementing tools to reshape the nuclear security enterprise and improve infrastructure investment planning and implementation for future needs. (The program management tools and processes are summarized in Chapter 3, Section 3.5.3.)

## 4.4.1 Budget

As described in Section 4.1, the Infrastructure and Operations budget consolidates most of what was previously in RTBF and Infrastructure and Safety in last year's SSMP. Infrastructure and Operations retains the Operations of Facilities, Maintenance and Repair of Facilities, Recapitalization, and Construction subprograms that were in Infrastructure and Safety in the *FY 2016 SSMP*. An additional funding line, Safety and Environmental Operations, consolidates activities that were previously in Infrastructure and Safety.

In response to Government Accountability Office recommendations, the following information is provided to improve transparency in the budget. **Table 4–3** below compares investments in Maintenance and Recapitalization to benchmarks (based on the percentage of Replacement Plant Value) derived from the DOE Real Property Asset Management Plan and associated guidance. To address these benchmark shortfalls, NNSA has increased the maintenance and recapitalization funding from the FY 2016 through FY 2020 FYNSP Request by $948 million and expanded the 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). NNSA is also assessing the potential to close down excess and underutilized facilities to reduce the NNSA footprint.




**Fiscal Year (Dollars in Millions)**

| | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|---|---|
| Operations of Facilities | 830.8 | 824.0 | 821.0 | 847.0 | 863.0 | 884.0 |
| Safety & Environmental Operations | 107.7 | 110.0 | 113.0 | 111.0 | 114.0 | 115.0 |
| Maintenance and Repair of Facilities | 277.0 | 294.0 | 305.0 | 327.0 | 315.0 | 328.0 |
| Recapitalization | 352.5 | 667.3 | 454.8 | 472.3 | 503.5 | 494.9 |
| Construction | 711.1 | 826.7 | 952.1 | 1,035.6 | 1,033.6 | 1,063.9 |
| Total Infrastructure and Operations | 2,279.1 | 2,722.0 | 2,645.9 | 2,792.9 | 2,829.1 | 2,885.8 |

Note: Numbers may not add due to rounding

**Figure 4–15. Infrastructure and Operations funding schedule for fiscal years 2016 through 2021**

**Table 4–3. Overview of planned FYNSP infrastructure maintenance and recapitalization**

| Fiscal Year (dollar in millions) and percentages | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | FY 2015 | FY 2016 | FY 2017* | FY 2018 | FY 2019 | FY 2020 | FY 2021 |
| **Replacement Plant Value (RPV)** | | 47,800 | 46,500 | 47,300 | 48,200 | 49,200 | 50,200 | 51,200 |
| Maintenance Benchmark 2-4% RPV | Infrastructure & Operations Maintenance Investments | 227.0 | 277.0 | 294.0 | 305.0 | 327.0 | 315.0 | 328.0 |
| | Other Maintenance Investments (direct- and indirect-funded) | 476.4 | 517.8 | 492.4 | 494.6 | 516.4 | 473.4 | 484.0 |
| | Total Maintenance Investments | 703.4 | 794.8 | 786.4 | 799.6 | 843.4 | 788.4 | 812.0 |
| | Maintenance as % RPV | 1.5% | 1.7% | 1.7% | 1.7% | 1.7% | 1.6% | 1.6% |
| Recapitalization Benchmark 1% | Infrastructure & Safety Recapitalization Investments | 168.8 | 253.7 | 554.6 | 335.0 | 339.6 | 353.3 | 374.7 |
| | Other Recapitalization Investments | 55.8 | 98.8 | 112.6 | 119.9 | 132.7 | 150.2 | 120.2 |
| | Total Recapitalization Investments | 224.6 | 352.5 | 667.3 | 454.8 | 472.3 | 503.5 | 494.9 |
| | Recapitalization as % RPV | 0.5% | 0.8% | 1.4% | 0.9% | 1.0% | 1.0% | 1.0% |

* The FY 2017 Infrastructure & Safety Recapitalization amount includes a one-time increase of $200 million for the disposition of the Kansas City Bannister Federal Complex, which is not included in RPV estimates for FY 2016 through FY 2021.
*Note:* Numbers may not sum due to rounding.

## 4.4.2 FY 2015 Accomplishments

Major accomplishments in this area include the following:

- Implemented Enterprise Risk Management framework to drive prioritization of investments.
- Developed Mission Dependency Index algorithm further to integrate several criteria for increased fidelity in prioritizing investments: the impact to the stockpile mission if the asset were lost, the difficulty to replace the asset, and the interdependency of assets.
- Developed G2 program management system further to standardize and automate processes for scope, cost, and schedule management.
- Completed framework and first draft of the NNSA Master Asset Plan to create and document a long-range vision for infrastructure planning and strategies.
- Made progress in increasing buying power, speeding up deactivation and decommissioning of excess facilities, and halting growth of DM.
- Developed and piloted, as part of the Asset Management Program, an approach to HVAC with a focus on energy-efficient systems that save operational costs. The effort will enter the program implementation phase in FY 2016 and be fully funded at $10 million per year in FY 2017.
- Finalized plans to demolish two of ten highest-risk excess facilities and perform characterization, stabilization, and roof repairs on several of the other top ten excess facilities.

### 4.4.3 Changes from the *FY 2016 SSMP*

Several projects, scheduled to start sometime during FY 2016 through FY 2020, have been deferred to outside the current FYNSP period to address higher NNSA priorities. These include Energetic Materials Characterization (LANL), the Weapons Engineering Facility (SNL), the HE Component Fabrication & Qualification Facility (Pantex), and the HE Science and Engineering Facility (Pantex).

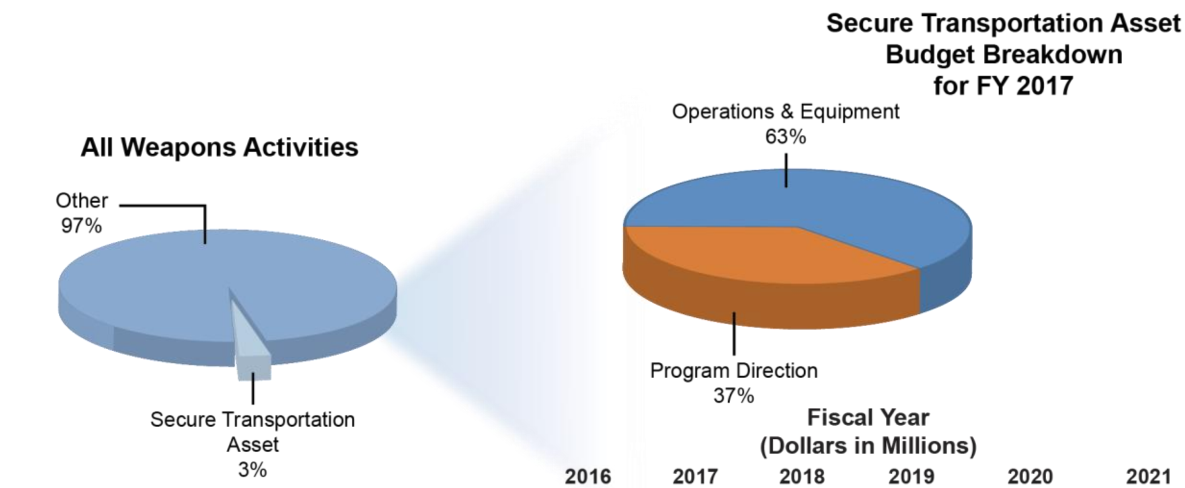
The U1a Complex Enhancements Project at the Nevada National Security Site is scheduled to start in FY 2017.

### 4.4.4 Milestones and Objectives

The schedules for construction projects are reflected in the Construction Resource Planning List found in Section 4.8.5.

## 4.5 Secure Transportation Budget

### 4.5.1 Budget




Fiscal Year (Dollars in Millions)

| | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|---|---|
| Operations & Equipment | 140.0 | 179.1 | 223.0 | 244.4 | 226.9 | 215.2 |
| Program Direction | 97.1 | 103.6 | 107.1 | 110.7 | 114.1 | 116.6 |
| Total Secure Transportation Asset | 237.1 | 282.7 | 330.1 | 355.1 | 341.0 | 331.8 |

Note: Numbers may not add due to rounding

**Figure 4–16. Secure Transportation funding schedule for fiscal years 2016 through 2021**

### 4.5.2 FY 2015 Accomplishments

- Completed 130 shipments without compromise or loss of nuclear weapons or components or release of radioactive material.
- Executed SGT risk-reduction initiatives: acquisition of components, refurbishment, and repair to ensure reliable safe operation.
- Accepted delivery of 76 of 89 Escort Vehicle Light Chassis to complete production in early FY 2016.

- Accepted delivery of 19 of 42 Replacement Armored Tractors, with the goal of finishing production by FY 2018.
- Retrofitted four of five Federal agent units' mission support vehicles with ARES. The last unit is scheduled for completion in FY 2017.
- Established a new Alternate Operations Facility to serve as a backup location for mission support communications.

### 4.5.3 Changes from the *FY 2016 SSMP*

- Vehicle production is continuing, with the Replacement Armored Tractor to be completed in FY 2018, a year earlier than expected in the *FY 2016 SSMP*.
- The Escort Light Chassis production will be completed and enter into life-cycle production in 2017, a year later than expected in the *FY 2016 SSMP*.
- The ARES installation and retrofits will be completed in FY 2017, a year later than expected in the *FY 2016 SSMP*.

### 4.5.4 Milestones and Objectives

- Execute Secure Transportation Fleet Plan to deliver tractors and escort vehicles to sustain mission and training operations.
- Complete prototype of Support Vehicle 2 with modular ARES and prepare platform for production.
- Finalize evaluation of SGT risk-reduction components that need to be procured.
- Complete reviews of MGT conceptual design and begin system development.
- Recruit and hire 48 Federal agents to achieve the goal of 370.

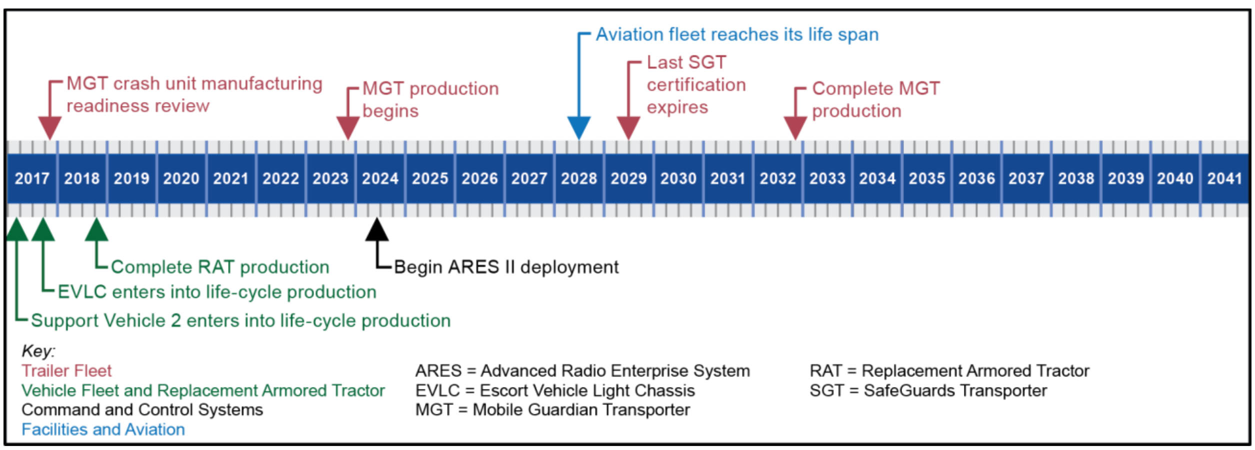
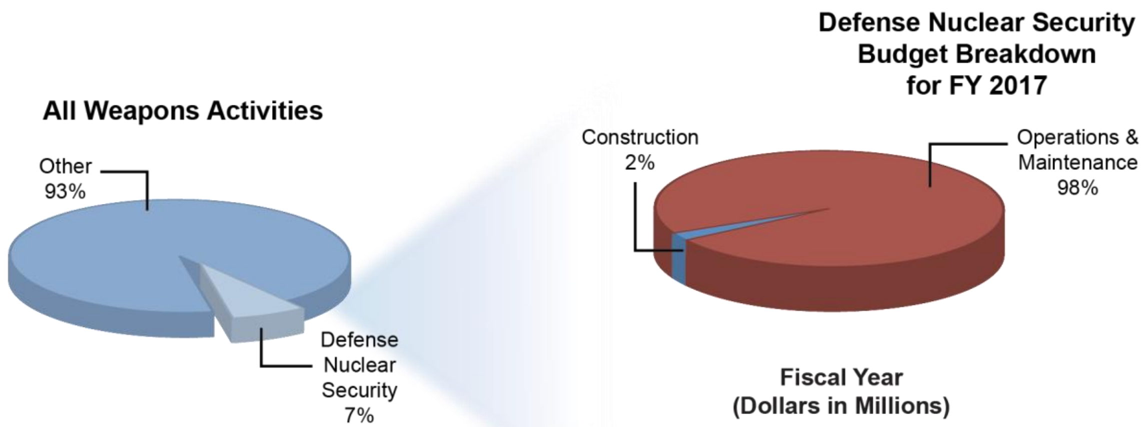



**Figure 4–17. Secure Transportation Asset Program milestones and objectives timeline**

# 4.6 Defense Nuclear Security Budget

## 4.6.1 Budget




Fiscal Year (Dollars in Millions)

| | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|---|---|
| Operations & Maintenance | 639.9 | 657.1 | 681.0 | 692.1 | 704.9 | 721.9 |
| Security Improvements Program | 30.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Construction | 13.0 | 13.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Total Defense Nuclear Security Activities | 682.9 | 670.1 | 681.0 | 692.1 | 704.9 | 721.9 |

Note: Numbers may not add due to rounding

**Figure 4–18. Defense Nuclear Security funding schedule for fiscal years 2016 through 2021**

## 4.6.2 FY 2015 Accomplishments

**Policy, Planning, Guidance**

- Developed and issued NNSA Security Roadmap.
- Completed draft Field Installation Guide for security system to enhance standardization efforts.
- Completed Phase I of Physical Security Technical Standard Guide for use enterprise-wide.
- Completed draft NNSA Test and Evaluation process for enterprise security systems.

**Physical Security Management and Technology Enhancement Initiatives**

- Completed Phase I of legacy alarm system field panel upgrade project ahead of schedule at LANL.
- Completed Portal 8 entry control facility enclosure at Y-12 to enhance access control at the Protected Area.
- Completed installation of razor tape around tritium limited area at SRS.
- Executed first facility-wide, live-active-shooter drill at KCNSC.

**Standardization Initiatives**

- Implemented a standard handgun—the Glock Model 17—across all sites to allow bulk ammunition procurements and facilitate cross-training of protective forces.
- Completed Access Control Standardization at the KCNSC New Mexico facility on time, providing a single access control system at KCNSC and its New Mexico location using the information technology standard failover capability, which will lower costs.
- Completed Phase I of Enterprise Risk Management initiative by conducting peer reviews to baseline the vulnerability and risk assessment programs at all NNSA sites.

**Protective Force Training Reform Initiatives**

- Conducted a pilot Adaptive Leader Training Workshop designed to improve problem solving, accountability, initiative, and awareness of protective force leaders at the sites.
- Partnered with the University of Tennessee's Institute for Assessments and Evaluations within the College of Education to create a Protective Force Instructor Evaluation program.

## 4.6.3 Changes from the *FY 2016 SSMP*

No substantive changes from the *FY 2016 SSMP*.

## 4.6.4 Milestones and Objectives

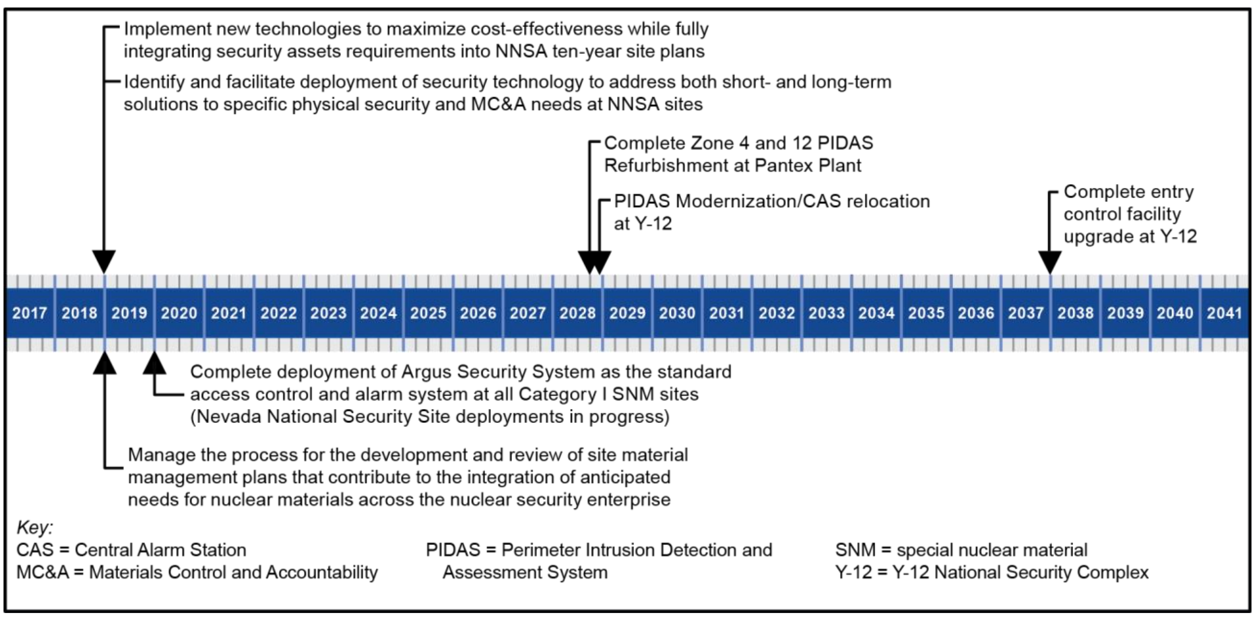
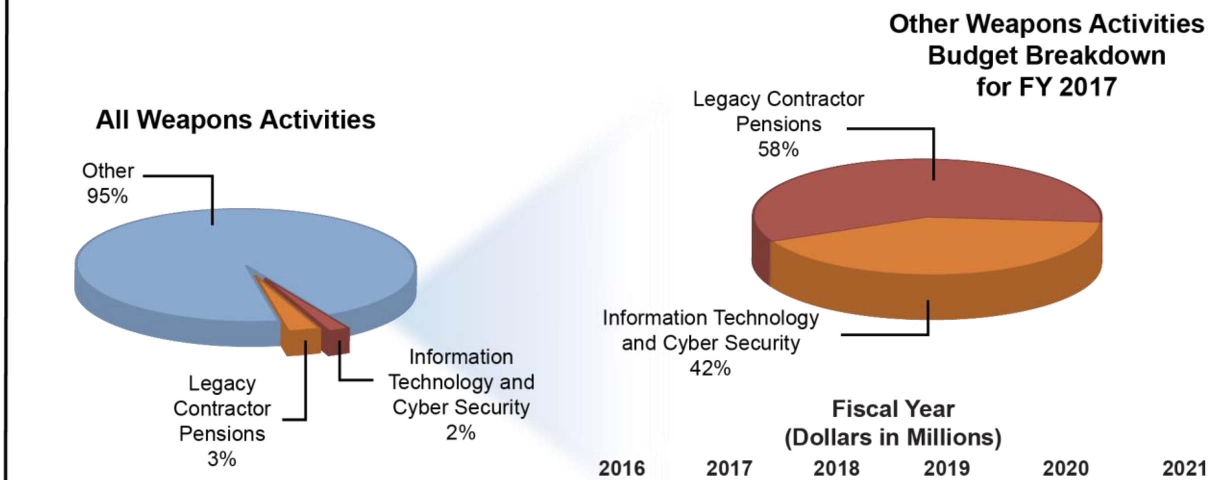



**Figure 4–19. Defense Nuclear Security program milestones and objectives timeline**

# 4.7 Other Weapons Activities

## 4.7.1 Budget




| Fiscal Year (Dollars in Millions) | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|---|---|
| Information Technology & Cyber Security | 157.6 | 176.6 | 178.7 | 184.3 | 188.7 | 192.5 |
| Legacy Contractor Pensions | 283.9 | 248.5 | 157.1 | 87.4 | 87.4 | 87.4 |
| Adjustments | 0.0 | (42.0) | 0.0 | 0.0 | 0.0 | 0.0 |
| Total Other Weapons Activities | 441.5 | 383.1 | 335.8 | 271.7 | 276.1 | 279.9 |

Note: Numbers may not add due to rounding

**Figure 4–20. Other Weapons Activities funding schedule for fiscal years 2016 through 2021**

## 4.7.2 2015 Accomplishments for Information Technology and Cyber Security

**Policy, Planning, Guidance**

- Developed implementation plans for the *Federal Information Technology Acquisition Reform Act* and Multi-Factor Authentication.
- Issued revised budget processes and procedures for Cyber Security and Information Technology.
- Completed Phase II of site Cyber Security baseline budget process.
- Completed draft baseline staffing profile for Cyber Security.

**Information Technology and Cyber Security**

- Completed Phase I of the Multi-Factor Authentication implementation requirements.
- Completed implementation of virtual desktop infrastructure solution within the classified environments.
- Completed development of software application development and testing environment.

**NNSA Information Assurance Response Center**

- Completed implementation of hand-off and rollover processes and procedures with the Joint Cybersecurity Coordination Center.
- Completed Phase II of network sensor upgrade across the NNSA sites.
- Completed Phase II of the NNSA Information Assurance Response Center and move to the Nevada National Security Site.

### 4.7.3 Changes from the *FY 2016 SSMP*

In previous SSMPs, Site Stewardship has appeared in the pie chart for Other Weapons Activities. This funding line no longer exists. Its activities are now funded in DSW, Science, or Infrastructure and Operations, as described above.

### 4.7.4 Milestones and Objectives

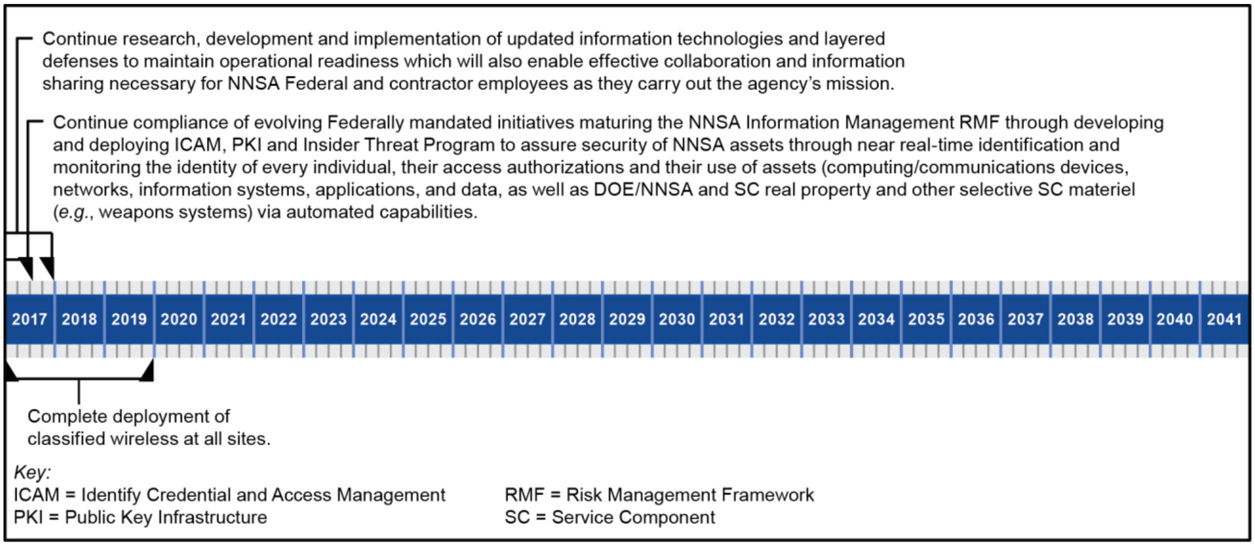



**Figure 4–21. Information Technology and Cyber Security milestones and objectives timeline**

## 4.8 Estimates of Requirements beyond the Future Years Nuclear Security Program

### 4.8.1 Estimate of Weapons Activities Program Costs and Its Affordability

**Figure 4–22** shows Weapons Activities funding in the FY 2017 President's budget and estimates for budget requirements for FY 2022 through FY 2041. The figure displays the relative makeup of the Weapons Activities program in terms of its major portfolios for the period from FY 2016 through FY 2041 by using program FYNSP values for FY 2016 through FY 2021 and estimated nominal program costs for FY 2022 through FY 2041. This information shows the potential evolution in program makeup and does not represent the precise costs in the out years for any of the portfolios shown.

The potential future cost for the program in the years beyond the FYNSP should be interpreted as the range between the red "high range" total lines and the green "low range" total lines for Weapons Activities shown in the figure. This range of total cost is necessary because of the significant uncertainties in the individual components that make up the estimate, in particular, for the LEPs and construction costs, which are described in more detail in the following sections. These same uncertainties are also present during the FYNSP period and may, as planning for these types of efforts mature, necessitate adjustments to the amounts shown for FY 2018 through FY 2021.

Figure 4–22 also displays a blue line that represents the nominal total shown in the *FY 2016 SSMP* so that a comparison can be made between Figure 4–22 and Figure 8–12 in the *FY 2016 SSMP*.

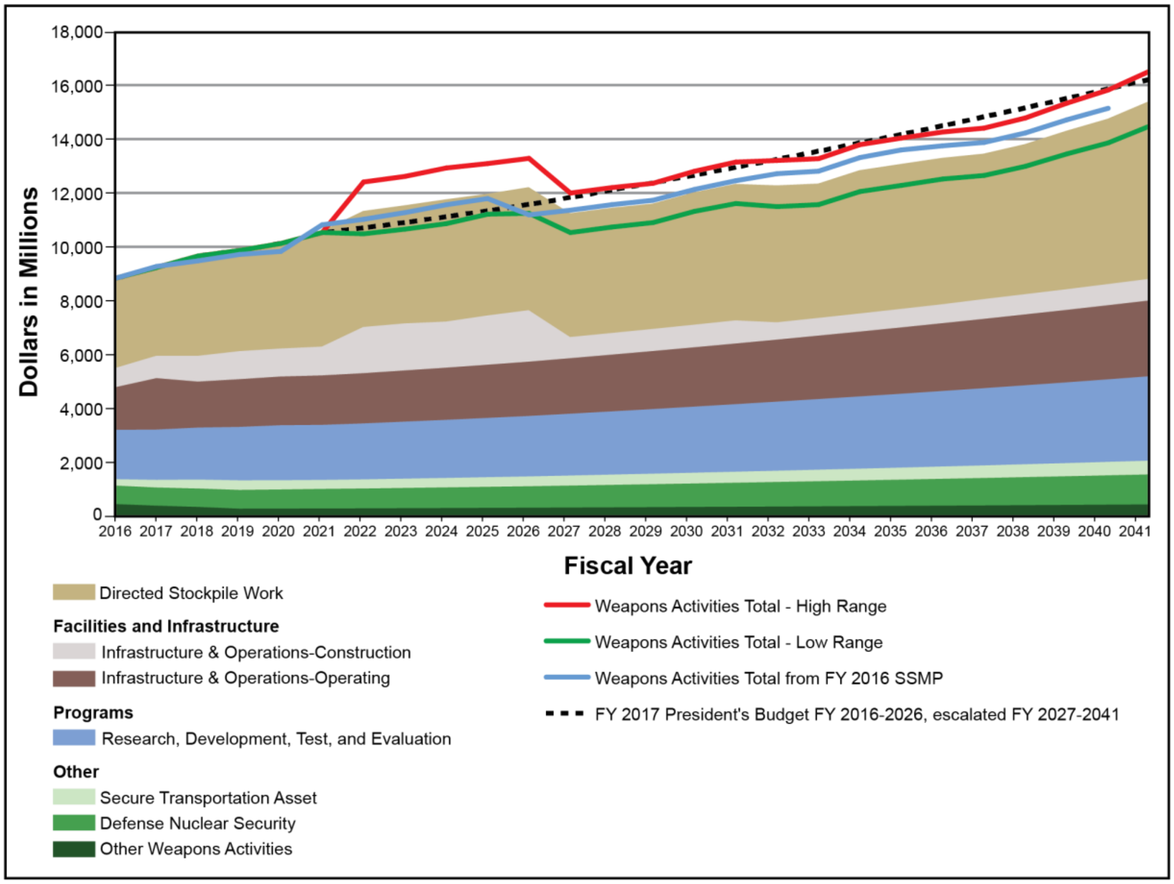



**Figure 4–22. Estimate of out-year budget requirements for NNSA Weapons Activities in then-year dollars**

The dashed black line in Figure 4–22 represents the FY 2017 President's budget for FY 2017 through FY 2026, with the FY 2026 total escalated for FY 2027 through FY 2041 at the same 2.25 percent rate used in all the budget requirements estimates for those years. This line is intended to reflect the level of funding the Weapons Activities program might expect to receive for these out years, but is subject to annual adjustment based on the results of the programming cycle and interactions with stakeholders. **Figure 4–23** in this section shows, in greater detail, the cost range for Weapons Activities in the out years.

The nominal cost of the overall program for FY 2022 through FY 2041 in Figure 4–23 falls within +5.2 and -9.4 percent of the escalated (dashed black) FY 2021 line. The uncertainty (resulting from the estimated costs of the LEPs and construction) from the nominal value ranges from +10.3 percent to -7.5 percent. While the nominal cost of the program does exceed the escalated line over the period from FY 2022 through FY 2026 by up to 5.2 percent (representing a potential $2.9 billion overage or 5.1 percent of the potentially available resources over this period), the escalation line falls within the high to low cost range in this period. In the years beyond FY 2026, the escalation line general falls around the high end of the potential cost range. The approximate billion-dollar reduction that occurs in FY 2027 is a result of the winding down of a number of number of construction projects slated for the FY 2022 through FY 2026 period to include MaRIE, the Radiation Hardened Microelectronics Capability, and a number of HE-related facilities. The program, as planned, is therefore generally affordable and more executable than the program proposed in the *FY 2016 SSMP* as a result of the FY 2017 programming process, adjustments of funding levels mandated by Congress in currently applicable budget acts, and the formal process of multi-agency budget development.

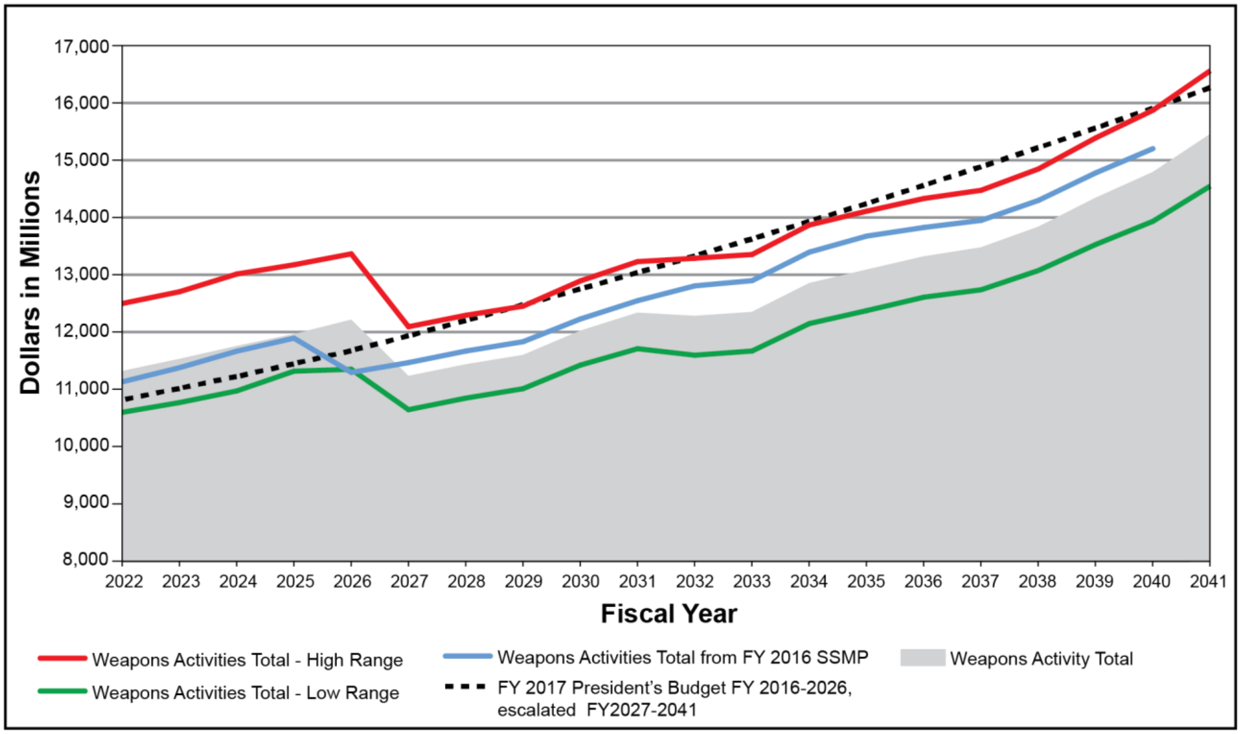



**Figure 4–23. Detail of out-year budget requirements for Weapons Activities of the NNSA in then-year dollars**

## 4.8.2 Basis for Cost Estimates

As noted in Section 4.8.1, Figure 4–22 displays both the FYNSP budget numbers and an estimate of program costs for the 20 years beyond the FYNSP. The FYNSP numbers were generated as part of the DOE planning and programming process that informed development of DOE's portion of the FY 2017 President's budget request and reflect the roll-up of literally hundreds, if not thousands, of individual estimates developed interactively by NNSA's M&O partners and Federal program managers using historical cost data, current plans for programs and projects, and expert judgment.

The basis for the cost estimates beyond the FYNSP vary depending on the individual programs or subprograms. Some portions of the Weapons Activities program are assumed to continue beyond the FYNSP at the same level of effort as in the FYNSP.[15] For these cost projections, escalation factors based on numbers provided by the Office of Management and Budget for 2017 were used.[16]

Some portions of the program cannot or should not be assumed to proceed at the same level of effort for FY 2022 through FY 2041. This would be true for major construction projects, LEPs, and, because of

[15] Projection of budget requirements for these efforts in this way assumes the continued manageability of whatever risks are present during the FYNSP at the same level of effort following the FYNSP period as, typically, is represented by the funding level of the last year of the FYNSP.

[16] Escalation rates for FY 2022-2026 matched those in the FY 2017 President's budget for those years. Rates for FY 2027 and beyond were 2.25, consistent with Office of Management and Budget projections of the Consumer Price Index.

the future evolution in the current stockpile to a 3+2 Strategy configuration, stockpile sustainment as represented by the funding lines for stockpile systems. The estimates and the basis for each of these elements of the Weapons Activities program are described in more detail in the following sections.

### 4.8.3 Stockpile Sustainment

Sustainment costs include warhead-specific assessment activities, LLC exchanges, required and routine maintenance, safety studies, periodic repairs, resolution and timely closure of significant finding investigations, military liaison work, and surveillance to assure the continued safety, security, and reliability of the stockpile. These costs are incurred every year that a weapon is in the stockpile.

**Figure 4–24** shows, in then-year dollars, the annual sustainment cost for FY 2017 through FY 2021 attributable to a particular warhead type based on FYNSP numbers, an estimate of the total sustainment cost by year for warheads of all types for FY 2022 through FY 2041, and the average cost from FY 2003 through FY 2016. The FY 2022 through FY 2041 costs account for the increased sustainment costs to be incurred during the transition from the current stockpile to the 3+2 stockpile.

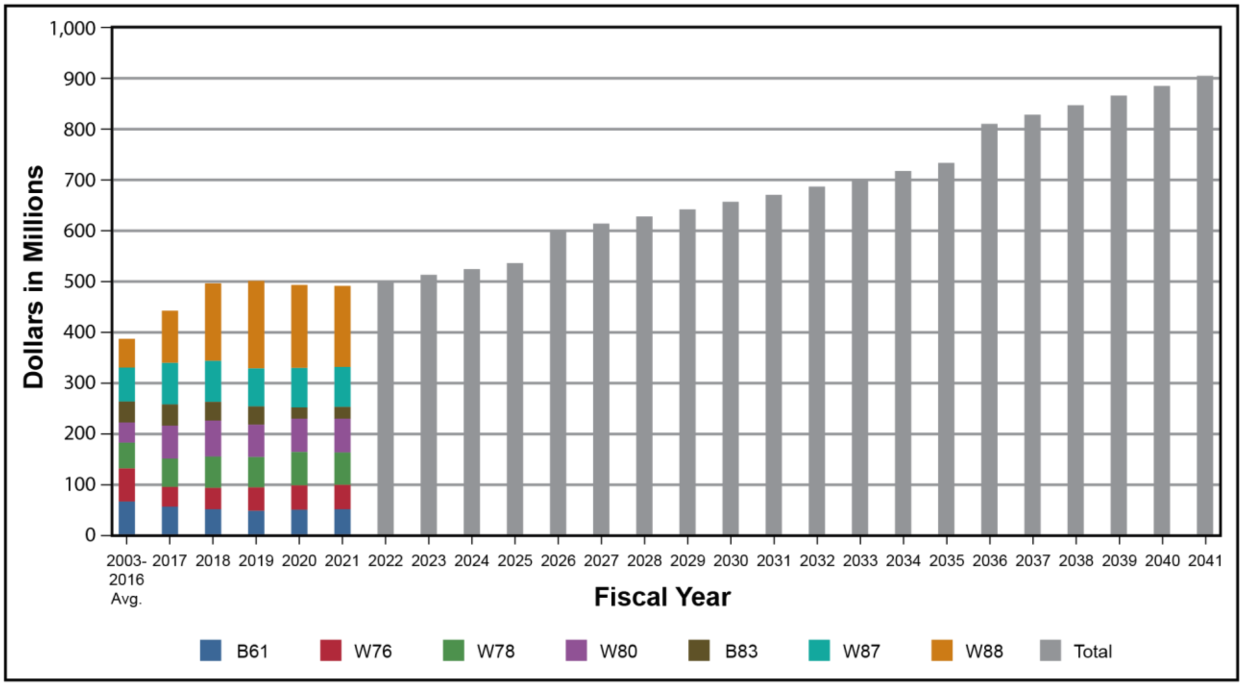



**Figure 4–24. Estimate of warhead-specific sustainment costs**

### 4.8.4 Life Extension Programs and Major Alterations

LEPs are undertaken separately from stockpile sustainment, with the goal of extending the lives of warheads for several additional decades. Major Alts make component changes to warheads and can have significant costs. Alts will not address all the aging issues in a warhead such that they would be considered an LEP. Both LEPs and major Alts may be subject to SAR requirements to Congress. These quarterly reporting requirements begin in the first quarter following entry into Phase 6.3 (Full-Scale Engineering Development) of the *Phase 6.x* process and constitute the first official performance baseline. Many of the estimates presented in the SSMP are independent planning estimates, not program baselines (as would be found in SARs), and are used for planning purposes and for benchmarking LEP performance at various program and budgetary milestones.[17]

The Defense Programs' Office of Cost Policy and Analysis is responsible for performing the independent cost estimates (ICEs) for the SSMP.[18] These ICEs use independent analysts and methodologies separate from the individual program offices. They provide both a check estimate of the baselined LEP programs (such as the W76-1 or B61-12) and an initial, but high-fidelity, planning estimate for pre-baselined LEP programs (such as the W80-4 and the IW-1, -2, and -3). For instance, at least four years of Defense Programs ICEs will be published prior to the initial W80-4 Program estimate at Phase 6.2A (Design Definition and Cost), which will likely constitute the performance baseline for that LEP. Defense Programs believes these early-stage, high-fidelity estimates are important for resource planning; however, an estimate made in advance of completion of an LEP study is not the final word regarding what an LEP will ultimately cost.

**Figures 4–25** through **4–32** and **Tables 4–4** through **4–11** show the cost profiles for each LEP and major Alt for FY 2016 through FY 2041. Each contains a "top-down" planning estimate (ICE), as well as a detailed "bottom-up" estimate if the respective program has completed its Phase 6.2A baseline.

All the ICE profiles include a "high" and "low" estimate range and are produced using a model based on the "top-down" approach for concept assessment, technology maturation, engineering development, production development (including initial low-rate production), and full-rate production. These costs are then distributed using well-established idealized cost distributions to provide some sense of the required year-by-year cost profiles for resource planning. The cost model is based, to a large extent, on the W76-1 program actuals, as it is currently the only LEP to complete development and most of production. These planning ICEs are produced independently of future budget availability and may therefore differ from proposed budgets, which can be affected by external funding constraints.

The Defense Programs ICEs are based on:

- LEP actual costs to date;
- W76-1 actual costs to date for LEP development and production;
- a standard LEP Work Breakdown Structure;
- evaluations of LEP scope and complexity by independent program and subject matter experts;
- estimates of non-LEP line-item costs, which are also critical to an LEP's success (namely Other Program Money and DOD costs) provided by program office experts;[19]

[17] When performed in advance of the LEP being baselined, the scope assumed for the estimate is one that reasonably meets current policy for life extensions (such as an upgrade to surety) in addition to extending the life of the warhead. The cost range of the estimate reflects the uncertainty in implementing that "point" solution rather than the potential cost of a range of options, as will be done as part of the LEP studies. When performed following the completion of LEP studies and baselining, the estimate uses the same scope as selected for the LEP baseline, which may differ from what was used for the planning estimate.

[18] A technical paper containing additional detail on the LEP cost model methodology was published in 2015 at several professional cost estimating forums and is available upon request.

[19] The SSMP figures attempt to account for all costs needed to execute each LEP or major Alt, regardless of the color of money. This is why the cost model is designed to estimate funding streams, not only for the LEP line items, but also for earlier-stage technology maturation activities covered by Other Program Money and even DOD, if applicable. As the overall program integrator, the Federal program manager assists in identifying the Other Program Money and DOD funding needed for their respective LEP to be successful.

- development costs distributed using standard, well-known Rayleigh profiles (these profiles are based on a data set of previously executed major defense acquisition programs); and
- production costs distributed using a similar nonlinear cost growth profile exhibited by the W76-1 program, adjusted for relative complexity.

The estimates presented reflect complexity factors evaluated by both the Federal program managers and a broad ranging team of subject matter experts from the national security laboratories and the nuclear weapons production facilities. This integrated team of subject matter experts and Federal program managers provides significant technical expertise on each LEP and major Alts by evaluating the relative scope complexity by Work Breakdown Structure element between the W76-1 and their respective LEPs. Coupled with the scope and scheduling experience of the Federal program managers, the ICE LEP estimates reflect a reasonable range of cost uncertainty based on the best information available.

If no bottom-up estimate exists for a specific program, such as for the W80-4 and IWs, which are at a pre-Phase 6.2A baseline, the midpoint between the high and low estimates is used as the nominal cost of the LEP or major Alt and shown on the bars in Figures 4–26 through 4–32.

The high and low lines on each LEP cost figure (included for all systems except the nearly complete W76-1) reflect the cost estimate uncertainties aggregated from the broad range of assessed complexity factors. The published cost ranges attempt to account for unforeseen technical issues, budget fluctuations, and even the level of component maturity available at a future date.

One important note is that early-stage LEPs can experience occasional, but significant, scope additions or redefinitions, possibly resulting in substantial changes in the cost range. This potential for differences in planning assumptions exists because LEPs in Phase 6.1 (Concept) or 6.2 (Feasibility Study and Option Down-Select) contain considerable design uncertainty. For example, the current W80-4 estimate assumes a moderate nuclear explosive package refurbishment. As design options are down-selected, the estimate may result in changes to the cost and program scope. Major differences in year-to-year planning assumptions will hopefully be minimal and exclusively for early-stage programs; however, if and when these differences occur, NNSA will publish them in the subsequent SSMP and provide a brief explanation of the change.

In cases where LEP or major Alt planning has proceeded through Phase 6.2A, the nominal total cost and cost profile being used is the official baseline for the effort, as reported in the SAR. For the first SAR, this is typically the total cost and cost profile reported in the Weapon Design Cost Report that is produced by Phase 6.2A of the *Phase 6.x* process. These bottom-up estimates are prepared by the project team based on a detailed Work Breakdown Structure and a master integrated schedule that captures all major activities and their costs, as estimated by the organizations that will be performing the work. These estimates also include specific consideration of project risks and the project management reserve and contingency based on these risks.

Those figures and tables displaying both the bottom-up program-based and model top-down high and low independent cost ranges show transparently the degree of consistency between the two estimates and the underlying methodologies. If total costs are comparable and their general profiles are similar, NNSA has confidence the baseline bottom-up estimate is reasonable. If total costs are similar for both, but there is a year-by-year profile discrepancy, NNSA has greater confidence in the bottom-up baseline estimate because it is based on a project-specific integrated schedule, rather than an idealized distribution and historic project estimates. For this reason, NNSA does not perform or encourage additional year-by-year comparisons between its two cost estimates beyond what is described above.

For each figure, the associated table displays the high, low, and nominal estimated total cost to NNSA and DOD in both constant FY 2016 and then-year dollars.[20] These are in **Tables 4–4** through **4–11**. The total estimated cost is provided because portions of four programs (the IW-1, -2, -3, and the next B61 LEP) fall outside the 25-year window for the *FY 2017 SSMP*. While figures are in then-year dollars, total estimated costs in current constant-year (FY 2016) dollars are also provided to assist in comparing LEPs scheduled over different time frames.[21] When compared, consideration should be given to the different quantities of warheads being refurbished. Production costs, following studies, and development and production engineering, are to a great degree driven by the total number of warheads undergoing refurbishment. The classified Annex to this report provides information on these production quantities.

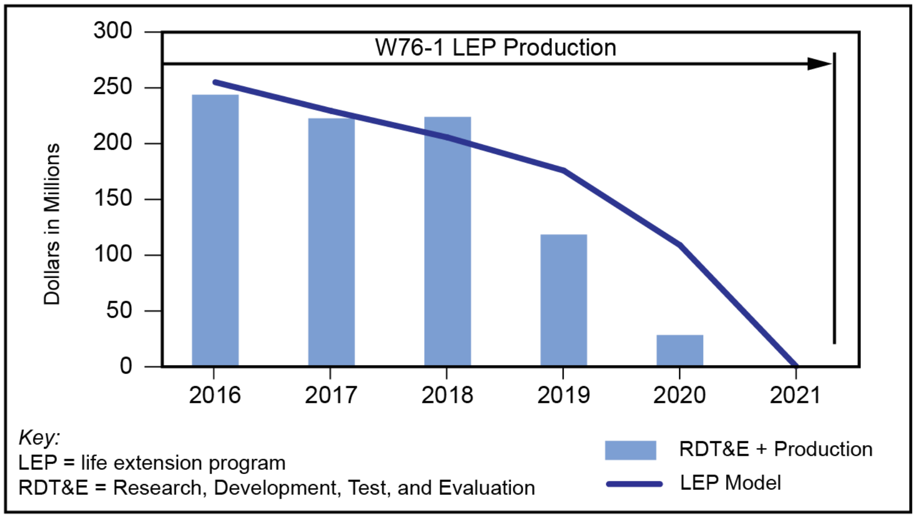



**Figure 4–25. W76-1 life extension program cost FY 2016 to completion**

**Table 4–4. Total estimated cost for W76 life extension program**

| *FY 1999 – FY 2020 (Dollars in Millions)* | *NNSA* | | *DOD* | |
|---|---|---|---|---|
| | *FY 2016 Dollars* | *Then-Year Dollars* | *FY 2016 Dollars* | *Then-Year Dollars* |
| SAR Value | 4,065 | 3,621 | Not in NNSA SAR | Not in NNSA SAR |

[20] The DOD costs are for weapon components for which DOD is responsible, such as arming and fuzing. While not budgeted or executed by NNSA, these estimated costs are published to be as transparent as possible of the "all in" costs for each LEP.

[21] For LEPs for which no SAR or Weapon Design and Cost Report has been prepared, only the cost range is provided in constant-year dollars for comparison to other LEPs. Moreover, when a SAR or Weapon Design and Cost Report value is provided, this represents only the costs associated with Phase 6.3 (Development Engineering) and forward without Other Program Money, based on reporting requirements.

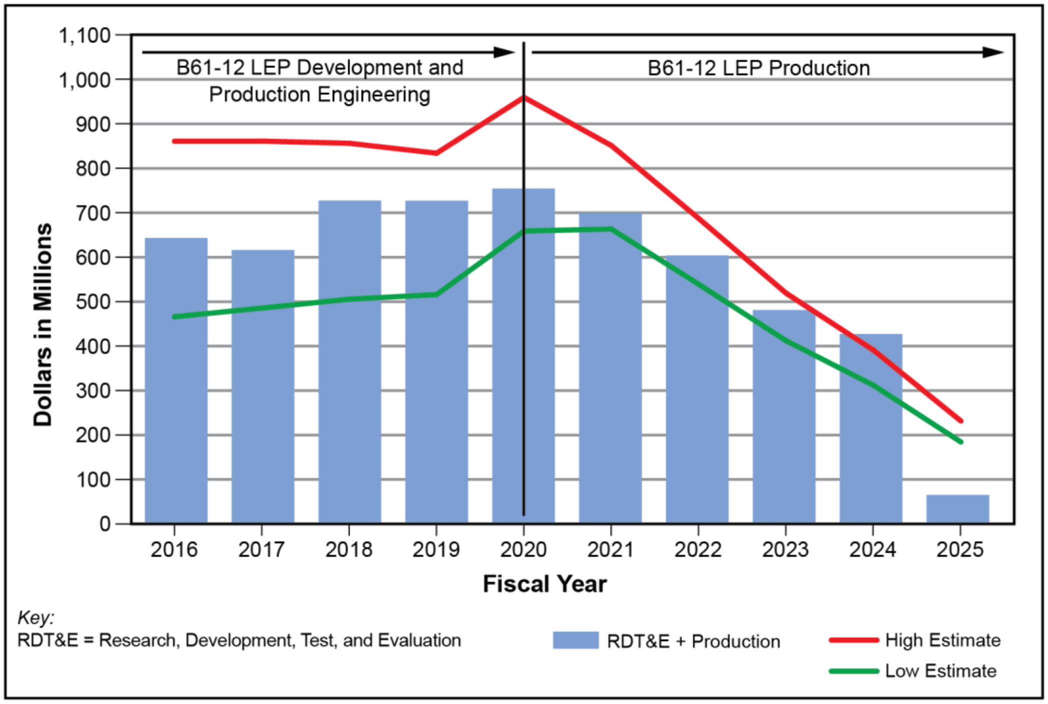



**Figure 4–26. B61-12 life extension program cost FY 2016 to completion**

**Table 4–5. Total estimated cost for B61-12 life extension program**

| *FY 2009 – FY 2025 (Dollars in Millions)* | *NNSA* | | *DOD* | |
|---|---|---|---|---|
| | *FY 2016 Dollars* | *Then-Year Dollars* | *FY 2016 Dollars* | *Then-Year Dollars* |
| High Total | 9,186 | 9,625 | 181 | 193 |
| Low Total | 7,014 | 7,312 | 49 | 50 |
| SAR Total | 6,961 | 7,372 | Not in NNSA SAR | Not in NNSA SAR |

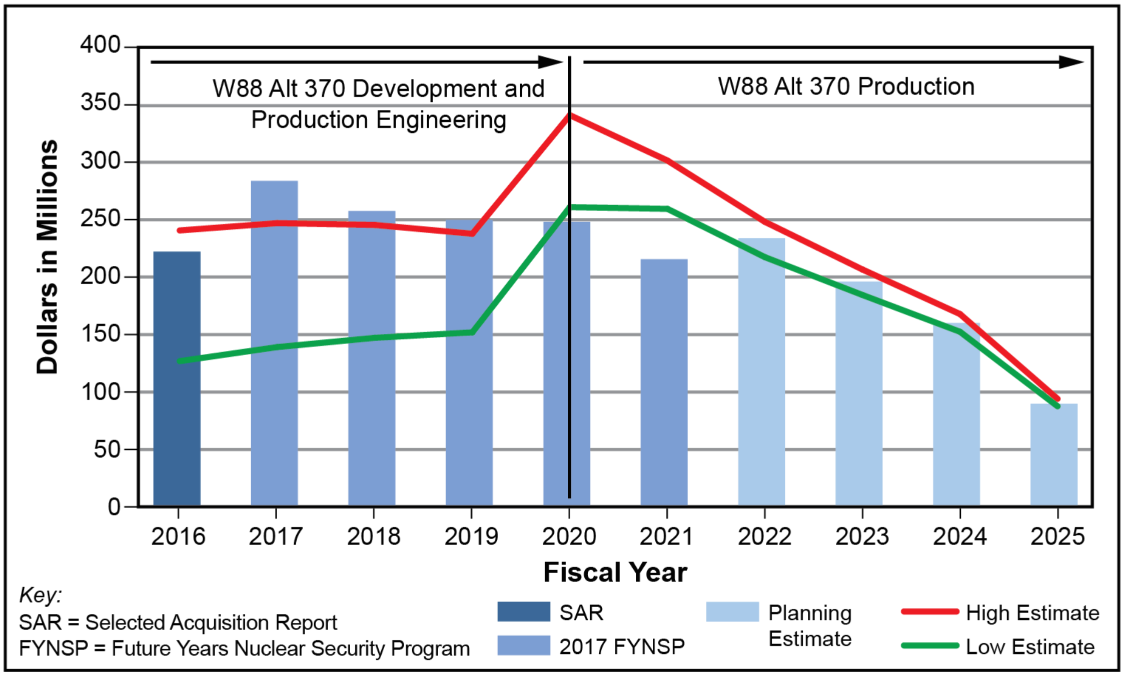



**Figure 4–27. W88 Alt 370 (with CHE refresh) cost FY 2016 to completion**

In November 2014, the Nuclear Weapons Council approved the addition of scope for the conventional high explosive refresh to the original Alt 370 non-nuclear scope. Additional funding was added to the effort based on a preliminary estimate. That estimate was updated in 2015 to reflect some additional scope needed for the conventional high explosive refresh and is reflected in the funding totals requested in the FY 2017 FYNSP. However, NNSA is still in the process of completing a Baseline Cost Report for the entire W88 Alt 370 (with conventional high explosive refresh included) by September 2016. Once completed, this Baseline Cost Report will be the cost and schedule baseline for the W88 Alt 370 program and will be reflected in future SARs and future budget materials. For planning purposes, the costs shown for FY 2022 through FY 2025 are the midpoint of the Defense Programs ICE prepared for this effort. No SAR value is reflected in the table below; however, for planning purposes, a budget requirement total is included.

**Table 4–6. Total estimated cost for W88 Alt 370 (with CHE refresh) life extension program**

| *FY 2010 – FY 2025 (Dollars in Millions)* | *NNSA* | | *DOD* | |
|---|---|---|---|---|
| | *FY 2016 Dollars* | *Then-Year Dollars* | *FY 2016 Dollars* | *Then-Year Dollars* |
| High Total | 2,706 | 2,880 | 1,039 | 1,106 |
| Low Total | 2,134 | 2,274 | 879 | 937 |
| Budget Requirement | NA | 2,600 | NA | 1,022 |

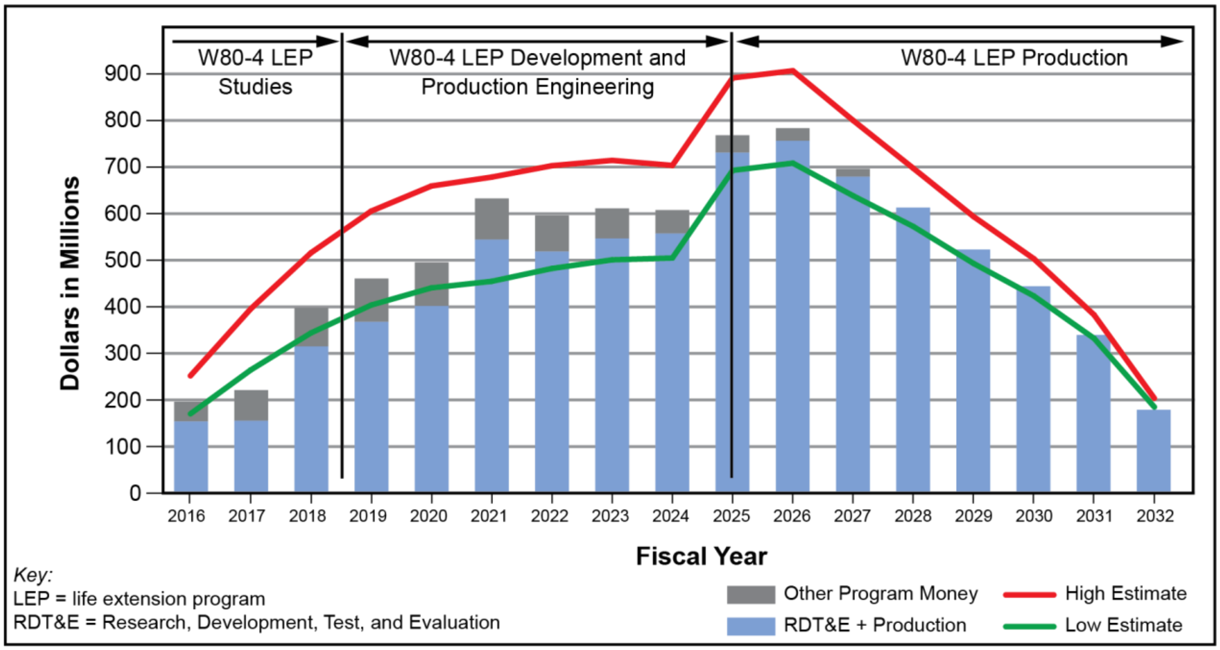



**Figure 4–28. W80-4 life extension program cost FY 2016 to completion**

Some amount of the funding in FY 2016 is expected to carry over to FY 2017 because of the late receipt of full funding, which will augment the funding available for FY 2017 study and technology maturation activities.

**Table 4–7. Total estimated cost for W80-4 life extension program**

| *FY 2015 – FY 2032 (Dollars in Millions)* | *NNSA* | | *DOD* | |
|---|---|---|---|---|
| | *FY 2016 Dollars* | *Then-Year Dollars* | *FY 2016 Dollars* | *Then-Year Dollars* |
| High Total | 8,369 | 9,938 | 209 | 251 |
| Low Total | 6,140 | 7,352 | 55 | 67 |
| Budget Requirement | NA | 8,645 | NA | 159 |

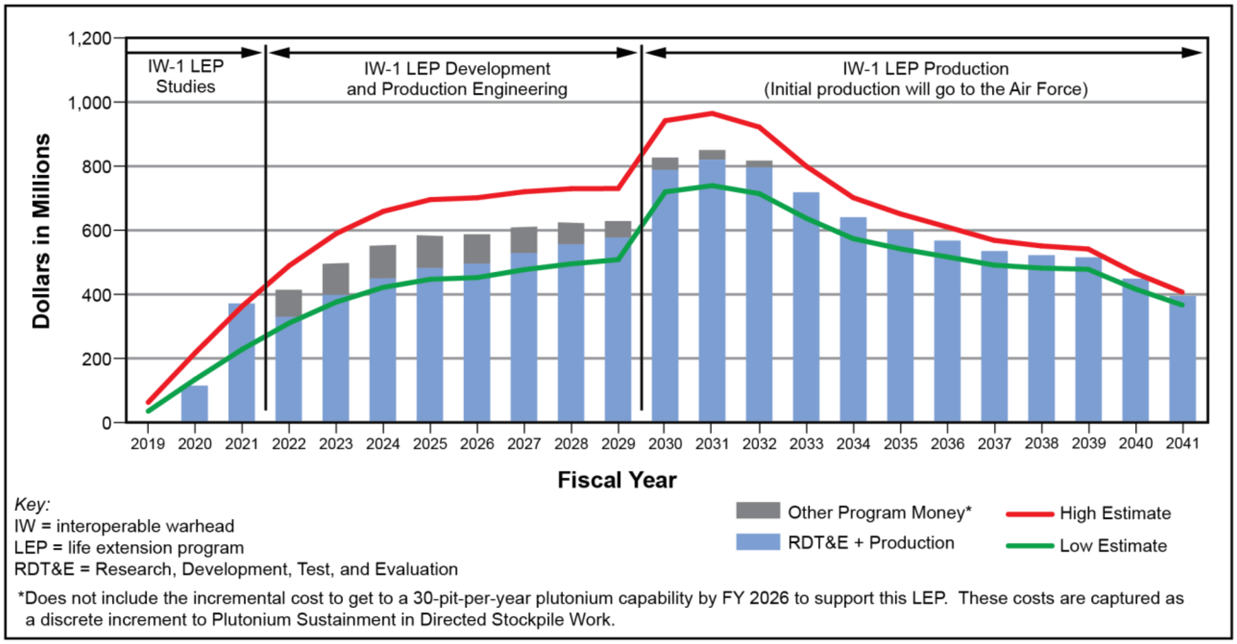



**Figure 4–29. IW-1 life extension program cost FY 2021 through FY 2041**

The ICE models assume a standard 12-year study and development period in advance of the first production unit. The IW-1 LEP, after deferral, is slated to recommence in FY 2020, compressing that period slightly, in part to account for the work accomplished in FY 2014 and before. To avoid an unexecutable "ramp" in funding from FY 2020 through FY 2021, additional funding has been added in the FY 2022 through FY 2029 period to provide the nominal funding profile shown with the required amount of funding in advance of the first production unit.

**Table 4–8. Total estimated cost for IW-1 life extension program**

| FY 2013-2014, FY 2020-2043 (Dollars in Millions) | NNSA | | DOD | |
|---|---|---|---|---|
| | FY 2016 Dollars | Then-Year Dollars | FY 2016 Dollars | Then-Year Dollars |
| High Total | 10,630 | 14,694 | 3,189 | 4,445 |
| Low Total | 7,974 | 11,198 | 1,063 | 1,503 |
| Budget Requirement | NA | 12,946 | NA | 2,974 |

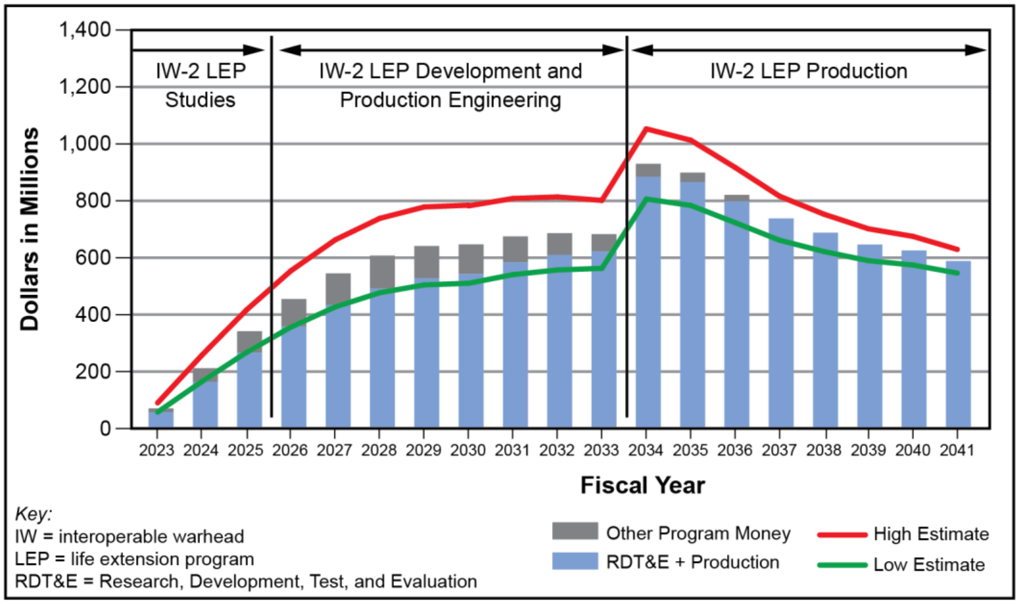



**Figure 4–30. IW-2 life extension program cost FY 2023 through FY 2041**

**Table 4–9. Total estimated cost for IW-2 life extension program**

| *FY 2023 – FY 2049 (Dollars in Millions)* | *NNSA* | | *DOD* | |
|---|---|---|---|---|
| | *FY 2016 Dollars* | *Then-Year Dollars* | *FY 2016 Dollars* | *Then-Year Dollars* |
| High Total | 11,218 | 17,249 | 3,189 | 4,944 |
| Low Total | 8,497 | 13,301 | 1,063 | 1,675 |
| Budget Requirement | NA | 15,275 | NA | 3,309 |

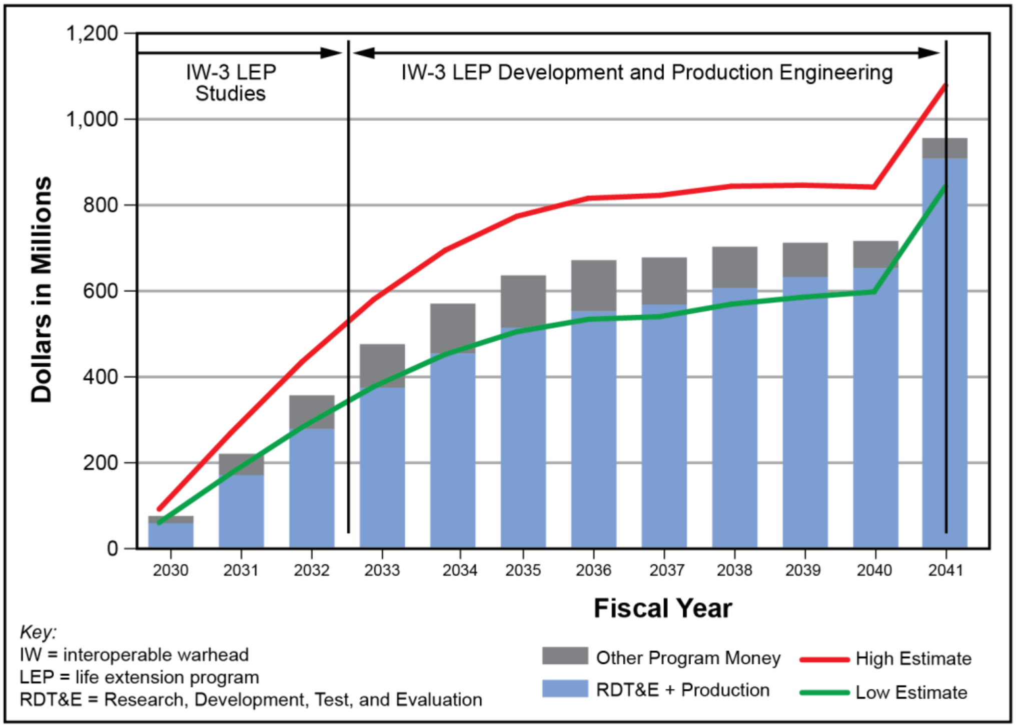



**Figure 4–31. IW-3 life extension program cost FY 2030 through FY 2041**

**Table 4–10. Total estimated cost for IW-3 life extension program**

| *FY 2030 – FY 2057 (Dollars in Millions)* | *NNSA* | | *DOD* | |
|---|---|---|---|---|
| | *FY 2016 Dollars* | *Then-Year Dollars* | *FY 2016 Dollars* | *Then-Year Dollars* |
| High Total | 10,698 | 19,461 | 3,189 | 5,850 |
| Low Total | 8,262 | 15,320 | 1,063 | 1,984 |
| Budget Requirement | NA | 17,390 | NA | 3,916 |

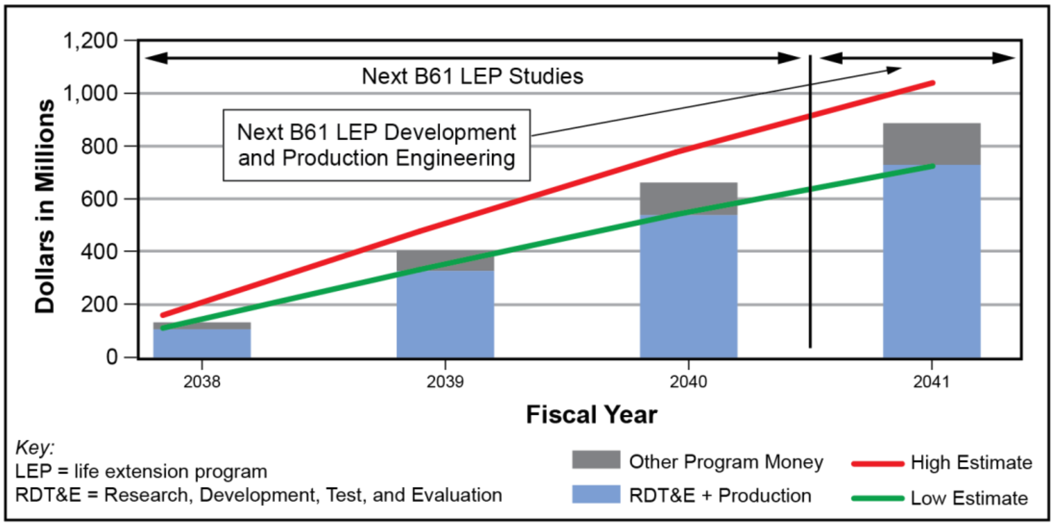



**Figure 4–32. Next B61 life extension program cost FY 2038 through FY 2041**

**Table 4–11. Total estimated cost for next B61 life extension program**

| *FY 2038 – FY 2057 (Dollars in Millions)* | *NNSA* | | *DOD* | |
|---|---|---|---|---|
| | *FY 2016 Dollars* | *Then-Year Dollars* | *FY 2016 Dollars* | *Then-Year Dollars* |
| High Total | 12,075 | 24,296 | 210 | 425 |
| Low Total | 8,981 | 18,184 | 56 | 113 |
| Budget Requirement | NA | 21,240 | NA | 269 |

**Figure 4–33** is a one-chart summary of the total projected nuclear weapons life extension costs from FY 2016 through FY 2041, based on the LEP schedule reflected in Chapter 2, Figure 2–10, of this *FY 2017 SSMP* and the nominal LEP costs shown in Figures 4–25 through 4–32.[22] The dotted line shows the total LEP cost reflected in the *FY 2016 SSMP*.

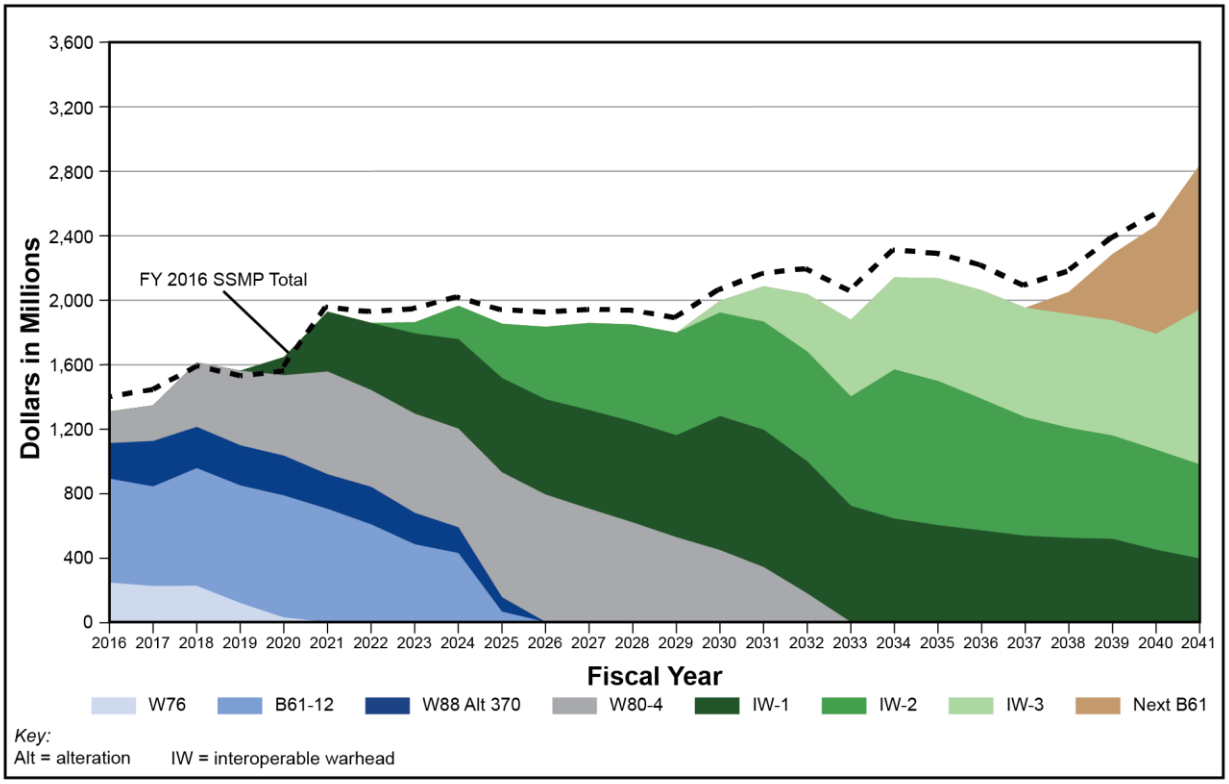



**Figure 4–33. Total U.S. projected nuclear weapons life extension costs for fiscal years 2016 through 2041 (then-year dollars)**

The principal differences between the FY 2016 and FY 2017 LEP costs are as follows:

- For those efforts reporting SAR values, the W76-1 LEP decreased slightly based on current execution, the B61-12 LEP decreased slightly as a result of reported Other Program Money costs, and the W88 Alt 370 increased as previously described.
- For those LEPs making use of ICE values for their nominal costs:
  - The assumed escalation factor beyond the FYNSP in FY 2021 was increased from last year's 2.24 percent to the updated Office of Management and Budget–published 2.25 percent value. This resulted in only a very minor change to any LEP estimate.
  - The W80-4 program had a new work scope addition identified during its development, resulting in a moderate increase to the overall program. The work scope on all other components was only slightly changed from last year.

[22] Nominal costs are used to allow for comparison of total LEP costs from SSMP to SSMP. Unless baselined, the cost of any particular LEP should be regarded as a cost range as shown in the tables accompanying each LEP figure.

– The IW-1, -2, and -3 programs had a shared component that was re-evaluated to be much simpler than in last year's SSMP, which affected all three systems to a similar and significant extent. The other work scope components were only slightly changed from last year.

- In addition to affecting the costs shown in Figure 4–33, changes to the ICE models will have also affected the high and low lines shown on Figures 4–26 through 4–32 from what was shown in the *FY 2016 SSMP*. Changes to those lines for the efforts that report SAR costs are as follows:

  – The B61-12 estimate in Figure 4–26 reflects a new feature in the LEP cost model to account for risks, particularly those previously identified, and have either subsequently been avoided or occurred. This model improvement should result in programs naturally narrowing from a larger to a smaller uncertainty range over time, which better reflects reality. This is exhibited most clearly in this year's B61-12 high and low range compared to last year's published range.

  – The W88 Alt 370 program had an expanded work scope addition identified during its development, resulting in a moderate increase to the overall program. The work scope on all other components were only slightly changed from last year. In addition, the model's assumed time-phasing was adjusted to better match the program's progress to date.

The total side-by-side differences between this and last year's ICEs are provided in **Figure 4–34** below.

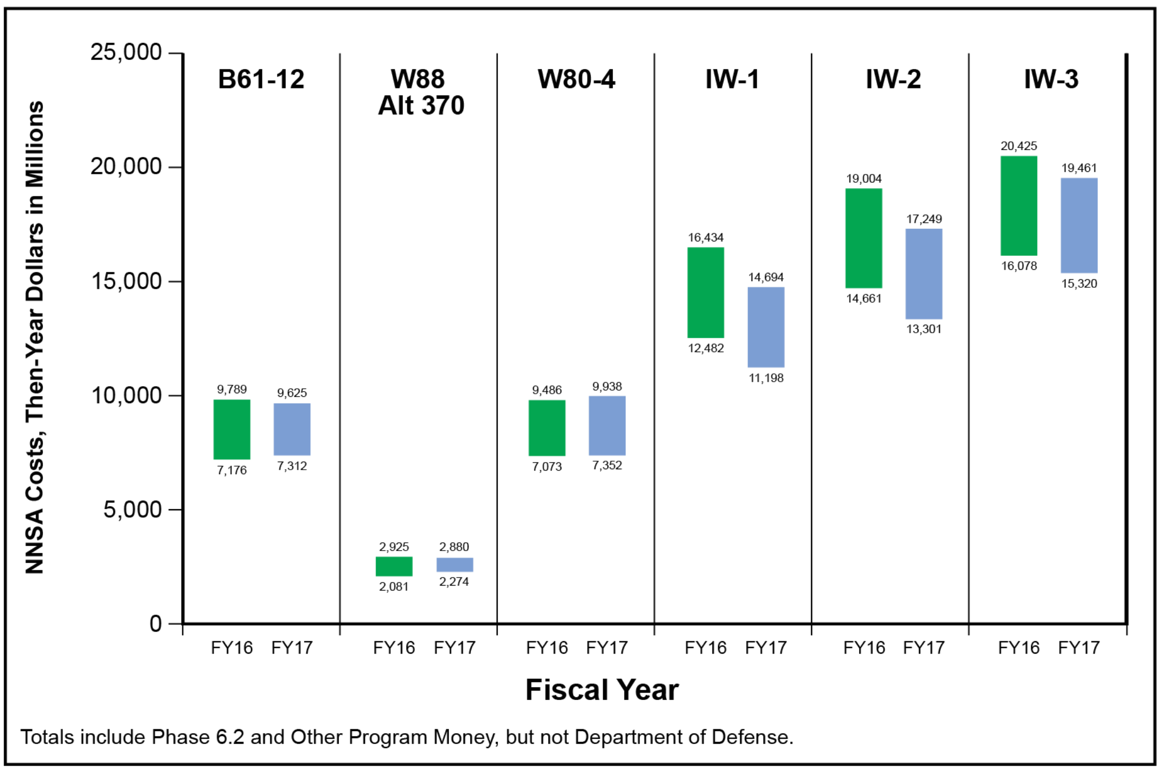



**Figure 4–34. *FY 2016 SSMP* versus *FY 2017 SSMP* independent cost estimates**

### 4.8.5 Construction Costs

The budget requirement estimate for construction in FY 2022 and beyond, as part of the Infrastructure construction total included in Figure 4–22, is based on the set of projects in the NNSA Construction Resource Planning List[23] shown in **Figure 4–35**. Because of the preliminary planning status for most of these projects, many have been binned in one of three cost ranges. For projects estimated to cost more than $500 million, upper bounds were estimated based on the best available data. The projects in the Construction Resource Planning List that will start beyond the FYNSP have also been binned in the five-year period in which they are expected to start, based on "hard requirements" for their completion or general priority. These are listed in alphabetical order in each bin because they are not in priority order within the bin. Construction funding for each of these periods is based on the total cost of the projects started in that period spread over the five years of the period.[24] It should be noted that this list does not constitute a specific 25-year construction plan, but rather as input to a method to forecast potential future construction costs. Specific decisions about funding individual projects will be made as part of the annual programming process for the FYNSP and in accordance with DOE construction-related orders.

**Table 4–12** shows the low, high, and midpoint total costs for executing all the projects on the Construction Resource Planning List that are scheduled for FY 2022 and beyond. As can be inferred from this table, significant uncertainty exists in these construction cost estimates because of the immaturity of planning for these projects. Most have not achieved CD-0 Mission need under DOE Order 413.3, nor have Analyses of Alternatives been conducted, which might result in decisions to pursue non-construction solutions to the mission need or significant changes to the construction cost estimates.

**Table 4–12. Total cost of construction for fiscal years 2022–2041**

| *Then-Year Dollars in Millions* | *Low* | *High* | *Midpoint* |
|---|---|---|---|
| Total Construction Resource Planning List cost | 11,143 | 33,847 [a] | 20,131 |

[a] The "high" estimate for construction includes provisional funding for a domestic uranium enrichment capability.

If the midpoint cost is compared to the value in the *FY 2016 SSMP* (for the overlapping years of the two estimates for construction, FY 2022 through FY 2040) the difference is an increase of about $2.2 billion. The increase is the result of the addition of 11 projects to the Construction Resource Planning List (in red) and increases in early projected cost ranges for MaRIE, the Radiation-Hardened Foundry, and the Plutonium Modular Approach.

[23] In the *FY 2016 SSMP*, this list was labeled "NNSA Integrated Project List for Capital Construction." The name has been changed to better reflect the use of this information, which is to produce a reasonable estimate of required out-year construction resources.

[24] For projects whose construction period exceeds five years, the project cost was split over two five-year periods.

| Project (all costs in FY 2015 dollars) | FY17 | FY18 | FY19 | FY20 | FY21 | FY22-26 | FY27-31 | FY32-36 | FY37-41 |
|---|---|---|---|---|---|---|---|---|---|
| U1a Complex Enhancements Project, NNSS | Green | Green | Green | Green | Green | | | | |
| Tritium Production Capability, SRS | | Green | Green | Green | Green | | | | |
| Lithium Production Facility, Y-12 | | | Green | Green | Green | Green | | | |
| TA-55 Reinvestment Project, Phase 3, LANL | Blue | Blue | Blue | Blue | | | | | |
| Transuranic Liquid Waste Facility, LANL | Blue | Blue | | | | | | | |
| Uranium Processing Facility, Y-12 | Orange | Orange | Orange | Orange | Orange | Orange | | | |
| CMRR Project, LANL | Orange | Orange | Orange | Orange | Orange | Orange | | | |
| Zone 11 High Pressure Fire Loop, PX | | | Blue | Blue | Blue | | | | |
| New 138K Power Transmission Event Corridor, NNSS | | | Blue | Blue | Blue | | | | |
| Fire Station, Y-12 | | Blue | | | | | | | |
| Expand Electrical Distribution System, LLNL | Blue | | | | | | | | |
| Albuquerque Complex Project | Blue | Blue | | | | | | | |
| Emergency Operatons Center, Y-12 | Blue | | | | | | | | |
| Emergency Operatons Center, LLNL | | Blue | | | | | | | |
| Emergency Operatons Center, SNL | | | Blue | | | | | | |
| Electrical Transmission and Distribution Capacity Upgrade, LANL | | | | | | Blue | | | |
| Energetic Materials Characterization, LANL | | | | | → | Blue | | | |
| Fire Station Replacement for older 1 & 5, LANL | | | | | | Blue | | | |
| H-Area New Manufacturing (HANM) Chiller EPA Compliance, SRS | | | | | | Blue | ← | | |
| High Explosive Formulation, PX | | | | | | Green | ← | | |
| HE Science, Technology & Engineering, PX | | | | | → | Green | | | |
| Los Alamos Canyon Bridge Upgrade, LANL | | | | | | Blue | | | |
| Livermore Computing Complex Modernization | | | | | | Blue | | | |
| MaRIE (Science Tool), LANL | | | | | | Orange | Orange | | |
| Production Support Fire Suppression Lead-ins, PX | | | | | | Green | Green | ← | |
| Plutonium Modular Approach, LANL | | | | | | Orange | Orange | | |
| Rad Hard Foundry, SNL | | | | | | Orange | Orange | | |
| Seismic Risk Mitigation Project, LLNL | | | | | | Blue | | | |
| Site 300 Nuclear Security Infrastructure Stabilization | | | | | | Blue | | | |
| Technical Area IV District Chilled Water Loop, SNL | | | | | | Blue | ← | | |
| Underground Electrical Distribution Replacement, PX | | | | | | Blue | | | |
| Utility Distribution System, LLNL | | | | | | Blue | | | |
| Weapons Engineering Facility, SNL | | | | | → | Green | | | |
| 12-037 New Facility, PX | | | | | | | Blue | | |
| Building 256 Network Communication Data Center, LLNL | | | | | | | Blue | | |
| Consolidated Mission Support Facility, NNSS | | | | | | | Blue | | |
| Gravity Weapons Certification, SNL/TTR | | | | | | | Blue | | |
| HANM Risk Reduction, SRS | | | | | | | Blue | | |
| Material Staging Facility, PX | | | | | | | Orange | | |
| Network Intelligence Research Facility, LLNL | | | | | | | Blue | | |
| NNSS Consolidated Operation Complex, NNSS | | | | | | | Blue | | |
| Office/Light Lab Replacement Building, LANL | | | | | | | Blue | ← | |
| PIDAS Reduction, Y-12 | | | | | | | Green | | Green |
| Radiography and Assembly Complex Replacement, LANL | | | | | | | Green | | |
| Steam Plant Replacement, LANL | | | | | | → | Green | Green | ← |
| Water Supply and Distribution System, NNSS | | | | | | | Blue | | |
| Weapons Manufacturing Support, LANL | | | | | | | Blue | | |
| Consolidated Environmental Test Facility, SNL | | | | | | | | Green | |
| HE Component Fab and Qual, PX | | | | | | | → | Green | |
| High Explosive Packaging & Staging, PX | | | | | | | | Green | |
| Inert Manufacturing Facility, PX | | | | | | | | Blue | |
| Materials Receiving and Storage Facility, Y-12 | | | | | | | | Blue | |
| Mission Support Science and Technology Laboratory, SNL | | | | | | | | Blue | |
| Modern Threat Abeyance Center, SNL | | | | | | | | Blue | |
| NEP Engineering & Materials Complex Replacement, LLNL | | | | | | | | Blue | |
| High Performance Sustainable Building Retrofit, NNSS | | | | | | | | Blue | |
| Radio Communications System Replacement, NNSS | | | | | | | | Blue | |
| Non-Destructive Evaluation Facility, PX | | | | | | | | Green | |
| Radiochemistry Laboratory Revitalization, LLNL | | | | | | | | Blue | |
| Research Reactor Facility, SNL | | | | | | | | Green | |
| Sitewide Storm Drainage Improvements, SNL | | | | | | | | Blue | |
| Truck Route Intersection and HE Road Renovation, LANL | | | | | | | | Blue | |
| Weapons Engineering Science and Technology, LLNL | | | | | | | | Green | |
| 11-051/11-051A/12-188 Replacement (laboratory facilities), PX | | | | | | | | | Blue |
| 12-005 Shops Replacement, PX | | | | | | | | | Blue |
| 12-026 East Refurbishment and 12-026 Replacement, PX | | | | | | | | | Blue |
| 12-064 Replacement (Weapons A/D), PX | | | | | | | | | Blue |
| 12-079 Inert Storage Refurbishment, PX | | | | | | | | | Blue |
| 9215 Capability Replacement, Y-12 | | | | | | | | | Green |
| Applied Technologies Laboratory, Y-12 | | | | | | | | | Blue |
| Consolidated Manufacturing Complex, Y-12 | | | | | | | | | Green |
| Fire Department Vehicle Storage and Training Facility, PX | | | | | | | | | Blue |
| HE Research and Development, LLNL | | | | | | | | | Blue |
| HE Special Facility Equipment, LLNL | | | | | | | | | Blue |
| HEDP Precision Targets and Diagnostic Facility, LLNL | | | | | | | | | Blue |
| Maintenance Facility, Y-12 | | | | | | | | | Blue |
| Materials Science Modernization, LLNL | | | | | | | | | Green |
| Mission Support Consolidation, SNL | | | | | | | | | Green |
| Multi-Purpose Office Building, LANL | | | | | | | | | Blue |
| Nuclear Security Applications Laboratory, LLNL | | | | | | | | | Blue |
| Receiving and Distribution Center Replacement, LANL | | | | | | | | | Blue |
| Robust Secure Communications Laboratory, SNL | | | | | | | | | Blue |
| Supercomputing and Analysis Complex Modernization, LLNL | | | | | | | | | Blue |
| Sustainable Supercomputing and Analysis Center, LLNL | | | | | | | | | Blue |
| Technical Area III and Remote Area, SNL | | | | | | | | | Blue |
| Tonapah Test Range Infrastructure, SNL | | | | | | | | | Blue |

**Project Key**

- (Blue) Total Project Costs $10M-$100M
- (Green) Total Project Costs $100M-$500M
- (Orange) Total Project Costs >$500M
- → Project Delayed from SSMP 2016
- ← Project Accelerated from SSMP 2016
- **New Projects in Red Type**

CMRR - Chemistry and Metallurgy Research Replacement
EPA - U.S. Environmental Protection Agency
HANM - H Area New Manufacturing
HE - High Explosive
HEDP - High Energy Density Physics
LANL - Los Alamos National Laboratory
LLNL - Lawrence Livermore National Laboratory
MaRIE - Matter-Radiation Interactions in Extreme
NEP - Nuclear Explosive Package
NNSS - Nevada National Security Site
PIDAS - Perimeter Intrusion Detection and Assessment System
PX - Pantex
SNL - Sandia National Laboratories
SRS - Savannah River Site
TA - Technical Area
TTR - Tonapah Test Range
UPF - Uranium Processing Facility
Y-12 - Y-12 National Security Complex

**Figure 4–35. NNSA Construction Resource Planning List**

# Chapter 5
# Conclusion

This DOE/NNSA *FY 2017 SSMP*, together with its classified Annex, is a key planning document for the nuclear security enterprise. It is a summary plan that updates the *FY 2016 SSMP,* the 25-year strategic program of record that captures the plans developed across numerous NNSA programs and organizations to maintain and modernize the scientific tools, capabilities, and infrastructure to ensure mission success. The NNSA Federal workforce prepares each SSMP in collaboration with its eight M&O partners. The plans in the *FY 2017 SSMP* were also coordinated with DOD through the Nuclear Weapons Council, which promulgates most requirements to ensure the Nation's nuclear deterrent remains safe, secure, and effective. As with previous SSMPs, a new version is published each year as NNSA updates its strategic plans in response to new requirements and challenges related to stewardship and management of the stockpile.

Much was accomplished in FY 2015 as part of the program of record described in this year's SSMP. Once again, the science-based Stockpile Stewardship Program allowed the Secretaries of Energy and Defense to assess that the stockpile remains safe, secure, and effective without the need for underground nuclear explosive testing. The talented scientists, engineers, and technicians at the three national security laboratories, the four nuclear weapons production plants, and the Nevada National Security Site are primarily responsible for this continued success.

The research, development, test, and evaluation programs have advanced NNSA's understanding of weapons physics, component aging, and material properties through first-of-a-kind shock physics experiments, along with numerous other critical experiments conducted throughout the nuclear security enterprise. The multiple LEPs that are underway made progress toward their first production unit dates. The W76-1 LEP is past the halfway point in total production, and the B61-12 completed three development flight tests.

Changes in plans since the *FY 2016 SSMP* include the following:

- In FY 2015, warhead dismantlement did not proceed at a rate to allow dismantlement of all weapons retired prior to FY 2009 by FY 2022. NNSA intends to increase that rate, starting in FY 2018, to recover the shortfall and complete the dismantlement a year early (by FY 2021 if the full amount of the requested funding is provided).
- Some Infrastructure and Operations projects have been deferred beyond the FY 2017 Future Years Nuclear Security Program to address higher NNSA priorities.
- With a restructuring to balance the effort on stockpile stewardship against the effort to understand ignition, the National Ignition Facility's contribution to stewardship has increased.
- An Enhanced Capability for Subcritical Experiments initiative has been approved to develop the capability to explore the late-time hydrodynamic behavior of scaled imploding systems at the U1a Complex using more energetic radiographic sources, as well as neutron reactivity.

- Several programs have been realigned because of higher priorities. The Engineering Program is shifting its emphasis to the immediate needs of the Directed Stockpile Program. Advanced Manufacturing Development has been realigned to address higher priorities.

NNSA recognizes the challenge of maintaining a quality workforce, which is crucial to mission success. Consequently, NNSA has already instituted several efforts to ensure that the workforce is challenged and exercised throughout the entire nuclear weapons life cycle. NNSA will also continue to examine how to best achieve a responsive infrastructure.

The schedule for the LEPs and major Alts is unchanged from the *FY 2016 SSMP*:

- Complete production of the W76-1 warheads by FY 2019.
- Deliver the first production unit of the B61-12 by FY 2020.
- Deliver the first production unit of the W88 Alt 370 (with refresh of the conventional high explosive) by FY 2020.
- Achieve a first production unit of the W80-4 by FY 2025.

Out-year objectives include the following:

- Produce 10 War Reserve pits in 2024, 20 War Reserve pits in 2025, and 30 War Reserve pits in 2026.
- Attain a 50 to 80 pits-per-year capability as part of a responsive infrastructure by 2030.
- End enriched uranium operations in Building 9212 at Y-12 National Security Complex and deliver the Uranium Processing Facility for no more than $6.5 billion by 2025.
- Implement the 3+2 Strategy for a smaller stockpile with upgraded safety and security and interoperable nuclear explosive packages (for missile warheads).

Unforeseen technological challenges, new requirements, and geopolitical events could affect the priorities underlying this strategic plan. The major challenge is continuing to balance requirements. These include meeting the near-term needs of the stockpile, sustaining or recapitalizing the infrastructure, and advancing the understanding of the performance of weapons in the stockpile. A responsive infrastructure will only be feasible through proper planning and national leadership commitment.

NNSA has confidence in its ability to execute the program described in this *FY 2017 SSMP* if funded at the requested levels. The LEPs are on schedule and, once completed, will assure an extended service life and improve the safety and effectiveness of the stockpile. With Congress' support, the safety, security, and reliability of the stockpile can be maintained and the Nation's stewardship sustained.

# Appendix A
# Requirements Mapping

## A.1 National Nuclear Security Administration Response to Statutory Reporting Requirements and Related Requests

The *FY 2017 SSMP* consolidates a number of statutory reporting requirements and related congressional requests. This appendix maps the statutory and congressional requirements to their respective chapter and section in the *FY 2016 SSMP* and *FY 2017 SSMP*.

## A.2 Ongoing Requirements

| *50 U.S. Code § 2521* | *FY 2016 Response* | *FY 2017 Response/Updates* |
|---|---|---|
| **§ 2521. Stockpile stewardship program**<br>(a) Establishment<br>The Secretary of Energy, acting through the Administrator for Nuclear Security, shall establish a stewardship program to ensure –<br>(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<br>(2) that the nuclear weapons stockpile is safe, secure, and reliable without the use of underground nuclear weapons testing. | *Unclassified*<br>All Chapters | *Unclassified*<br>All Chapters |
| (b) Program elements<br>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. | *Unclassified*<br>Chapter 3, Section 3.6.2; Appendix C | *Unclassified*<br>Chapter 3, Section 3.1.2; Chapter 4, Section 4.3.4; Appendix B |
| (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. | *Unclassified*<br>Chapter 3, Sections 3.5, 3.6, 3.7 | *Unclassified*<br>Chapter 2, Section 2.3.2; Chapter 3, Section 3.2; Chapter 4, Sections 4.3.1, 4.3.3 |
| (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. | *Unclassified*<br>Chapter 3, Sections 3.5, 3.6, 3.7; Chapter 4, Section 4.3.3 | *Unclassified*<br>Chapter 3, Sections 3.2.1, 3.2.2; Chapter 4, Section 4.8.5 |

| 50 U.S. Code § 2521 | FY 2016 Response | FY 2017 Response/Updates |
|---|---|---|
| (4) Support for the use of, and experiments facilitated by, the advanced experimental facilities of the United States, including -<br>(A) the National Ignition Facility at Lawrence Livermore National Laboratory;<br>(B) the Dual Axis Radiographic Hydrodynamic Testing facility at Los Alamos National Laboratory;<br>(C) the Z Machine at Sandia National Laboratories; and<br>(D) the experimental facilities at the Nevada National Security Site. | *Unclassified*<br>Chapter 3, Sections 3.5, 3.6, 3.7 | *Unclassified*<br>Chapter 3, Section 3.2; Chapter 4, Sections 4.3.1, 4.3.2, 4.3.3, 4.3.4, 4.8.5 |
| (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 -<br>(A) the nuclear weapons production facilities; and<br>(B) production and manufacturing capabilities resident in the national security laboratories. | *Unclassified*<br>Chapter 2, Section 2.4.6; Chapter 4, Section 4.4 | *Unclassified*<br>Chapter 3, Sections 3.3.1, 3.3.2, 3.3.3, 3.3.4, 3.3.5, 3.3.6; Chapter 4, Sections 4.1, 4.3, 4.8.5 |
| ***(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. | *Unclassified*<br>Chapter 3, Section 3.6.2; Appendix C | *Unclassified*<br>Chapter 3, Sections 3.1.1, 3.1.2, 3.1.2; Appendix B |
| (b) MILESTONES.—The plan required by subsection (a) shall include major programmatic milestones in—<br>(1) the development of a prototype exascale computer for the stockpile stewardship program; and<br>(2) mitigating disruptions resulting from the transition to exascale computing. | *Unclassified*<br>Chapter 3, Section 3.6.2; Appendix C | *Unclassified*<br>Chapter 3, Sections 3.1.1, 3.1.2, 3.1.3; Chapter 4, Section 4.3.4; Appendix B |
| (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))). | *Unclassified*<br>Chapter 3, Section 3.6.2; Appendix C | *Unclassified*<br>Appendix B |
| (d) INCLUSION OF COSTS IN FUTURE-YEARS NUCLEAR SECURITY PROGRAM.—The Administrator shall—<br>(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—<br>(A) developing exascale computing and incorporating such computing into the stockpile stewardship program; and<br>(B) mitigating potential disruptions resulting from the transition to exascale computing; and<br>(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. | *Unclassified*<br>Appendix C | *Unclassified*<br>Chapter 4, Section 4.3.4; Appendix B |

| ***50 U.S. Code § 2521*** | ***FY 2016 Response*** | ***FY 2017 Response/Updates*** |
|---|---|---|
| (e) SUBMISSION TO CONGRESS.—The Administrator shall submit the plan required by subsection (a) to the congressional defense committees 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 18th power floating point operations per second. | | |

| ***50 U.S. Code § 2522*** | ***FY 2016 Response*** | ***FY 2017 Response/Updates*** |
|---|---|---|
| **§ 2522. Report on stockpile stewardship criteria** | | |
| (a) Requirement for criteria<br>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. | *Unclassified*<br>Chapter 3, Section 3.4.2<br>———<br>*Classified*<br>Chapter 3, Section 3.2 | *Unclassified*<br>Chapter 2, Sections 2.1.1, 2.1.2, 2.1.3, 2.3.1, 2.3.2; Chapter 3, Section 3.1, 3.2; Chapter 4, Sections 4.3.1, 4.3.2, 4.3.3, 4.3.4 |
| (b) Coordination with Secretary of Defense<br>The Secretary of Energy, in developing the criteria required by subsection (a), shall coordinate with the Secretary of Defense. | | |

| ***50 U.S. Code § 2523*** | ***FY 2016 Response*** | ***FY 2017 Response/Updates*** |
|---|---|---|
| **§ 2523. Nuclear weapons stockpile stewardship, management, and infrastructure plan** | | |
| (a) Plan requirement<br>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 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*<br>All Chapters | *Unclassified*<br>All Chapters<br>———<br>*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). | *N/A* | *Unclassified*<br>All chapters |
| (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). | *Unclassified*<br>All chapters | *N/A* |
| (3) The summaries and reports required by this subsection shall be submitted in unclassified form, but may include a classified annex. | | |

| ***50 U.S. Code § 2523*** | ***FY 2016 Response*** | ***FY 2017 Response/Updates*** |
|---|---|---|
| (c) Elements of biennial plan summary<br>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. | *N/A* | *Unclassified*<br>Chapter 2,<br>Section 2.1<br>———<br>*Classified Annex* |
| (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. | *N/A* | *Unclassified*<br>Chapter 2,<br>Section 2.2;<br>Chapter 4<br>———<br>*Classified Annex* |
| (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. | *N/A* | *Unclassified*<br>Chapter 2,<br>Section 2.3;<br>Chapter 3,<br>Sections 3.1, 3.2 |
| (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. | *N/A* | *Unclassified*<br>Chapter 1,<br>Section 1.6;<br>Chapter 3,<br>All Sections;<br>Chapter 4,<br>All Sections |
| (5) Identification of any modifications or updates to the plan since the previous summary or detailed report was submitted under subsection (b). | *N/A* | *Unclassified*<br>Executive Summary;<br>Chapter 5 |
| (6) Such other information as the Administrator considers appropriate. | *N/A* | *Unclassified*<br>Chapter 5 |
| (d) Elements of biennial detailed report<br>Each detailed report on the plan submitted under subsection (b)(2) shall include, at a minimum, the following: | | |
| (1) With respect to stockpile stewardship and management— | | |
| (A) the status of the nuclear weapons stockpile, including the number and age of warheads (including both active and inactive) for each warhead type; | *Unclassified*<br>Chapter 1,<br>Section 1.2;<br>Chapter 2,<br>Section 2.1<br>———<br>*Classified*<br>Chapter 2,<br>Sections 2.2, 2.4.1 | *N/A* |

| *50 U.S. Code § 2523* | *FY 2016 Response* | *FY 2017 Response/Updates* |
|---|---|---|
| (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—<br>(i) the planned number of nuclear warheads (including active and inactive) for each warhead type in the nuclear weapons stockpile; and<br>(ii) the past and projected future total lifecycle cost of each type of nuclear weapon; | *Unclassified*<br>Chapter 8, Sections 8.9.1, 8.9.2<br>———<br>*Classified*<br>Chapter 2, Sections 2.1.1, 2.1.2 | *N/A* |
| (C) the status, plans, budgets, and schedules for warhead life extension programs and any other programs to modify, update, or replace warhead types; | *Unclassified*<br>Chapter 2, Sections 2.3, 2.4; Chapter 8, Section 8.9.2<br>———<br>*Classified*<br>Chapter 2, Section 2.3 | *N/A* |
| (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; | *Unclassified*<br>Chapter 2, Section 2.2.1 | *N/A* |
| (E) a description of the process used in recertifying the safety, security, and reliability of each warhead type in the nuclear weapons stockpile; | *Unclassified*<br>Chapter 2, Sections 2.1.1, 2.1.2, 2.4.3, 2.5.1; Chapter 3, Sections 3.4.2, 3.5.1, 3.6.1, 3.6.4 | *N/A* |
| (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); | *Unclassified*<br>Chapter 2, Section 2.1.2; Chapter 3, Section 3.3<br>———<br>*Classified*<br>Chapter 2, Section 2.3 | *N/A* |
| (G) mechanisms to provide for the manufacture, maintenance, and modernization of each warhead type in the nuclear weapons stockpile, as needed; | *Classified*<br>Chapter 2; Chapter 3, Section 3.1.3 | *N/A* |
| (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; | *Unclassified*<br>Chapter 2, Sections 2.2.1, 2.2.2, 2.4.5 | *N/A* |
| (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; | *Unclassified*<br>Chapter 2, Section 2.1.4; Chapter 7, Section 7.3.2 | *N/A* |

| *50 U.S. Code § 2523* | *FY 2016 Response* | *FY 2017 Response/Updates* |
|---|---|---|
| (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; | *Unclassified*<br>Chapter 2, Section 2.4.3 | *N/A* |
| (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 | *Unclassified*<br>Chapter 4, Section 4.4; Chapter 8, Sections 8.1, 8.9 | *N/A* |
| (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. | *Unclassified*<br>Chapter 8, Section 8.1 | *N/A* |
| (2) With respect to science-based tools— | | *N/A* |
| (A) a description of the information needed to determine that the nuclear weapons stockpile is safe and reliable; | *Unclassified*<br>Chapter 2, Section 2.1.1; Chapter 3, Section 3.4.2<br>———<br>*Classified*<br>Chapter 3, Section 3.2 | *N/A* |
| (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 | *Unclassified*<br>Chapter 3, Section 3.4.2<br>———<br>*Classified*<br>Chapter 3, Section 3.2 | *N/A* |
| (C) the criteria developed under section 2522(a) of this title (including any updates to such criteria). | | *N/A* |
| (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— | | *N/A* |
| (A) an identification and description of—<br>(i) any key technical challenges to the stockpile stewardship program; and<br>(ii) the strategies to address such challenges without the use of nuclear testing; | *Unclassified*<br>Chapter 3, Section 3.3<br>———<br>*Classified*<br>Chapter 3, Section 3.2 | *N/A* |
| (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; | *Unclassified*<br>Chapter 3<br>———<br>*Classified*<br>Chapter 3, Section 3.2 | *N/A* |

| *50 U.S. Code § 2523* | *FY 2016 Response* | *FY 2017 Response/Updates* |
|---|---|---|
| (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 | *Unclassified* Chapter 3, Section 3.3<br>*Classified* Chapter 3, Section 3.2 | *N/A* |
| (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— | *Unclassified* Chapter 7, Section 7.4.2 | *N/A* |
| (i) the number of scientists, engineers, and technicians, by discipline, required to maintain such competencies; and | *Unclassified* Appendix D | *N/A* |
| (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. | *Unclassified* Appendix D | *N/A* |
| (4) With respect to the nuclear security infrastructure— | | *N/A* |
| (A) a description of the modernization and refurbishment measures the Administrator determines necessary to meet the requirements prescribed in— | *Unclassified* Chapter 4, Section 4.3 | *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 404a of this title if such strategy has been submitted as of the date of the plan; | | *N/A* |
| (ii) the most recent quadrennial defense review if such strategy has not been submitted as of the date of the plan; and | | *N/A* |
| (iii) the most recent Nuclear Posture Review as of the date of the plan; | | *N/A* |
| (B) a schedule for implementing the measures described under subparagraph (A) during the 10-year period following the date of the plan; and | *Unclassified* Chapter 4, Section 4.2.4 | *N/A* |
| (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. | *Unclassified* Chapter 8, Sections 8.4, 8.5, 8.9 | *N/A* |
| (5) With respect to the nuclear test readiness of the United States— | | *N/A* |
| (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; | *Unclassified* Chapter 3, Section 3.2 | *N/A* |
| (B) a description of the level of test readiness that the Administrator, in consultation with the Secretary of Defense, determines to be appropriate; | *Unclassified* Chapter 3, Section 3.2 | *N/A* |
| (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; | *Unclassified* Chapter 3, Section 3.2 | *N/A* |
| (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 | *Unclassified* Chapter 3, Section 3.2 | *N/A* |

| 50 U.S. Code § 2523 | FY 2016 Response | FY 2017 Response/Updates |
|---|---|---|
| (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). | *Unclassified*<br>Chapter 3,<br>Section 3.2 | *N/A* |
| (6) A strategy for the integrated management of plutonium for stockpile and stockpile stewardship needs over a 20-year period that includes the following: | | *N/A* |
| (A) An assessment of the baseline science issues necessary to understand plutonium aging under static and dynamic conditions under manufactured and nonmanufactured plutonium geometries. | *Unclassified*<br>Chapter 3,<br>Section 3.4.2<br>———<br>*Classified*<br>Chapter 3,<br>Section 3.2.1 | *N/A* |
| (B) An assessment of scientific and testing instrumentation for plutonium at elemental and bulk conditions. | *Unclassified*<br>Chapter 3,<br>Sections 3.1, 3.5.3, 3.6.1, 3.6.4<br>———<br>*Classified*<br>Chapter 3,<br>Section 3.2.1 | *N/A* |
| (C) An assessment of manufacturing and handling technology for plutonium and plutonium components. | *Unclassified*<br>Chapter 2,<br>Section 2.4.6;<br>Chapter 4,<br>Section 4.3.3 | *N/A* |
| (D) An assessment of computational models of plutonium performance under static and dynamic loading, including manufactured and nonmanufactured conditions. | *Unclassified*<br>Chapter 3,<br>Section 3.6.2<br>———<br>*Classified*<br>Chapter 3,<br>Section 3.2.1 | *N/A* |
| (E) An identification of any capability gaps with respect to the assessments described in subparagraphs (A) through (D). | *Unclassified*<br>Chapter 3,<br>Sections 3.3, 3.4.2<br>———<br>*Classified*<br>Chapter 3,<br>Section 3.2 | *N/A* |
| (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. | *Unclassified*<br>Chapter 8,<br>Section 8.3 | *N/A* |
| (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. | *Unclassified*<br>Chapter 8,<br>Section 8.3 | *N/A* |
| (H) Such other items as the Administrator considers important for the integrated management of plutonium for stockpile and stockpile stewardship needs. | *Unclassified*<br>Chapter 2,<br>Section 2.4.6;<br>Chapter 4,<br>Section 4.3.3 | *N/A* |

| *50 U.S. Code § 2523* | *FY 2016 Response* | *FY 2017 Response/Updates* |
|---|---|---|
| (7) Identification of any modifications or updates to the plan since the previous summary or detailed report was submitted under subsection (b). | *Unclassified* Executive Summary | *N/A* |
| (e) Nuclear Weapons Council assessment | *N/A* | *N/A* |
| (f) Definitions<br>In this section:<br>(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.<br>(2) The term "future-years nuclear security program" means the program required by section 2453 of this title.<br>(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.<br>(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.<br>(5) The term "weapons activities" means each activity within the budget category of weapons activities in the budget of the Administration.<br>(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—<br>(A) nuclear nonproliferation;<br>(B) nuclear forensics;<br>(C) nuclear intelligence;<br>(D) nuclear safety; and<br>(E) nuclear incident response. | | |

| *50 U.S. Code § 2524* | *FY 2016 Response* | *FY 2017 Response/Updates* |
|---|---|---|
| **§ 2524. Stockpile management program** | | |
| (a) Program required<br>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. | *Unclassified* Chapter 2, Section 2.1.4 | *Unclassified* Chapter 2, Section 2.2 |
| (2) To further reduce the likelihood of the resumption of underground nuclear weapons testing. | *Unclassified* Chapter 3, Section 3.4 | *Unclassified* Chapter 3, Section 3.2 |

| *50 U.S. Code § 2524* | *FY 2016 Response* | *FY 2017 Response/Updates* |
|---|---|---|
| (3) To achieve reductions in the future size of the nuclear weapons stockpile. | *Unclassified* Chapter 1, Section 1.3<br>———<br>*Classified* Chapter 2, Section 2.5.2 | *Unclassified* Chapter 2, Section 2.2 |
| (4) To reduce the risk of an accidental detonation of an element of the stockpile. | *Unclassified* Chapter 2, Section 2.2<br>———<br>*Classified* Chapter 2, Section 3.2.3 | *Unclassified* Chapter 2, Sections 2.1, 2.1.1, 2.1.2, 2.1.4, 2.1.5, 2.2.4; Chapter 3, Sections 3.1, 3.2, 3.3.5 |
| (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. | *Unclassified* Chapter 2, Section 2.2; Chapter 6, Section 6.1.5 | *Unclassified* Chapter 2, Section 2.2.4; Chapter 3, Section 3.2, 3.6.1; Chapter 4, Section 4.2.2 |
| (b) Program limitations<br>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 | | *N/A* |
| (2) any such changes made to the stockpile shall--<br>(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<br>(B) use the design, certification, and production expertise resident in the nuclear security enterprise to fulfill current mission requirements of the existing stockpile. | | *N/A* |
| (c) Program budget<br>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. | | *N/A* |

| *50 U.S. Code § 2453* | *FY 2016 Response* | *FY 2017 Response/Updates* |
|---|---|---|
| (b) Elements | | |
| (5) A plan, developed in consultation with the Director of the Office of Health, Safety, and Security of the Department of Energy, 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 applicable five-fiscal-year period, together with— | *N/A* | *Unclassified*<br>Chapter 3, Section 3.6; Chapter 4, Section 4.6, 4.7 |
| (A) for each site in the nuclear security enterprise, a description of the technologies deployed to address the physical and cyber security threats posed to that site; | *N/A* | *Unclassified*<br>Chapter 3, Section 3.6, 3.6.1, 3.6.2 |
| (B) for each site and for the nuclear security enterprise, the methods used by the Administration to establish priorities among investments in physical and cyber security technologies; and | *N/A* | *Unclassified*<br>Chapter 3, Section 3.6 |
| (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*<br>Chapter 4, Section 4.6, 4.7 |

# A.3 Other Requirements

| *FY 2015 National Defense Authorization Act, Pu L. 113-66* | *FY 2016 Response* | *FY 2017 Response/Updates* |
|---|---|---|
| Section 3112 of this Act adds the following section to 50 U.S.C. 2521-<br>Section 4219—Plutonium Pit Production Capacity<br>(a) REQUIREMENT—Consistent with the requirements of the Secretary of Defense, the Secretary of Energy shall ensure that the nuclear security enterprise--<br>(1) during 2021, begins production of qualification plutonium pits;<br>(2) during 2024, produces not less than 10 war reserve plutonium pits;<br>(3) during 2025, produces not less than 20 war reserve plutonium pits;<br>(4) during 2026, produces not less than 30 war reserve plutonium pits; and<br>(5) during a pilot period of not less than 90 days during 2027 (subject to produce war reserve plutonium pits at a rate sufficient to produce 80 pits per year. In a coordinated manner, DOE and DOD may slip this requirement up to 2 years. | *Unclassified*<br>Message from the Secretary; Chapter 2, Section 2.4.6; Chapter 4, Section 4.3.3<br>———<br>*Classified*<br>Chapter 2, Section 2.1.2 | *Unclassified*<br>Chapter 3, Section 3.3.1; Chapter 5 |

| *FY 2015 National Defense Authorization Act, Pu L. 113-66* | *FY 2016 Response* | *FY 2017 Response/Updates* |
|---|---|---|
| (b) AUTHORIZATION OF TWO-YEAR DELAY OF DEMONSTRATION REQUIREMENT—The Secretary of Energy and the Secretary of Defense may jointly delay, for not more than two years, the requirement under subsection 2 (a)(5) if—<br>(1) the Secretary of Defense and the Secretary of Energy jointly submit to the congressional defense committees a report describing—<br>(A) the justification for the proposed delay;<br>(B) the effects of the proposed delay on stockpile stewardship and modernization, life extension programs, future stockpile strategy, and dismantlement efforts; and<br>(C) whether the proposed delay is consistent with national policy regarding creation of a responsive nuclear infrastructure; and<br>(2) the Commander of the United States Strategic Command submits to the congressional defense committees a report containing the assessment of the Commander with respect to the potential risks to national security of the proposed delay in meeting<br>(A) the nuclear deterrence requirements of the United States Strategic Command; and<br>(B) national requirements related to creation of a responsive nuclear infrastructure. | | |
| (c) ANNUAL CERTIFICATION.—Not later than March 1, 2015, and each year thereafter through 2027, 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) | | Administrator's Letter |
| Section 3119—Production of Nuclear Warhead for Long-Range Standoff Weapon<br>(a) First Production Unit. The Secretary of Energy shall deliver a first production unit for a nuclear warhead for the long-range standoff weapon by not later than September 30, 2025. | *Unclassified* Chapter 2, Sections 2.1.4, 2.4.1, 2.5.2<br>———<br>*Classified* Chapter 2, Section 2.6 | *Unclassified* Chapter 2, Sections 2.1.5, 2.2.4 |

| *National Defense Authorization Act for Fiscal Year 2016, H.R. 1735, Section 3112* | *FY 2016 Response* | *FY 2017 Response/Updates* |
|---|---|---|
| **Sec. 3112. STOCKPILE RESPONSIVENESS PROGRAM**<br>(a) SENSE OF CONGRESS.—It is the sense of Congress that— | | |
| (1) a modern and responsive nuclear weapons infrastructure is only one component of a nuclear posture that is agile, flexible, and responsive to change; and<br>(2) to ensure the nuclear deterrent of the United States remains safe, secure, reliable, credible, and responsive, the United States must continually exercise all capabilities required to conceptualize, study, design, develop, engineer, certify, produce, and deploy nuclear weapons. | *N/A* | *Unclassified* Chapter 3, Introduction |
| (b) ESTABLISHMENT OF PROGRAM.— | | |
| (1) IN GENERAL.—Subtitle A of title XLII of the Atomic Energy Defense Act (50 U.S.C. 2521 et seq.) is amended by adding at the end the following new section: | *N/A* | |

| *National Defense Authorization Act for Fiscal Year 2016, H.R. 1735, Section 3112* | *FY 2016 Response* | *FY 2017 Response/Updates* |
|---|---|---|
| **Sec. 4220. 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. | *N/A* | |
| (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 4201 and the stockpile management program under section 4204, to identify, sustain, enhance, integrate, and continually exercise all capabilities required to conceptualize, study, design, develop, engineer, certify, produce, and deploy nuclear weapons. | *N/A* | *Unclassified* Chapter 3, Introduction |
| (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. | *N/A* | *Unclassified* Chapter 3, Introduction |
| (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. | *N/A* | *Unclassified* Chapter 3, Introduction |
| (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. | *N/A* | *Unclassified* Chapter 2, Section 2.2.2; Chapter 3, Introduction; Chapter 4, Section 4.2.2 |
| (4) Shorten design, certification, and manufacturing cycles and timelines to minimize the amount of time and costs leading to an engineering prototype and production. | *N/A* | *Unclassified* Chapter 3, Introduction; Chapter 4, Section 4.3.5 |
| (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. | *N/A* | *Unclassified* Chapter 3, Introduction |
| (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.''. | | |

# Appendix B
# Exascale Computing

This appendix updates the plan to develop an exascale computing system for stockpile stewardship, as outlined in Appendix C of the *FY 2016 SSMP*.

## B.1 Introduction

The predictive capabilities of ASC's IDCs are the products of scientific and engineering advances and extraordinary increases in computing capabilities. These capabilities are sufficient to support NNSA missions today; however, they must be improved to support future missions. Aging of weapon components, advanced and additive manufacturing techniques, and LEPs and Alts are moving the stockpile further from original design configuration and associated underground nuclear explosive test data. In part, predictive capability is currently limited by approximations in the physics models, the inability to resolve critical geometric and physics features at very small length scales, and the unmet computing cycle needs to quantify margins and uncertainties. Progress in limiting many of these problems requires NNSA to move beyond today's computer systems to capable exascale[1] computing systems.

**High Performance Computing**

*NNSA has taken major steps to support the President's Executive Order, the National Strategic Computing Initiative, while advancing stockpile stewardship capabilities. In 2015, Los Alamos and Sandia National Laboratories received the first hardware delivery for Trinity, NNSA's next-generation, high performance computer. Trinity will be one of the most advanced computers in the world, with initially at least seven times better performance than the Cielo supercomputer. NNSA continued its CORAL collaboration with Lawrence Livermore National Laboratory, the DOE national laboratories at Oak Ridge, Tennessee, and Argonne, Illinois, and with IBM, Intel, and other vendors to develop next-generation platforms that will dramatically improve the ability to run complex codes. CORAL will be a significant step on the path to exascale computing. The Advanced Simulation and Computing Crossroads supercomputer, which will be ready for production use in FY 2021, is not expected to be an exascale system, but will help maintain momentum on that path. NNSA's participation in DOE's Exascale Computing Project, a portion of the National Strategic Computing Initiative, should allow deployment of a capable exascale system within the next decade. The synergy between the Exascale Initiative and the ASC Platform Procurement plan would provide the first exascale-class capable machine at LLNL in the mid 2020s.*


Computer hardware and architectures are evolving rapidly in response to market pressures created by mobile computing devices and other consumer electronics that are not focused on high performance computing. Making computer circuits faster by shrinking the components is becoming no longer economically feasible. The computer industry is responding by incorporating more processing cores on a single chip, resulting in "multi-core" chips, with many cores running in parallel to complete a single computation. The historically slow improvement in memory devices, relative to the speedup in computing, has also led to the memory subsystem becoming the primary driver of cost and power consumption. Any

[1] A capable exascale computing system is a system that can perform at least $10^{18}$ floating point operations per second and can increase sustained mission application performance at least 25-fold over the current largest ASC supercomputer, Sequoia.

exascale system built with off-the-shelf components is not envisioned being viable for stewardship applications in the next decade.

President Obama formally recognized the challenges of next-generation computing by establishing the multiagency National Strategic Computing Initiative on July 29, 2015. DOE is the lead agency responsible for executing a program focused on advanced simulation *via* exascale computing, which is a component of the initiative. An Exascale Computing Project currently being developed by NNSA in concert with the DOE Office of Science will emphasize sustained performance on applications to support DOE missions.

## B.2 Challenges

Providing capable exascale computing while maintaining and modifying the IDCs requires an effort to:

- develop computing systems that provide at least a 25-fold increase in sustained application code performance over the current largest ASC supercomputer, Sequoia,
- limit system power consumption to no more than 30 megawatts, and
- address code performance issues caused by next-generation hardware.

To partially address these challenges, ASC established the Advanced Technology Development and Mitigation subprogram to mitigate the risk that IDCs will not run effectively on future high performance computing platforms. This subprogram is rewriting key application packages for next-generation systems and engaging early with hardware vendors on applications of critical importance to stockpile stewardship. With the exception of platform acquisitions, NNSA's exascale preparation work is entirely in the Advanced Technology Development and Mitigation subprogram.

NNSA will continue to acquire the high performance computing systems on a strategically predetermined schedule to meet the needs of the weapons program. Developing and adapting IDCs to the new architectures is part of ASC's core mission, as is system acquisition. Both are activities that have been achieved over previous generations of computer upgrades, and both will continue to be funded outside a national exascale program.

## B.3 Approach and Strategy

Historically, industry has delivered new leading-edge systems every four to five years. Capable exascale systems will require more than incremental technology improvements. A capable exascale system will be much more difficult to achieve than previous systems; however, these barriers can be overcome, in part by relaxing constraints and in part by adapting and augmenting the existing ASC and DOE's ASCR Programs, which include research activities at universities, vendor-laboratory partnerships, development of prototype systems, and strategic acquisitions. Because of the complexity of exascale computing, these approaches are being augmented by substantial new efforts.

Given the challenges of achieving capable exascale computing, code developers must recognize the trends and opportunities of architecture and technologies, and the platform developers must understand the intended applications. This system-level design process among applications, software, and hardware developers is referred to as the co-design process. Through ASC and ASCR investments, several "co-design centers" have already begun to perform exploratory research to co-design the hardware and architecture, software stacks, and numerical methods and algorithms for mission applications, as well as to determine tradeoffs in the design of exascale hardware, system software, and application codes.

The realization of a capable exascale system involves complex tradeoffs among algorithms; hardware (*e.g.,* processors, memory, energy efficiency, reliability, and interconnectivity.); and software (programming models, scalability, data management, productivity, *etc.*). Applications software must be redesigned and restructured to meet challenges that hardware and software research cannot resolve fully.

The strategy to address these challenges will focus in four areas:

- **Application Development:** developing next-generation codes to address extreme parallelism, reliability and resiliency, memory hierarchies, and other performance issues caused by next-generation computing hardware.
- **Software Technology:** developing an expanded, vertically integrated software stack to support applications on next-generation hardware.
- **Hardware Technology:** supporting vendor R&D activities to deploy next-generation systems suitable for DOE/NNSA applications.
- **Exascale Systems:** supporting non-recurring engineering activities by vendors, reducing the costs of system expansion and site preparation, providing the associated power and cooling needed to run the next-generation supercomputers, and enhancing acquisition and support of prototypes and testbeds for application, software, and hardware evaluation activities.

ASC has developed several key milestones from FY 2017 to FY 2023 to ensure its code performance objective is achieved. These milestones, which can be found in Chapter 4 under Section 4.3.4, represent advances in codes and computing systems to achieve a viable path to exascale. These milestones also contribute to Predictive Capability Framework pegposts.

## B.4 Collaborative Management

ASC is partnering with DOE's ASCR to execute an Exascale Computing Project that will fully address exascale computing challenges. The effort will use teams comprised of personnel from a mix of DOE laboratories, large and small high performance computing vendors, and universities selected through peer review processes to conduct research, development, and engineering. Recognizing the synergies available through collaboration, ASC and ASCR are committed to joint planning and execution of activities to tackle a common set of problems to achieve common objectives, eliminate duplication, focus the vendor community, decrease costs by increasing acquisition volumes, and improve solutions using the broad, combined experience and strengths of both programs.

Joint activities include collaborations with vendors, co-design efforts, high performance computing system procurement, and exascale planning. However, each program (ASC and ASCR) will continue to have its own unique challenges that must be addressed for full utilization of exascale resources. Budget authority for the current advanced technologies work, which is congruent with the path to exascale, continues to reside within the respective ASC and ASCR Programs.

## B.5 Conclusion

Developing and using a capable exascale computing system will be a tremendous challenge. Driven by market forces and faced with physical limitations in microprocessors, the computing industry is driving toward immensely complex computer architectures composed of massive, multi-core processors with inadequate memory systems. NNSA's ASC is navigating this complex landscape by working aggressively with vendors; co-designing hardware, software, and next-generation codes; and developing software technologies to mitigate the performance impact on IDCs. ASC, in collaboration with ASCR, is making steady progress. Should a multi-year Exascale Computing Project be approved, this progress will accelerate substantially and will increase the clout of high performance computing within the marketplace by providing "trickle-down" benefits for the broader computing community.

# Appendix C
# Glossary

*3+2 Strategy*—The strategy to reduce the stockpile size and number of warhead types, increase interoperability, and provide flexibility to respond to geopolitical and technological surprise. The objective is a stockpile consisting of three interoperable warheads deployed on both submarine-launched and intercontinental ballistic missiles and two air-delivered warheads or bombs.

*Alteration (Alt)*—A limited scope change that affects assembly, tests, maintenance, and/or storage of weapons. An alteration may address identified defects and component obsolescence; it does not change a weapon's operational capabilities.

*Annual Assessment Process*—The authoritative method to evaluate the safety, reliability, performance, and military effectiveness of the stockpile; 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 assessment of the stockpile, and the Commander of the U.S. Strategic Command provides a separate assessment of military effectiveness. The assessments also determine whether an 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.

*B61-12 Life Extension Program (LEP)*—An LEP to consolidate four families of the B61 bomb into one and to improve the safety and security of the oldest weapon system in the U.S. arsenal.

*Boost*—The process that increases the yield of a nuclear weapons primary stage through fusion reactions.

*Canned subassembly*—A component of a nuclear weapon that is hermetically sealed in a metal container. A canned subassembly and the primary make up a weapon's nuclear explosive package.

*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 system's stockpile-to-target-sequence.

*Component*—An assembly or combination of parts, subassemblies, and assemblies mounted together during manufacture, assembly, maintenance, or rebuild.

*Construction Resource Planning List*—An enterprise-wide chronological project list of approved and proposed construction projects that indicates rough orders of magnitude for the total project cost and schedule. Near-term approved projects (usually within the *Future Years Nuclear Security Program*) are in more advanced stages of development. Proposed projects are pre-conceptual and have not been fully scoped. The project list is re-evaluated each budget year, and schedules shift based on mission need and funding availability.

*Conventional high explosive*—A high explosive that detonates when given sufficient stimulus *via* a high-pressure shock. Stimuli from severe accident environments involving impact, fire, or electrical discharge may also initiate a conventional high explosive. See also insensitive high explosive.

*Co-design*—An inclusive process to develop designs that encourages participants to find solutions within the context of the total system, rather than based on individual areas of expertise and interest.

*Deuterium*—An isotope of hydrogen whose nucleus contains one neutron and one proton.

*Exascale computing*—The use of systems capable of at least a thousand petaflops or a quintillion ($10^{18}$) floating point operations per second.

*First production unit*—The first completed item of a weapon system delivered to a user (*e.g.,* DOD).

*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 of the isotopes of hydrogen (namely, 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.

*High explosives*—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.

*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*—A simulation code containing multiple physics and engineering models that have been validated experimentally and computationally. An Integrated Design Code is used to simulate, understand, and predict the behavior of nuclear and non-nuclear components and nuclear weapons under normal, abnormal, and hostile conditions.

*Interoperable warhead*—A warhead that has a common nuclear explosive package, is integrated with systems to maximize the use of common and adaptable non-nuclear components, and can be deployed on multiple delivery platforms.

*Life cycle*—The series of stages through which a component, system, or weapon passes from initial development until it is consumed, disposed of, or altered in order to extend its lifetime.

*Life Extension Program (LEP)*—A program that refurbishes warheads of a specific weapon type by replacing aged components to extend the service life of a weapon. LEPs can extend the life of a warhead by 20 to 30 years, while increasing safety, improving security, and addressing defects.

*Limited life component*—A weapon component or subsystem whose performance degrades with age and must be replaced.

*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.

*Modification (Mod)*—A modernization 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 laboratory*—The term refers to Los Alamos National Laboratory, Sandia National Laboratories, or Lawrence Livermore National Laboratory.

*Non-nuclear components*—The parts or assemblies designed for use in nuclear weapons or in nuclear weapons training; such components are not available commercially (*e.g.*, radiation-hardened electronic circuits or arming, fuzing, and firing components) and do not contain special nuclear material.

*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 security enterprise*—The physical infrastructure, technology, and human capital at the national security laboratories, the nuclear weapons production facilities, and the Nevada National Security Site.

*Nuclear Weapons Council*—The joint DOE/DOD 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 production facility*—The term refers to the National Security Campus, Pantex Plant, Y-12 National Security Complex, or Savannah River Site. Also includes Los Alamos National Laboratory and Sandia National Laboratories with respect to some specific weapons production activities.

*Out years*—The years that follow the five-year period of the Future Years Nuclear Security Program.

*Pit*—The critical core component of a nuclear weapon that contains fissile material.

*Phase 6.x Process*—An expanded subset of the Quantity Production and Stockpile phase (Phase 6) of the Joint Nuclear Weapons Life Cycle Process. The *Phase 6.x Process* provides a framework to conduct and manage life extension activities for existing weapons.

*Quantification of margins and uncertainties*—The methodology used in the post-nuclear-testing era to facilitate analysis and communicate confidence in assessing and certifying that stockpile weapons will perform safely, securely, and reliably. Scientific judgment of experts at the national security laboratories plays a crucial role in this determination, which is based on metrics that use experimental data, physical models, and numerical simulations.

*Safeguards Transporter*—A highly specialized trailer designed to safeguard nuclear weapons and special nuclear materials while in transit.

*Secondary*—The portion of a warhead that provides additional energy release and is activated by energy from the primary.

*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.

*Subcritical experiment*—An experiment conducted underground at the Nevada National Security Site that is 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 a comprehensive nuclear explosive test ban.

*Surety*—The assurance that a nuclear weapon will operate safely, securely, and effectively 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, materiel (*e.g.*, military equipment and supplies), personnel, and execution of procedures.

*Surveillance*—Activities to determine whether nuclear weapons meet established safety, security, and reliability standards.

*Sustainment*—A program to modify and maintain a set of nuclear weapon systems.

*Test readiness*—The preparedness to conduct an underground nuclear explosive testing if required to ensure the safety and effectiveness of the stockpile or if directed by the President for policy reasons.

*Tractor*—A modified and armored vehicle to transport the Safeguards Transporter trailer.

*Tritium*—A radioactive isotope of hydrogen whose nucleus contains two neutrons and one proton and that is produced in nuclear reactors by the action of neutrons on lithium nuclei.

*W76-1 LEP*—A life extension program for the W76 submarine-launched ballistic missile warhead, delivered by a U.S. Navy Trident II.

*W78*—An intercontinental ballistic missile warhead, delivered by the U.S. 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 U.S. Air Force B-52 bomber and future launch platforms.

*W88*—A submarine-launched ballistic missile warhead, delivered by a U.S. Navy Trident II D5 Fleet Ballistic Missile.

*W88 Alt 370*—An alteration of the W88 warhead to replace the arming, fuzing, and firing components and the conventional high explosive main charge.

*Warhead*—The part of a missile, projectile, torpedo, rocket, or other munitions that contains either the nuclear or thermonuclear system intended to inflict damage.

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# A Report to Congress

# Fiscal Year 2017 Stockpile Stewardship and Management Plan – Biennial Plan Summary

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