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Report to Congressional Committees

December 2024

NATIONAL NUCLEAR SECURITY ADMINISTRATION

Assessments of Nuclear Weapon Acquisitions

GAO-25-106048

GAO Highlights

Highlights of GAO-25-106048, a report to congressional committees

December 2024

NATIONAL NUCLEAR SECURITY ADMINISTRATION

Assessments of Nuclear Weapon Acquisitions

Why GAO Did This Study

The United States is investing tens of billions of dollars in nuclear weapon acquisition programs to modernize aging nuclear weapons. NNSA is currently managing seven such programs, in coordination with DOD.

Two Senate Armed Services Committee reports include provisions for GAO to review NNSA's management of its nuclear weapon acquisition programs, as well as the status of these programs biennially. This report assesses (1) the processes NNSA uses for managing these programs and (2) the challenges NNSA faces. The report also includes individual assessments of the five NNSA nuclear weapon acquisition programs under way at the start of GAO's review.

GAO reviewed NNSA documentation and directives on agency processes, program cost and schedule baselines, and design and technology issues. GAO assessed performance in these areas using criteria in NNSA directives, as well as criteria from GAO's Technology Readiness Assessment Guide. GAO also visited NNSA sites and interviewed agency officials and contractors about challenges.

What GAO Recommends

GAO recommends that NNSA document, in a formal and comprehensive manner, the process its nuclear weapon acquisition programs must follow to identify which technologies are critical technologies. NNSA agreed with GAO's recommendation.

View GAO-25-106048. For more information, contact Allison B. Bawden at (202) 512-3841 or bawdena@gao.gov.

What GAO Found

The National Nuclear Security Administration (NNSA) uses several processes to manage its nuclear weapon acquisition programs. These processes include the Phase X and Phase 6.X processes, which provide a framework to coordinate NNSA's activities with those of the Department of Defense (DOD). NNSA also uses an internal process—called the product realization process—whereby an NNSA program office leads each program while multiple contractor teams of experts from NNSA's laboratories and production sites manage technical work.

NNSA's acquisition processes can be organized into three phases: (1) initiation, which explores options and early designs; (2) development, which covers the design, testing, and evaluation of technologies and the maturing of production processes; and (3) production. Within these phases, NNSA has established numerous requirements that its programs must follow regarding, among other things, the establishment of cost and schedule baselines and the assessment of technology readiness. However, NNSA has not documented, in a formal or comprehensive manner, the process that its programs must follow to identify which technologies are critical technologies—that is, technologies critical to meeting a system's operational requirements that are new or novel or are used in a new or novel way. By more formally and comprehensively documenting its process, NNSA may help ensure that its nuclear weapon programs do not waste valuable funding and schedule resources.

NNSA programs face several challenges in managing nuclear weapons acquisitions, including in maturing technologies, producing or procuring components, and overseeing contractors. For example, according to NNSA officials, it is difficult to estimate how long it will take to mature technologies to a manufacturing-ready state. As a result, NNSA's programs have had difficulty reaching technology readiness milestones. Specifically, of the technologies tracked by NNSA's Office of Cost Estimating and Program Evaluation in the two NNSA programs for which data were available and which had reached the development phase, a majority had not reached NNSA's minimum required readiness level for critical technologies by the start of that phase (see table).

Number of Technologies in Nuclear Weapon Acquisition Programs Reaching NNSA's Technology Readiness Milestone at the Start of Development Phase

Acquisition program	Number of technologies	Number of technologies meeting NNSA's readiness milestone for critical technologies
B61-12 bomb	37	12
W80-4 warhead	42	5

Source: GAO analysis of National Nuclear Security Administration's (NNSA) Office of Cost Estimating and Program Evaluation information. | GAO-25-106048

Partly to address this challenge, NNSA established an office in 2019 to perform early stage research and development activities to advance technologies to a higher level of readiness before passing them on to nuclear weapon acquisition programs for further development.

Contents

Tables

Figures

Abbreviations

DOD	Department of Defense
DOE	Department of Energy
M&O contractors	management and operating contractors
NNSA	National Nuclear Security Administration
TRA	technology readiness assessment
TRL	technology readiness level

U.S. GOVERNMENT ACCOUNTABILITY OFFICE
441 G St. N.W.
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December 17, 2024

The Honorable Jack Reed
Chairman
The Honorable Roger F. Wicker
Ranking Member
Committee on Armed Services
United States Senate

The Honorable Mike Rogers
Chairman
The Honorable Adam Smith
Ranking Member
Committee on Armed Services
House of Representatives

Over the next 2 decades, the United States plans to spend tens of billions of dollars to modernize its stockpile of nuclear warheads and bombs, as well as the research and production infrastructure on which stockpile programs depend.[1] The National Nuclear Security Administration (NNSA)—a separately organized agency within the Department of Energy (DOE)—is responsible for managing these efforts, in coordination with the Department of Defense (DOD). Both the weapons and the infrastructure used to produce them are aging, with some facilities having been in operation since the 1940s and some weapons in the active nuclear stockpile having been fielded in the 1970s.

NNSA relies on management and operating (M&O) contractors to conduct the work needed to fulfill NNSA's missions.[2] Historically, DOE and NNSA have had challenges in managing and overseeing their contractors, including completing projects within their performance baselines, which are quantitative definitions of cost, schedule, and technical performance.

[1]All nuclear weapons in the U.S. stockpile are designated either as warheads (e.g., the W88 warhead) or as bombs (e.g., the B61-12 bomb). Weapons that have certain engineering requirements because they must interface with a missile system are called warheads. Weapons that interface directly with an aircraft release system and free-fall are called bombs.

[2]M&O contracts are agreements under which the government contracts for the operation, maintenance, or support, on its behalf, of government-owned or government-controlled research, development, special production, or testing establishments wholly or principally devoted to one or more of the major programs of the contracting agency. 48 C.F.R. § 17.601.

In 1990, we placed DOE contract management—including project management—on our High Risk list of programs and operations that are vulnerable to waste, fraud, abuse, or mismanagement.[3] More recently, we have issued reports highlighting cost and schedule overruns that NNSA and its contractors have encountered in nuclear weapon programs.[4]

For more than 20 years, we have issued annual assessments of DOD weapon systems acquisitions. In these annual assessments, we have applied principles that we refer to as knowledge-based acquisition practices to evaluate DOD's acquisitions. The knowledge-based acquisition practices derive from a body of work that we initiated over 25 years ago in which we found that successful programs take steps to gather knowledge at key points to confirm that technologies are mature, designs are stable, and production processes are in control.[5]

The Senate report accompanying a bill for the National Defense Authorization Act for Fiscal Year 2022 includes a provision for us to review NNSA's management of its warhead acquisition programs and address the extent to which they apply knowledge-based acquisition practices.[6] In addition, the Senate report accompanying a bill for the National Defense Authorization Act for Fiscal Year 2023 includes a provision for us to report on the status of NNSA's nuclear weapon acquisition programs on a biennial basis.[7]

In this report, we present information on the processes NNSA uses to manage nuclear weapon acquisition programs, including the extent to which these processes reflect knowledge-based acquisition practices,

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[3]Our most recent report is GAO, *High-Risk Series: Efforts Made to Achieve Progress Need to Be Maintained and Expanded to Fully Address All Areas,* GAO-23-106203 (Washington, D.C.: Apr. 20, 2023).

[4]See, for example, GAO, *Nuclear Weapons: Action Needed to Address the W80-4 Warhead Program's Schedule Constraints*, GAO-20-409 (Washington, D.C.: July 24, 2020); and *B61-12 Nuclear Bomb: Cost Estimate for Life Extension Incorporated Best Practices, and Steps Being Taken to Manage Remaining Program Risks*, GAO-18-456 (Washington, D.C.: May 31, 2018).

[5]See, for example, GAO, *Weapon Systems Annual Assessment: Programs Are Not Consistently Implementing Practices That Can Help Accelerate Acquisitions*, GAO-23-106059 (Washington, D.C.: June 8, 2023).

[6]S. Rpt. No. 117-39, at 359-60 (2021) (accompanying S. 2792, a bill for the National Defense Authorization Act for Fiscal Year 2022).

[7]S. Rpt. No. 117-130, at 371 (2022) (accompanying S. 4543, a bill for the National Defense Authorization Act for Fiscal Year 2023).

and the challenges it faces in doing so. Our report also includes our first biennial assessments of the five major programs currently underway, which we provide in appendix I. This report is a companion to our recently issued assessment of NNSA's major projects to modernize its production infrastructure, also the first of its kind.[8] We plan to update both assessments biennially in alternating years.

To complete this report, we (1) reviewed documents that established best practices for program management, including knowledge-based acquisition principles; (2) reviewed documents that establish processes, requirements, and guidance for NNSA's nuclear weapon programs; (3) reviewed documents that provide information on the projected and actual acquisition performance of NNSA nuclear weapon programs; (4) visited NNSA sites that manage design and production activities; and (5) interviewed NNSA officials and contractors to understand the processes they use to manage nuclear weapon acquisition programs and the challenges they face in doing so. Appendix II provides additional information on our objectives, scope, and methodology.

We conducted this performance audit from June 2022 to December 2024 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

NNSA Weapon Acquisition Programs and the Nuclear Triad

NNSA is currently managing the following five nuclear weapon acquisition programs, in coordination with DOD:

- **B61-12 Life Extension Program.**[9] The B61-12 program plans to replace and extend the service life of three variants of the original B61 bomb, first added to the U.S. nuclear stockpile in 1968.

[8]GAO, *National Nuclear Security Administration: Assessments of Major Projects*, GAO-23-104402 (Washington, D.C.: Aug. 17, 2023).

[9]NNSA and DOD undertake life extension programs to refurbish or replace nuclear weapons' components to extend their lives, enhance their safety and security characteristics, and consolidate the stockpile into fewer weapon types to minimize maintenance and testing costs while preserving needed military capabilities.

- **W88 Alteration 370 Program.**[10] The W88 program plans to modify the W88 warhead, first added to the U.S. nuclear stockpile in 1988.
- **W80-4 Life Extension Program.** The W80-4 program plans to replace and extend the service life of the W80-1 warhead, first added to the U.S. nuclear stockpile in 1982.
- **W87-1 Modification Program.**[11] The W87-1 program plans to replace the existing W78 warhead, first added to the U.S. nuclear stockpile in 1979.
- **W93 Program.** The W93 program plans to design and produce a new warhead to provide flexibility and adaptability to meet future warfighter needs.

See appendix I for an assessment of each of these five programs.

In addition, the National Defense Authorization Act for fiscal year 2024 authorizes two additional nuclear weapon acquisitions, the B61-13 and a sea-launched nuclear cruise missile.[12] According to DOD, the B61-13 is intended to replace some of the B61 variants in the current stockpile and be substituted for some of the previously planned production quantity of the B61-12. In testimony before Congress, officials from DOD and NNSA have said that initial activities are underway to explore options for the sea-launched nuclear cruise missile, including whether to develop a variant of the W80-4 warhead for the weapon or pursue a different option. These acquisitions were authorized after our study was underway and were not included in our assessments as a result.

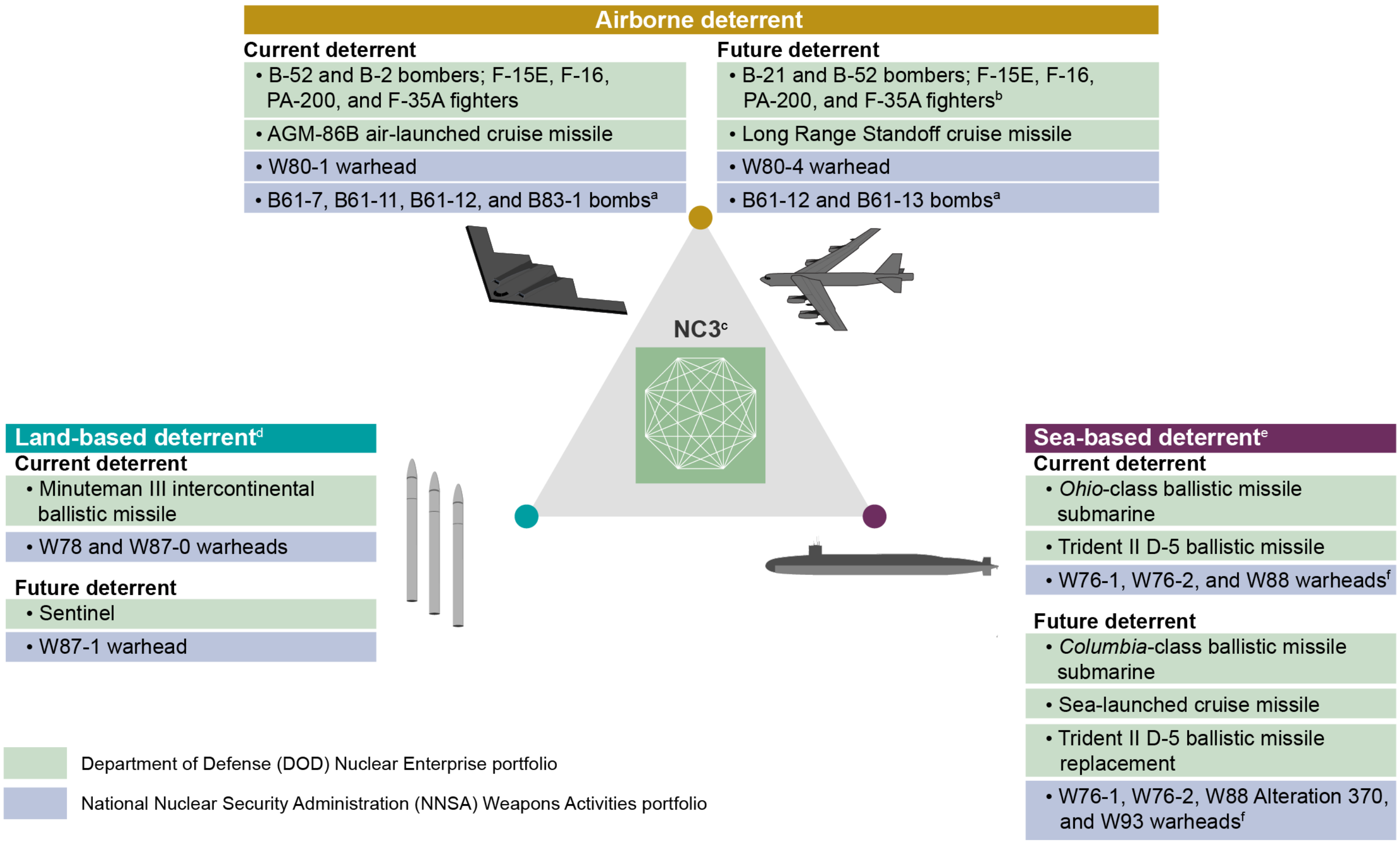
NNSA's nuclear weapon acquisition programs support the United States' triad of nuclear weapon systems—submarine-launched ballistic missiles, intercontinental ballistic missiles, and aircraft-delivered missiles and bombs. Figure 1 illustrates the nuclear triad, showing current systems and modernization programs underway in NNSA and DOD.

[10]An alteration is usually a replacement of an older component with a newer component that does not impact military operations, logistics, or maintenance.

[11]Throughout the history of nuclear weapons development, the United States has developed families of weapons based on a single weapon design. Thus, some weapons in the U.S. stockpile were developed as modifications to an already complete design. For example, the B61 bomb has had 13 designated modifications over time, from the B61-0 through the B61-12.

[12]National Defense Authorization Act for Fiscal Year 2024, Pub. L. No. 118-31, §§ 1640, 4701, 137 Stat. 136, 595, 924 (2023).

Figure 1: Nuclear Triad Systems and Modernization Programs



Source: GAO analysis of DOD and National Nuclear Security Administration (NNSA) information; GAO (icons). | GAO-25-106048

[a]We listed the B61-12 twice because some units are already in the stockpile, but full-rate production remains ongoing. The B61-13 is a variant of the B61 bomb.

[b]The B-21 bomber will eventually replace the B-2 bomber, but DOD will modernize and continue to operate the B-52 bomber as part of the strategic nuclear triad.

[c]Nuclear command, control, and communications (NC3) capabilities are used to support planning, situation monitoring, decision-making, force management, and communication of force direction between the President and nuclear forces.

[d]The land-based strategic deterrent also includes reentry vehicles that protect warheads as they reenter the atmosphere from space.

[e]The sea-based strategic deterrent also includes reentry bodies that protect warheads as they reenter the atmosphere from space.

[f]We listed the W88 twice because some units are already in the stockpile, but full-rate production remains ongoing.

Overview of Selected Nuclear Weapon Technologies

Most nuclear weapons in the U.S. stockpile are two-stage weapons. The first stage (or primary) consists of a hollow pit typically made of plutonium and other materials, surrounded by explosives that compress the pit and create a nuclear reaction.[13] Two classes of high explosives perform this function: conventional high explosives and insensitive high explosives. An insensitive high explosive is less susceptible to accidental detonation than a conventional high explosive and less violent upon accidental ignition; therefore, it is safer to handle.

The second stage (or secondary) of a nuclear weapon may consist of uranium, lithium, and other materials. The primary and secondary together, housed within a radiation case, are referred to as the weapon's nuclear explosive package. When detonated, these nuclear components produce the weapon's explosive energy, or yield.

Other technologies used in nuclear weapons include:

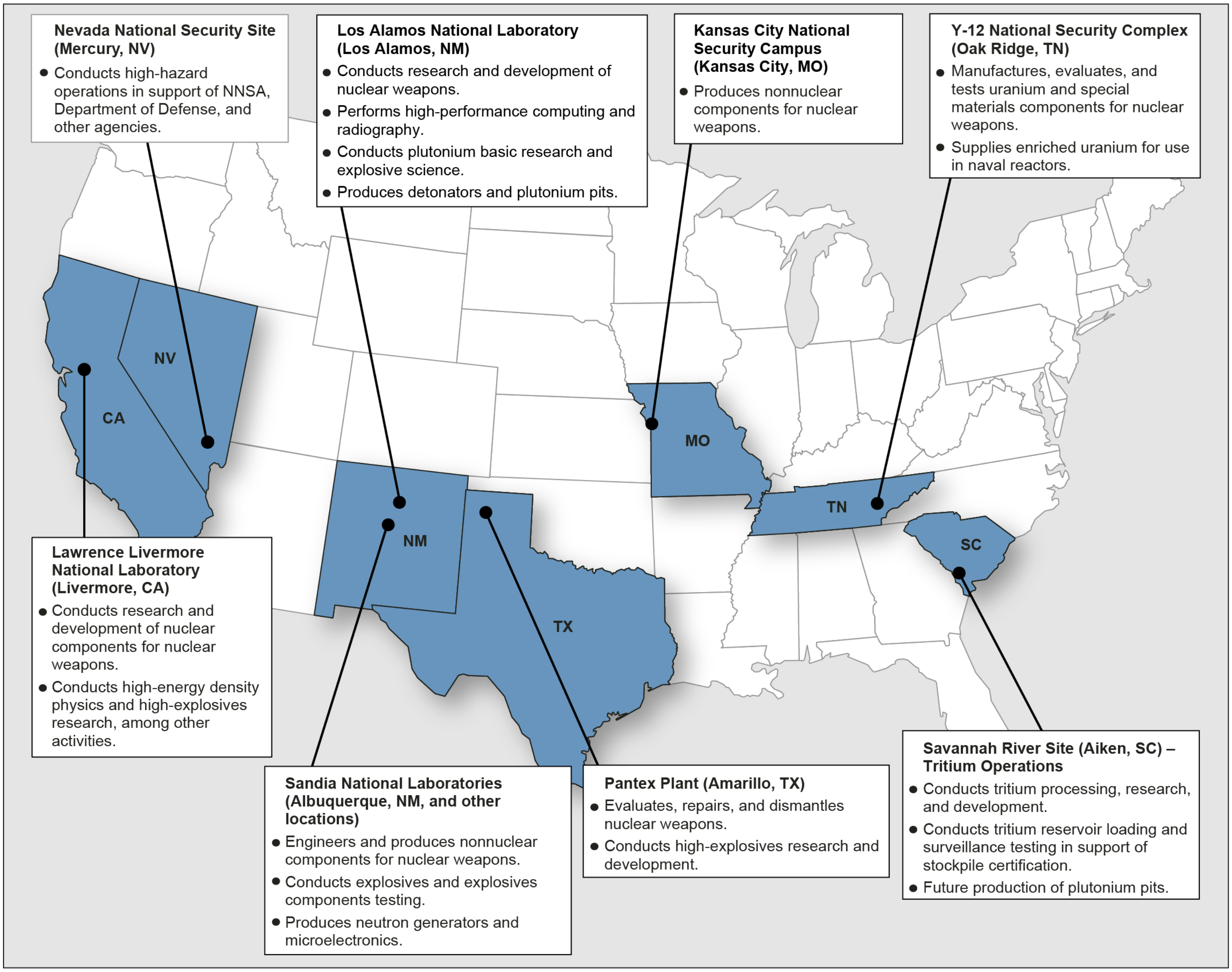
- the arming, fuzing, firing, and surety systems, which together ensure that a weapon will operate safely, securely, reliably, and only when authorized;
- neutron generators, which facilitate the nuclear reaction; and
- gas transfer systems, which can enhance the nuclear reaction by injecting gases into the pit.

Nuclear Security Enterprise Sites

NNSA's M&O contractors perform their work at eight government-owned sites that constitute the nuclear security enterprise, under the management of NNSA's Office of Defense Programs. The sites comprise laboratories and production facilities that design and produce nuclear weapons, along with associated test facilities. Nuclear security enterprise sites depend on a broad industrial base to provide certain components and materials. Figure 2 illustrates the nuclear security enterprise and summarizes the specific responsibilities of each site.

[13]The United States has not produced significant numbers of pits since 1989. As a result, most pits in the stockpile are at least 30 years old.

Figure 2: Sites in the Nuclear Security Enterprise



Sources: GAO presentation of National Nuclear Security Administration information; Map Resources (map). | GAO-25-106048

Role of the Nuclear Weapons Council

The Nuclear Weapons Council is a joint DOD and DOE senior-level body established by statute and responsible for coordinating planning and risk management efforts relating to the nuclear weapons stockpile, the U.S. nuclear security enterprise, and the delivery platforms for nuclear weapons.[14] For each nuclear warhead or bomb type, the Nuclear Weapons Council uses joint DOD-DOE/NNSA groups called Project Officers Groups to coordinate activities between the departments, ensure the development and assure the compatibility of warheads with their designated delivery platforms, and facilitate communication about programmatic risks throughout the life of each program.[15]

DOE and NNSA Directives

DOE's departmental directives program establishes directives as the primary means to set, communicate, and institutionalize policies, requirements, responsibilities, and procedures for departmental elements and contractors.[16] The National Nuclear Security Administration Act, through which Congress established the NNSA, also gives the NNSA Administrator the authority to establish NNSA-specific policies, unless disapproved by the Secretary of Energy.[17] To implement DOE's directives program, NNSA has issued its own related directive, which defines the term "directive" as including supplemental directives, policies, advance change directives, and business operating procedures.[18]

Technology Maturity

A critical technology is a new or novel technology, or technology being used in a new or novel way, that is needed for a system to meet its operational performance requirements within defined cost and schedule parameters. However, technologies identified as critical may change as programmatic or mission-related changes occur, system requirements are revised, or if technologies do not mature as planned.

NNSA uses a nine-level scale, called technology readiness levels (TRL), to determine how far a critical technology has matured and to evaluate the technology's readiness to be integrated into a system. This approach is intended to ensure that new technologies are sufficiently mature in time to be used successfully in a program and to reduce the technical and cost

[14]10 U.S.C. § 179.

[15]DOD Manual 5030.55, *DOD Procedures for Joint DOD-Department of Energy/National Nuclear Security Administration (DOE/NNSA) Nuclear Weapons Life-Cycle Activities* (Apr. 5, 2019).

[16]DOE Order 251.1E, *Departmental Directives Program* (Washington, D.C.: June 10, 2024).

[17]Pub. L. No. 106-65, title XXXII, 113 Stat. 512, 953 (1999) (codified as amended at 50 U.S.C. §§ 2401-2484).

[18]NNSA, *Directives Management*, Supplemental Directive, NNSA SD-251.1B (Oct. 26, 2020). In this report, we use the term "directive" to refer to all such documents, as well as NNSA guidance documents.

risks associated with the introduction of new technologies. TRLs progress from the least mature level, in which the basic technology principles are observed (TRL 1), to the highest maturity level, in which the technology has proven itself in operational testing or actual usage in the product's operating environment (TRL 9). It can take years to successfully mature a technology from TRL 1 to TRL 9. Appendix III provides NNSA's description of each TRL.

A technology readiness assessment (TRA) is a systematic, evidence-based process that evaluates the maturity of technologies (hardware, software, and processes) critical to the performance of a larger system or the fulfillment of the key objectives of an acquisition program, including cost and schedule. TRAs do not eliminate technology risk, but they can illuminate concerns and serve as the basis for realistic discussions on how to address potential risks as programs move from early research and technology development to system development and beyond.

GAO has found that the readiness of critical technologies at the start of technology development affects the schedule and cost of developing a product.[19] Therefore, a TRA performed before development provides important information for developers and managers responsible for developing a product, as well as governance bodies overseeing an acquisition program.

In keeping with this principle, NNSA requires its nuclear weapon acquisition programs to conduct a TRA early in the acquisition process.[20] As part of this requirement, programs are to develop a plan and schedule for conducting the TRA, issue a TRA report, and develop a plan to mature

[19]See GAO, *Technology Readiness Assessment Guide: Best Practices for Evaluating the Readiness of Technology for Use in Acquisition Programs and Projects*, GAO-20-48G (Washington, D.C.: Jan. 2020). The Guide draws heavily from DOD, DOE, and NASA for best practices and terminology. In addition, the Guide draws from resources, materials, and tools developed and applied by experts and organizations to capture the current thinking on technology readiness and maturity. Existing government agency guidance is largely geared toward conducting TRAs to support major acquisition decisions, in particular the decision to authorize the start of product or system development and allocation of substantial resources. Demonstrating that a program's critical technologies have been proven to work in their intended operational environment before making a commitment to product development has also been the focus of GAO's work on technology readiness since the late 1990s.

[20]See National Nuclear Security Administration, *Technology Readiness Assessments*, NNSA Policy Letter, NAP-413.4 (Washington, D.C.: Apr. 16. 2020). Programs must conduct these reviews prior to the start of Phase 6.2. In addition to these reviews, NNSA's M&O contractors conduct less formal TRAs on an ongoing basis.

any immature technologies (if applicable). In addition, NNSA's Office of Cost Estimating and Program Evaluation is to review these TRA reports and issue an evaluation memo.[21]

Knowledge-Based Acquisition Practices

Our prior work on knowledge-based acquisition practices found that successful programs take steps to gather knowledge that confirms their technologies are mature, their designs are stable, and their production processes are in control.[22] We found that these programs ensure a high level of knowledge is achieved at key junctures in development. We characterize these junctures as knowledge points. More specifically:

- At Knowledge Point 1, technologies, time, funding, and other resources match customer needs, and agencies confirm the decision to invest in product development.
- At Knowledge Point 2, the design is stable and performs as expected, and agencies confirm the decision to start building and testing production-representative prototypes.
- At Knowledge Point 3, production meets cost, schedule, and quality targets, and agencies confirm the decision to produce the first units for the customer.

In June 2022 and July 2024, we updated this work to reflect new advances in product development undertaken by leading commercial companies. This work found that leading companies now develop complex products through iterative processes that are enabled by continuous user feedback and digital engineering tools. We have begun applying these leading practices, which differ considerably from our traditional knowledge-based acquisition practices, in our latest assessments of DOD weapon systems.[23]

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[21]The Office of Cost Estimating and Program Evaluation advises the NNSA administrator on policies and procedures for cost analysis and estimation and conducts independent cost estimates for warhead modernization programs, among other activities. The directorate for the office was established under the National Defense Authorization Act for Fiscal Year 2014. Pub. L. No. 113-66, title XXXI, § 3112, 127 Stat. 672, 1050 (2013) (codified as amended at 50 U.S.C. § 2411).

[22]See, for example, *Weapon Systems Annual Assessment: DOD Is Not Yet Well-Positioned to Field Systems with Speed*, GAO-24-106831 (Washington, D.C.: June 17, 2024) and GAO-23-106059.

[23]GAO-24-106831; *Leading Practices: Iterative Cycles Enable Rapid Delivery of Complex, Innovative Products*, GAO-23-106222 (Washington, D.C.: July 27, 2023); and *Leading Practices: Agency Acquisition Policies Could Better Implement Key Product Development Principles*, GAO-22-104513 (Washington, D.C.: Mar. 10, 2022).

NNSA Uses a Variety of Processes to Manage Nuclear Weapon Acquisition Programs, and a Key Process Has Not Been Formalized

NNSA uses a variety of processes to manage its nuclear weapon acquisition programs. These processes include the Phase X and Phase 6.X processes, which provide a framework for managing these programs through the coordination of activities by NNSA, DOD, and the Nuclear Weapons Council. NNSA also uses an internal process—referred to as the product realization process—to manage its acquisition programs and has developed numerous directives to implement this process. These directives specify requirements that programs must follow regarding the establishment of cost and schedule baselines and the assessment of technology maturity. However, NNSA has not documented, in a formal and comprehensive manner, the process that its programs must follow to identify which technologies are critical technologies. In its overall management of nuclear weapon acquisition programs, NNSA seeks to follow an incremental approach to building knowledge, much like GAO's knowledge-based acquisition practices and correspondent with how DOD has structured its acquisition process.[24]

What are the Phase X and Phase 6.X processes for managing nuclear weapon acquisition programs?

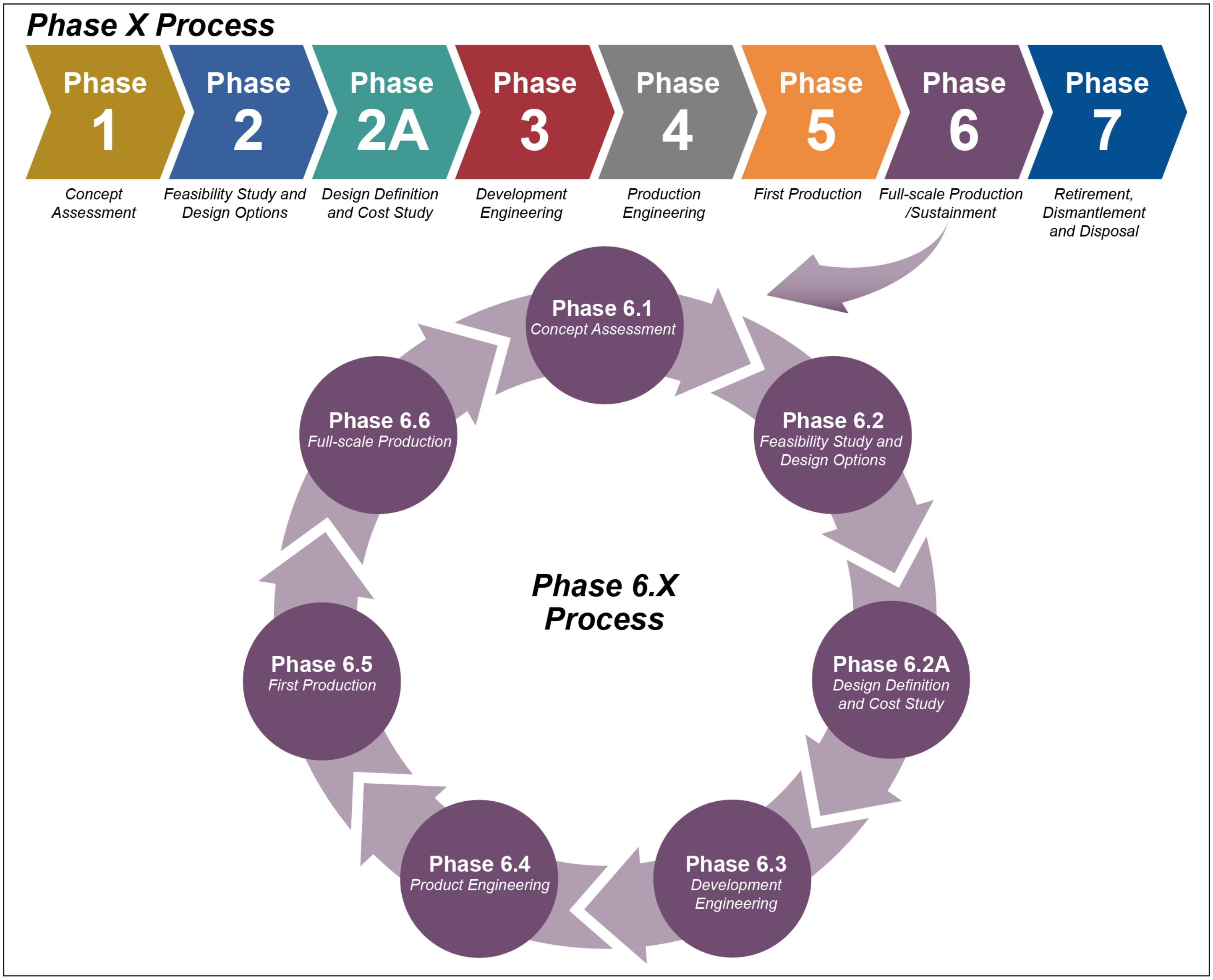
The Phase X and Phase 6.X processes are a framework for managing nuclear weapon acquisition programs through the coordination of activities by the Nuclear Weapons Council, NNSA, and DOD. Specifically:

- The Phase X process consists of eight life cycle phases from concept assessment to retirement, dismantlement, and disposal (see fig. 3). NNSA and DOD use the Phase X process to develop new weapons, although the process has not been exercised in its entirety since the end of the Cold War. Of the current weapon acquisition programs, the only program using Phase X is the W93 program.
- Since the late 1990s, NNSA and DOD have used the Phase 6.X process to manage life extension programs and major nuclear weapon alterations and modifications.[25] Phase 6.X mirrors the Phase X process but takes place entirely within Phase 6, signaling that the program is based on an existing design. Phase 6.X differs from Phase X in that it does not include a retirement, dismantlement, and disposal phase. Four of the five acquisition programs we assessed are in the Phase 6.X process: the B61-12 Life Extension Program, the W88 Alteration 370 Program, the W87-1 Modernization Program, and the W80-4 Life Extension Program.

[24] In this report, when discussing DOD's acquisition process, we refer to what DOD's Adaptive Acquisition Framework defines as the major capability acquisition pathway.

[25] Phase 6.X does not apply to limited-life component exchanges such as gas transfer system reservoir replacements, which are managed under routine maintenance programs.

Figure 3: The Phase X and Phase 6.X Processes for Managing Nuclear Weapon Acquisition Programs



Source: GAO analysis of National Nuclear Security Administration (NNSA) information. | GAO-25-106048

The Nuclear Weapons Council has issued guidance that describes its role, along with the roles of DOD and NNSA, in managing the Phase X and 6.X processes.[26] In addition, DOD and NNSA each have department-specific directives for implementing these processes.[27]

DOD plays a central role in the Phase X and Phase 6.X processes. For example, DOD is responsible for developing the performance requirements for nuclear weapons, such as their military characteristics and stockpile-to-target sequence.[28] These requirements are significant for NNSA because they define DOD's requirements and expectations for the nuclear weapon systems that NNSA produces. DOD's performance requirements, and changes to these requirements during the acquisition process, can greatly impact NNSA's program schedule and cost. DOD develops preliminary performance requirements beginning in Phase 1/6.1, but reviews and revises stockpile-to-target requirements as needed throughout the life cycle of a nuclear weapon acquisition.

DOD also participates in groups that evaluate nuclear weapon acquisition programs against performance requirements. For example, during Phase 2/6.2, the joint DOD-NNSA Project Officers Group develops design options and analyzes alternatives to evaluate the feasibility of potential options to meet performance requirements. During Phase 3/6.3, DOD convenes a preliminary design review and acceptance group to review design objectives, descriptions, and qualification activities to determine compliance with performance requirements. The Nuclear Weapons Council ultimately approves performance requirements during Phase 3/6.3 and before entry into Phase 4/6.4.

[26]Nuclear Weapons Council, *Procedural Guideline for the Phase 6.X Process* (Dec. 16, 2015), and *Procedural Guideline for the Joint DoD-DOE/NNSA Nuclear Weapons Life-Cycle Process* (Apr. 2021).

[27]See, for example, DOD Directive 3150.01, *Joint DOD-Department of Energy/National Nuclear Security Administration (DOD-DOE/NNSA) Nuclear Weapon Life-Cycle Activities* (Aug. 31, 2018); DOD Manual 5030.55, *DOD Procedures for Joint DOD-Department of Energy/National Nuclear Security Administration (DOE/NNSA) Nuclear Weapons Life-Cycle Activities* (Apr. 5, 2019); DOE, *Management of the Department of Energy Nuclear Weapons Complex*, Order 452.3 (June 8, 2005); and NNSA, *Phase X / 6.X Processes*, Supplemental Directive 452.3-2A (Nov. 8, 2022).

[28]A nuclear weapon's military characteristics define its operational, nuclear yield, and maintenance requirements. Its stockpile-to-target sequence defines the range of physical environments in which the weapon should be able to perform as it travels from stockpile storage to a potential target.

How does NNSA manage nuclear weapon acquisition programs under the Phase X and Phase 6.X processes?

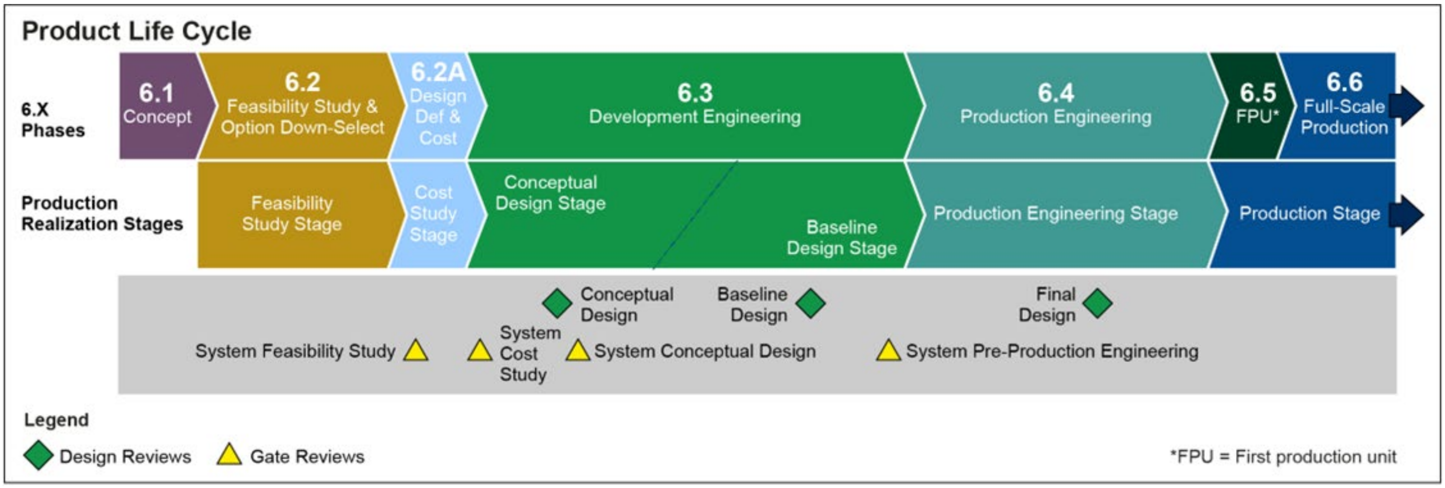
NNSA uses an internal product realization process to manage nuclear weapon acquisition programs under the Phase X/6.X processes and has developed directives to implement this process.[29] The product realization process is intended to apply a systems engineering approach to manage the interactions among NNSA's design laboratories and production sites and assess technology and manufacturing system maturity.[30]

Product realization begins at Phase 2/6.2 and is divided into stages that align with each remaining phase of the Phase X/6.X processes through production. Each stage of product realization includes a series of activities at the subsystem or component level and corresponding activities at the weapon system level (see fig. 4). For example, the product realization process includes a series of gate reviews generally intended to ensure the program is meeting requirements before NNSA management approves its entry into the next stage. Gate reviews begin in Phase 2/6.2 and include system feasibility, system cost study, system conceptual design, and system pre-production engineering reviews. Similar gate reviews are conducted at the subsystem/component level.

[29]NNSA implements the product realization process through the Defense Programs Business Process System. This system contains directives categorized as federal requirements documents, contractor agreements, and tools (referred to as "R," "C," and "T" documents, respectively). According to NNSA officials, as of July 2024, the system contained 21 R, nine C, and 90 T documents. See NNSA, *Defense Programs Business Process System,* Supplemental Directive 452.3-1A (Feb. 25, 2016).

[30]DOE defines "systems engineering approach" as a proven, disciplined approach that supports management in clearly defining the mission or problem; managing system functions and requirements; identifying and managing risk; establishing bases for informed decision-making; and verifying that products and services meet customer needs.

Figure 4: NNSA's Product Realization Process



Source: GAO analysis of National Nuclear Security Administration (NNSA) information. | GAO-25-106048

Note: The Phase X process is similar to the Phase 6.X process, with the addition of a seventh phase for retirement, dismantlement, and disposal in the Phase X process.

In addition, NNSA's product realization process includes a series of design reviews at both the subsystem/component level and at the weapon system level to ensure that a weapon's design complies with military characteristics and stockpile-to-target sequence requirements.[31] Design reviews begin in Phase 3/6.3 and include conceptual, baseline, and final design reviews.

Dedicated federal program offices in NNSA's Office of Stockpile Modernization manage programmatic aspects of nuclear weapon acquisitions. NNSA assigns a federal program manager to oversee each weapon acquisition program. Program managers have several responsibilities, including baselining the program's scope, schedule, and cost. NNSA federal program managers are ultimately accountable for ensuring that programs meet milestones on time and within budget.

Under the direction of the federal program offices, M&O contractor teams at the sites manage technical aspects of nuclear weapon acquisition programs. Specifically, M&O contractors are responsible for developing, maturing, and producing weapon technology. At the component level,

[31]In addition to these design reviews, the product realization process includes other technical reviews, including a system requirement, production definition and documentation, and production readiness review.

product realization teams, consisting of experts from the M&O contractors, manage the technical aspects of the technology maturation process. For example, as programs proceed, product realization teams assess the TRL of each major component, providing important input to NNSA's programmatic-level TRAs. See table 1 for a list of the numbers of product realization teams that NNSA has established for each ongoing weapon acquisition program.

Table 1: Number of Product Realization Teams per Nuclear Weapon Acquisition Program, as of July 2024

Program	Number of Product Realization Teams
B61-12 Life Extension Program	48
W88 Alteration 370 Program	35
W80-4 Life Extension Program	45
W87-1 Modernization Program	42
W93 Program	37[a]

Source: National Nuclear Security Administration. │ GAO-25-106048

[a]NNSA anticipates that this number will increase as the program advances.

When do NNSA nuclear weapon acquisition programs establish cost and schedule baselines?

As specified in an NNSA directive, programs establish cost and schedule baselines during the first part of Phase 3/6.3. The cost baseline includes the total estimated program cost, consisting of design and production costs, as well as contingency to cover cost and schedule risks. The schedule baseline includes estimates for key milestones, including completion of the first production unit and completion of production.[32]

Prior to establishing cost and schedule baselines, NNSA programs issue a report containing preliminary estimates of cost and schedule. Specifically, in Phase 2A/6.2A, programs issue a weapon design and cost report, which describes the options and preliminary cost estimates for design, qualification, and production activities.

During Phase 3/6.3, NNSA programs update the cost and schedule estimates from their weapon design and cost reports and document their cost and schedule baselines in a baseline cost report. Programs issue

[32]The cost and schedule baselines are part of a program's overall performance baseline, which also includes the number of weapons to be produced and key performance parameters that define essential characteristics, functions, or requirements associated with the completed weapon.

these reports before entry into the production engineering phase (Phase 4/6.4) of the acquisition process. The cost baselines in baseline cost reports do not include some costs associated with program activities early in the acquisition phase.[33] In addition, NNSA programs use the cost and schedule baselines from these reports to update the information in Selected Acquisition Reports, which they are required to submit to Congress during Phase 3/6.3.[34]

In developing the cost and schedule baselines for a program, NNSA programs conduct an analysis of the risks that, if realized, might result in cost increases and schedule delays and develop mitigation strategies to lessen or eliminate these risks. According to an NNSA directive, confidence levels are the principal tool used to establish and compare risk in cost and schedule estimates.[35] Generally, the higher the confidence level, the more likely a project will be completed within the corresponding cost and schedule estimates. Weapon acquisition programs are directed to establish two confidence levels associated with their cost estimates: (1) a “low” confidence level, at the 50th percentile; and (2) a “high” confidence level, at the 80th percentile. Different levels of confidence may translate into different amounts of contingency being added to a program’s cost estimate to account for risks.

Even with contingency, a program may encounter unforeseen challenges during production that affect its ability to meet its performance baseline. In such cases, a change to the program’s performance baseline may be approved, subject to requirements established by NNSA’s Office of Defense Programs.[36] The level of approval authority for baseline changes depends on the significance of the change. For example, the federal program manager may approve a schedule change that affects key

[33]For this reason, we have added these early costs to NNSA’s cost baselines (as presented in its baseline cost reports) for the weapon acquisition programs we reviewed to present total program costs. See appendix I.

[34]NNSA, at the end of the first quarter of each fiscal year, is to submit to the congressional defense committees a report on each nuclear weapon system undergoing life extension or major alteration, known as a Selected Acquisition Report. The information provided in the Selected Acquisition Report is to be the same as the information contained in the Selected Acquisition Report for a major defense acquisition program under section 4351 of title 10, expressed in terms of the nuclear weapon system. 50 U.S.C. § 2537.

[35]NNSA, *Confidence Levels and Escalation for Cost Estimating*, Policy 413.6 (Washington, D.C.: Sept. 23, 2022). This document was published after cost and schedule baselines were established for programs assessed in this report.

[36]See NNSA, *Office of Defense Programs Program Execution Instruction* (Sept. 30, 2021).

program milestones but maintains the first production unit date of the program. However, the NNSA Deputy Administrator must approve any schedule change that affects the program's first production unit date, and the Nuclear Weapons Council must approve any schedule change that affects the weapon's initial operational capability date.

In addition, NNSA's Office of Cost Estimating and Program Evaluation plays an important role in independently reviewing program cost estimates. Specifically, at the completion of Phase 2/6.2, the office evaluates a program's initial cost estimates for each potential design option by assessing the reasonableness of the estimate quality, assumptions, and risks. In Phase 2A/6.2A, the office prepares an independent cost estimate for the program and does so again in Phase 3/6.3. Programs must also review and reconcile any differences between their cost estimates and the office's independent estimates.

When do NNSA nuclear weapon acquisition programs assess the maturity of critical technologies?

As specified in NNSA directives, programs must assess the maturity of critical technologies at multiple points in the Phase X/6.X process. However, NNSA has not documented, in a formal and comprehensive manner, the process that its programs must follow in identifying which technologies are critical technologies.

According to NNSA directives, programs must conduct a TRA prior to Phase 2/6.2 authorization.[37] In addition, programs must ensure that their critical technologies demonstrate specific TRLs at different points in the Phase X/6.X process.[38] Specifically, programs must ensure that their critical technologies reach a minimum of:

- TRL 5 prior to the start of Phase 3/6.3,
- TRL 6 prior to the start of Phase 4/6.4, and
- TRL 8 prior to the start of Phase 6/6.6.[39]

[37]Relevant NNSA directives that we reviewed include NNSA Policy Letter 413.4, *Technology Readiness Assessments* (Apr. 16, 2020), and NNSA *Office of Defense Programs Program Execution Instruction* (Sept. 30, 2021). For a more detailed list of the directives we reviewed, see appendix II.

[38]NNSA uses the term "key technologies" to describe its requirements related to critical technologies. For purposes of this report, we use the term "critical technologies" instead of "key technologies" to refer to these requirements.

[39]According to the *Program Execution Instruction*, if minimum readiness levels are not demonstrated, then the NNSA Deputy Administrator of Defense Programs or a designated representative must accept associated program risk to allow the technology to proceed.

According to an NNSA directive, one best practice in conducting a TRA is to provide evidence of a disciplined, systems engineering method for identifying critical technologies. Moreover, GAO's TRA guide states that critical technologies should be rigorously identified and documented with an approach that is open and transparent to everyone in the process.[40] Our guide describes a four-step process for identifying critical technologies, as shown in table 2.

Table 2: Best Practices for Identifying Critical Technologies

Process described in GAO's Technology Readiness Assessment Guide
Step 1: Follow the agency's policy or guidance for identifying critical technologies and choose an agreed-upon approach.
Step 2: Use critical technology definition and questions to establish an initial list of critical technologies.
Step 3: Refine the list of critical technologies through collaboration between the technology readiness assessment team, program manager, or governance body.
Step 4: Review and repeat the process as requirements change.

Source: GAO, Technology Readiness Assessment Guide: Best Practices for Evaluating the Readiness of Technology for Use in Acquisition Programs and Projects, GAO-20-48G (Washington, D.C.: Jan. 2020). | GAO-25-106048

However, we found that NNSA directives related to TRAs did not document, in a formal and comprehensive manner, the process that NNSA programs must follow in identifying which technologies are critical technologies. For example:

- NNSA's directive on conducting TRAs states that the TRA must be planned and resourced for a comprehensive analysis. It also states that a TRA schedule and action plan must be developed for the complete assessment process. However, it does not specify a process that programs must follow for identifying which technologies are critical technologies.
- NNSA's Office of Defense Programs' instruction on program management refers programs to NNSA's TRA directive on the processes and procedures for conducting TRAs. It also does not specify a process that programs must follow for identifying which technologies are critical technologies.

As a result, we found that NNSA program managers gave different responses to questions about how their programs identified critical technologies. For example, one program manager stated that their program did not identify a formal list of critical technologies but instead focused on those technologies that may be problematic or pose greater

[40]GAO-20-48G.

risk. Another program manager stated that their program focused on technologies that are on the program's "critical path."[41]

According to federal standards for internal control, management should implement control activities through policies.[42] For example, management may document policies related to each unit's responsibilities. In addition, a well-documented approach to identifying critical technologies would provide NNSA with a more disciplined method for identifying critical technologies. As noted in our technology readiness guide, correctly identifying and selecting critical technologies can prevent wasting valuable resources—funds and time—later in the acquisition program.[43]

For 2 decades, we have shown that using effective management practices and processes to assess how far a technology has matured and how this has been demonstrated are fundamental to evaluating its readiness to be integrated into a system. By formally and comprehensively documenting the process that its nuclear weapon acquisition programs must follow to identify which technologies are critical technologies, NNSA may help ensure that its programs identify their critical technologies based on principles that are consistently applied across programs. Doing so may also help ensure that NNSA's nuclear weapon acquisition programs are better positioned to manage their funding and schedule resources.

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[41]A program's critical path is the path of longest duration through a program's sequence of activities. The critical path method of program schedule development is used to derive a program's critical activities—activities that cannot be delayed without delaying the end date of the program. See GAO, *Schedule Assessment Guide: Best Practices for Project Schedules*, GAO-16-89G (Washington, D.C.: Dec. 2015).

[42]GAO, *Standards for Internal Control in the Federal Government*, GAO-14-704G (Washington, D.C.: Sept. 10, 2014).

[43]GAO-20-48G. As we note in the guide, there should be no limitations on the number of critical technologies identified, but if an overly conservative approach is used and critical technologies are over-identified, resources can be diverted from those technologies that require an intense maturation effort. However, the under-identification of critical technologies because of a real or perceived limitation on the number of critical technologies allowed may prove disastrous in that such areas may fail to meet requirements, resulting in overall system failure. In addition, the under-identification of critical technologies may result in a poor representation of the number of interfaces or integration needs, a significant cause of system failures.

How does NNSA's acquisition process compare to knowledge-based acquisition principles and DOD's acquisition process?

In managing nuclear weapon acquisition programs under the Phase X/6.X process, NNSA follows an incremental approach to building knowledge, much like the approach defined in GAO's knowledge-based acquisition practices and correspondent with DOD's acquisition process structure.[44] The phases within Phase X/6.X can be grouped into three overarching phases that broadly align with GAO's three Knowledge Points:

1. **Initiation**, during which programs explore options and early designs;
2. **Development**, during which programs advance the design, testing, and evaluation of technologies and components, establish and test production processes, and complete the first production unit; and
3. **Production**, during which programs begin full-scale production of war reserve weapons.

We use these three phases in the program assessments that appear in appendix I.

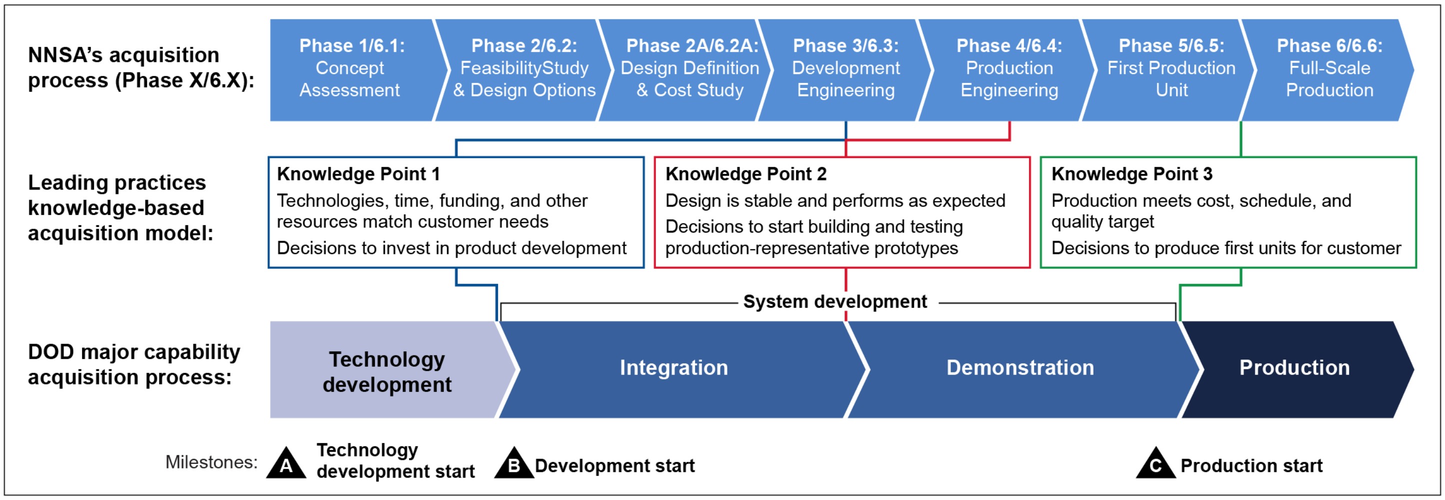
NNSA's and DOD's acquisition processes are similar but have some notable differences. DOD's acquisition process includes three key decision milestones—Milestones A, B, and C. The Milestone A decision approves program acquisition strategy and entry into the technology maturation and risk reduction phase. The Milestone B decision approves entry into the engineering and manufacturing development phase and commits the required investment resources to support the award of phase contracts. The Milestone C decision approves program entry into the production and deployment phase.

In general, DOD's key decision points are analogous to NNSA's Phases 2/6.2, 3/6.3, and 5/6.5. However, DOD's Milestone B occurs at a point that is analogous to sometime mid-way between NNSA's Phase 3/6.3 and Phase 4/6.4. In addition, DOD may target higher readiness levels for critical technologies as compared to similar NNSA decision points. Specifically, DOD recommends TRL 6 by Milestone B—partway through NNSA's development engineering phase (3/6.3)—whereas NNSA directs achievement of TRL 5 by Phase 3/6.3 and TRL 6 by Phase 4/6.4.[45]

[44]We listed GAO's knowledge-based acquisition practices criteria in appendix IV of GAO-23-106059.

[45]DOD and NNSA use slightly different language in their respective TRL directives, but they follow the same general process in the same sequence.

Figure 5: Comparison of NNSA Nuclear Weapon Acquisition Process with DOD Major Capability Acquisition Process and GAO Knowledge Points



Source: GAO analysis of National Nuclear Security Administration (NNSA) and Department of Defense (DOD) information. | GAO-25-106048

According to NNSA's Office of Cost Estimating and Program Evaluation, unsynchronized technological development between DOD's and NNSA's acquisition processes poses cost and schedule risks for NNSA programs when it comes to concurrent development of the warhead and its delivery system. In response to a provision in a Senate report accompanying a bill for the National Defense Authorization Act for Fiscal Year 2023, NNSA and DOD completed a joint review of the Phase X process and its alignment with DOD's acquisition process.[46] A report to Congress based on this review, issued in September 2024, recommended changes that would require NNSA to mature technologies to TRL 6 prior to the development phase, bringing NNSA's requirements in line with DOD's requirements for entry into Milestone B.[47] However, the report stated that these changes cannot be made within the current program planning period and therefore would not affect NNSA's current program of record.

[46]S. Rep. No. 117-130, at 371 (2022).

[47]NNSA, *Review of the Phase X Process* (Washington, D.C.: Sept. 2024).

NNSA Programs Face Several Challenges in Managing Nuclear Weapon Acquisitions

NNSA programs face several challenges in managing nuclear weapon acquisitions, including challenges related to maturing technologies, producing or procuring components, and overseeing contractors. According to NNSA officials and contractor representatives, the agency and its contractors have taken steps to address these challenges.

What challenges do NNSA nuclear weapons acquisition programs face in maturing technologies?

NNSA's nuclear weapons acquisition programs face two main challenges in maturing technologies, based on our review of NNSA documentation and interviews with agency officials and contractor representatives. These challenges involve accurately estimating the time it takes to fully mature technologies and being dependent on DOD acquisition programs for testing assets. Partly because of these challenges, we found that NNSA programs generally have not reached technology maturity milestones prior to the start of the development phase, as required in NNSA's weapons acquisition process. In addition, we found that some programs were not able to sufficiently mature newer technologies in time and, as a result, had to rely on older, existing technologies. According to NNSA officials, the agency has taken steps to address these challenges.

The first challenge is that it can be difficult to accurately estimate the amount of time it will take to fully mature technologies so that they can be manufactured. This is partly because, according to officials from NNSA's Office of Cost Estimating and Program Evaluation, it is far easier to demonstrate the maturity of a technology in a laboratory environment (i.e., at TRL 4) than it is to fully develop it for manufacture. According to these officials, M&O contractor sites that are responsible for designing components may have a small-scale capability to manufacture some components on site for testing purposes. In some cases, programs may set optimistic schedules for maturing these components based on their experiences with this small-scale manufacturing.

Producing components also entails applying component certification and acceptance standards, as well as rules for ensuring repeatability in a manufacturing environment. As a result, many components may end up taking longer to fully mature to enable full-scale manufacturing because the schedules for technology maturation may not have been realistic, according to NNSA officials.

In addition, officials noted that NNSA's production sites have not produced some legacy technology components in the last 30 years, and there is no clear alternative or substitute for those legacy components.

This compounds the challenge of producing accurate estimates of manufacturing time. The officials cited this factor as affecting the W80-4, W87-1, and W93 programs in particular.

One result of this challenge is that NNSA's weapon acquisition programs have had difficulties reaching technology readiness milestones. Specifically, NNSA's Office of Defense Programs currently directs its programs to ensure that their critical technologies reach TRL 5 by the beginning of Phase 3/6.3—the beginning of the acquisition phase we refer to as the development phase.[48] However, according to NNSA's Office of Cost Estimating and Program Evaluation, for the two life extension programs we reviewed that have reached the development phase and for which data are available, a majority of program technologies had not reached the TRL 5 milestone by the beginning of that phase, as shown in table 3.[49]

[48]National Nuclear Security Administration, *Office of Defense Programs Program Execution Instruction* (Sept. 30, 2021). According to this directive, if minimum readiness levels are not demonstrated, then the NNSA Deputy Administrator of Defense Programs or a designated representative must accept associated program risk to allow the technology to proceed. Officials noted that the current version of the directive was not in effect at the inception of the B61-12 Life Extension Program, W88 Alteration 370 Program, or W80-4 Life Extension Program.

[49]More specifically, according to information provided by NNSA's Office of Cost Estimating and Program Evaluation, 12 of the 37 technologies that office tracked in the B61-12 program had reached TRL 5 at the beginning of Phase 6.3, while five of the 42 technologies the office tracked in the W80-4 program had reached TRL 5 at the beginning of Phase 6.3. Furthermore, the office projected in September 2021 that eight of the 108 technologies it tracked in the W87-1 program would reach that threshold when it entered Phase 6.3. The office is currently reviewing the W87-1 program's actual performance.

Table 3: Number of Technologies in Nuclear Weapon Acquisition Programs Reaching NNSA's Maturity Milestone at the Start of Development

Weapon Program	Number of Technologies	Number of Technologies Meeting NNSA's Maturity Milestone for Critical Technologies
B61-12 Life Extension Program	37	12
W80-4 Life Extension Program	42	5

Source: GAO analysis of National Nuclear Security Administration's (NNSA) Office of Cost Estimating and Program Evaluation information. │ GAO-25-106048

Another result of NNSA's challenges in maturing technologies is that programs, in some cases, have not been able to adopt newer technologies and instead have had to proceed with older, existing alternatives. For example, according to contractor representatives at Los Alamos, some programs were unable to use a technology known as an optical initiator—developed at Los Alamos to enhance the safety and security of nuclear weapons' detonation sequence—in part because the laboratory ran out of time to advance its maturity within the planned time frames of the acquisition programs. As a result, the programs opted to use older, existing detonation technologies and forego the potential safety and security benefits of the newer technology.

Partly to address this challenge, NNSA established its Office of Research, Development, Testing, and Evaluation in 2019. This office is responsible for developing new technologies for potential use in nuclear weapons outside the context of an acquisition program. According to NNSA officials, this office develops new technologies until they reach TRL 5, in consultation with NNSA officials responsible for ongoing weapon programs. After a technology reaches TRL 5, the office may pass them on to a program for further development.[50]

A second challenge faced by NNSA programs in maturing critical technologies is that they are dependent on DOD acquisition programs to provide the testing assets needed to conduct testing procedures. Specifically, NNSA programs must conduct flight testing to advance the design maturity of warheads and their underlying components. However, DOD is also conducting acquisition programs to modernize the delivery systems across all legs of the nuclear triad. As a result, the concurrent development of DOD delivery systems and NNSA warheads creates challenges for NNSA and DOD in aligning the schedules of their related acquisition programs and ensuring that testing assets are available when needed for NNSA programs to conduct flight testing.

For example, the W80-4 program needed to conduct early functional flight tests before the Air Force could supply prototypes of its delivery vehicle, the Long-Range Standoff Weapon. NNSA programs have taken some steps to address this challenge. According to program officials, the W80-4 program developed workarounds for some of its flight tests, such as by using an airplane to simulate the planned flight patterns of the delivery vehicle. However, the program still requires further testing to fully validate the design of the warhead.

NNSA anticipates similar timing challenges with flight testing for both the W87-1 and W93 programs. Specifically:

- The W87-1 program is reliant on the Mk21A reentry vehicle, and both of these programs are reliant on the Sentinel missile program. According to Air Force officials, with the announcement of the Sentinel program experiencing a significant cost increase and schedule delay, the availability of hardware and flight-testing dates are in question.

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[50]According to NNSA officials, the Office of Research, Development, Testing, and Evaluation does not continue to mature technologies beyond TRL 5 in part to ensure that NNSA adheres to statutory requirements relating to new weapon designs. Specifically, NNSA must request congressional authorization and funding before engaging in the design of a new or modified nuclear weapon, and must obtain presidential approval before producing nuclear weapons or nuclear weapon parts. 42 U.S.C. § 2121(a)(2); 50 U.S.C. § 2529(a)(1). A December 2022 statutory amendment clarified the extent to which DOE and NNSA may perform early-stage research and development activities on component technologies without specific authorization and a funding request. 50 U.S.C. § 2529(a)(1) (as most recently amended by James M. Inhofe National Defense Authorization Act for Fiscal Year 2023, Pub. L. No. 117-263, div. C. title XXXI, § 3111, 136 Stat. 2395, 3051 (2022)).

The issue is unlikely to be resolved, according to Air Force officials, until more is known about a restructured Sentinel program. In the meantime, NNSA officials said that the W87-1 program has pursued agreements with the Air Force to field a first flight test unit via the Rocket Systems Launch Program, using already planned flights, to obtain environmental reentry data needed for W87-1 qualification.

- The joint program to develop the W93 warhead and its Mk7 reentry body is reliant on flight data to inform design activities. According to NNSA officials, the Mk7 reentry body will present new mechanical stresses on the W93 warhead, and the W93/Mk7 program will not be able to obtain flight testing data based on the new Mk7 design until March 2027. NNSA officials said that they are in communication with the Navy regarding the reentry body and are using the best information available to manage design activities.

What challenges do NNSA programs face in producing or procuring components?

NNSA programs face two main challenges in producing or procuring components, based on our review of NNSA documentation and interviews with agency officials and contractor representatives. These challenges are ensuring that (1) all components meet strict design requirements and (2) components manufactured using a new or newly reconstituted production process do not introduce unexpected variances in weapon performance. In some cases, these challenges have led to cost increases and schedule delays. NNSA officials and contractor representatives said that they have taken steps to address these challenges.

First, NNSA programs must ensure that all components—whether produced at NNSA sites or procured from outside vendors—meet strict design requirements. For example, according to contractor representatives at the Kansas City National Security Campus, the design of the B61-12 bomb required a certain component. According to contractor representatives, the program had to develop several iterations of tooling and equipment to produce the component and certify its suitability for use in the weapon. Contractor representatives said that they managed the challenges by building time into the schedule for iteration and consulting regularly with contractors at the design laboratories to ensure that produced components met design requirements.

Additionally, procurement of commercially available parts for use in nuclear weapons has created difficulties for NNSA. Notably, NNSA discovered problems with a procured part for two weapon acquisition programs, resulting in the need to procure replacement parts for use in several components shared by the two programs. NNSA estimated that this development delayed both programs' milestones for completion of the first production unit and added about $850 million to their combined cost.

To help reduce the risk associated with this challenge, NNSA and its contractor representatives developed a revised quality assurance process for electronic parts, referred to as the Electronic Parts Program. Under this program, product realization teams conduct qualification testing for electronic parts earlier in the design process and develop a list of approved parts that are suitable for use in weapon acquisition programs.[51]

Second, NNSA programs must ensure that a component manufactured using a new or newly reconstituted production process will not introduce unexpected variances in weapon performance. Aged infrastructure makes the use of new facilities and equipment inevitable, but because the United States has observed a moratorium on nuclear explosive testing since the early 1990s, NNSA cannot fully test all newly manufactured parts in their operating environments. As a result, the use of parts with different materials or produced using a different process may introduce risk to the performance of a nuclear weapon.

Nevertheless, some acquisition programs will rely on the construction of new facilities, or the modernization of existing facilities, to manufacture special materials used in nuclear weapons. These facilities may use different processes, or newly reconstituted processes, to produce components and materials used in nuclear weapons, which may introduce some risk. In addition, many of these planned facilities are over budget and behind schedule. For example:

- Some programs will rely on the construction or modernization of facilities to produce plutonium pits. However, the United States has not regularly manufactured pits since 1989. To address this issue, NNSA is constructing or modernizing multiple buildings at both the Los Alamos National Laboratory and Savannah River Site. According to NNSA's estimates in its fiscal year 2025 budget justification, the overall Los Alamos Plutonium Pit Production Project will enable production of 30 plutonium pits per year at Los Alamos National

[51]For more information on the Electronic Parts Program, see GAO, *National Nuclear Security Administration: Update on Actions to Manage Production Challenges at the Kansas City Site*, GAO-24-105858 (Washington, D.C.: Nov. 16, 2023).

Laboratory by the end of fiscal year 2032 at a cost of over $5 billion.[52] These figures represent a 4-year delay and a cost increase of over $1 billion since the overall project's April 2021 alternative selection milestone. In addition, according to NNSA's estimates, the overall Savannah River Plutonium Processing Facility will enable production of 50 plutonium pits per year at the Savannah River Site by as late as the end of fiscal year 2038 and at a cost of potentially $18 billion to $25 billion.[53] At the project's alternative selection milestone in June 2021, NNSA estimated that the project would be completed by fiscal year 2035 at a cost ranging from $6.9 billion to $11.1 billion.

- Some programs will rely on the construction or modernization of facilities to produce uranium components. NNSA continues to rely on some facilities at the Y-12 National Security Complex that date back to the 1940s and 1950s to produce some of these components. To address this issue, NNSA is constructing or modernizing multiple buildings at the Y-12 National Security Complex as part of the overall Uranium Processing Facility project. However, as we previously reported, in 2023 NNSA updated the cost and schedule estimates for this group of projects, which added over $1 billion and about 3 years to the projects' schedule.[54] According to NNSA's estimates in its fiscal year 2025 budget justification, the overall Uranium Processing Facility will not be completed until fiscal year 2030 at a cost over $9 billion.[55]

NNSA officials and contractor representatives said that regular communication among representatives from both the design laboratories and the production sites is essential in managing these challenges for ongoing weapon acquisition programs. The officials cited product realization teams as a key mechanism to facilitate communication.

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[52]According to NNSA officials, Los Alamos National Laboratory is currently executing the Los Alamos Plutonium Pit Production Project 30 base subproject, which aims to provide a 30 pit-per-year capability as close to 2028 as possible, although at a lower reliability.

[53]We reported in 2023 that NNSA had not developed a cost estimate for its pit production activities that provided a complete and structured accounting of all resources required to develop and sustain a complete scope of work. We also reported that NNSA's pit production schedule does not meet minimum qualifications to be considered an integrated master schedule, according to GAO's best practices for scheduling. See GAO, *Nuclear Weapons: NNSA Does Not Have a Comprehensive Schedule or Cost Estimate for Pit Production Capability*, GAO-23-104661 (Washington, D.C.: Jan. 12, 2023).

[54]GAO-23-104402.

[55]This project has a baseline change proposal pending approval from DOE and NNSA that will determine a revised estimated project cost and schedule that may exceed $9 billion and finish in 2030.

In addition, some programs rely in part on production processes that have never been used in the context of nuclear weapon manufacturing. According to NNSA officials, the use of new production processes introduces challenges related to qualifying and certifying components. For example, the W80-4 program is using additive manufacturing processes to produce warhead components.[56] According to NNSA officials, additive manufacturing offers advantages in rapid prototyping, process precision, labor savings, and weapon performance. However, components produced from additive manufacturing have never been used before in weapons in the nuclear stockpile.

To address the risks posed by the introduction of components produced using additive manufacturing, NNSA officials said that the W80-4 program needs to demonstrate that the materials in these components meet compatibility, performance, and durability requirements for the weapon. The officials said that the W80-4 program has confidence that the new components will work, based on data from peer-reviewed tests of the new components and analogous components already in the stockpile.

What challenges do NNSA programs face in overseeing their contractors?

NNSA programs face two related challenges in overseeing their contractors, based on our review of NNSA documentation and interviews with agency officials and contractor representatives. These challenges involve having a relatively small number of federal program staff oversee the work of hundreds of contractors, as well as having these federal staff function as the integrators of all programmatic activities across the eight sites of the nuclear security enterprise. In some cases, these challenges have contributed to cost increases and schedule delays for weapon acquisitions. According to NNSA officials, the agency is pursuing ways to improve the efficiency of its oversight of acquisition programs.

First, NNSA programs rely on a relatively small number of dedicated federal staff to oversee the work and performance of hundreds of M&O contractor employees. As shown in table 4, the number of federal staff who work on nuclear weapon acquisitions varies with the phase of the acquisition process but generally ranges from seven to nine staff for programs in the initiation or development phases of the acquisition cycle.

[56]Additive manufacturing, often referred to as three-dimensional printing, refers to a layer-by-layer approach for producing objects from a digital model using materials such as metal powders, plastic, and foundry sand. Since its inception in the 1980s, additive manufacturing has been used by private industry as a tool for design and prototyping. Today, private industry is using additive manufacturing to produce finished end-parts. See GAO, *Defense Additive Manufacturing: DOD Needs to Systematically Track Department-wide 3D Printing Efforts*, GAO-16-56 (Washington, D.C.: Oct. 14, 2015).

In addition, these federal staff are supported by a larger number of support contractors, who are hired under support service contracts and provide a variety of professional support services to NNSA. The number of support contractors assigned to an acquisition program varies from around 15 to 30 contractors. Even with these support contractors, the number of NNSA staff managing the nuclear weapon acquisition programs is relatively small. For example, for NNSA's two programs in the development phase, each NNSA program staff is associated with an average of over $400 million in programmatic activities.

Table 4: Number of NNSA Program Staff per Weapon Acquisition Program

Program	Acquisition phase	Federal staff[a]	Support contractors[b]
B61-12 Life Extension Program	Production	4	12
W88 Alteration 370 Program	Production	5	18[c]
W80-4 Life Extension Program	Development	9	33
W87-1 Modernization Program	Development	7	17
W93 Program	Initiation	7	15

Source: National Nuclear Security Administration (NNSA). | GAO-25-106048

[a]Positions filled as of March 2024, not including DOD commissioned officer billets.

[b]Contractors under support service contracts provide a variety of professional support services to NNSA, such as program management support.

[c]Three of the 18 contractors work less than 50 percent per month on the W88 program. Of the 18 contractor positions, seven are split with the W93 program.

We recently reported more broadly on the efforts of NNSA's offices to oversee the work and performance of its M&O contractors. Specifically, as noted in our May 2024 report, NNSA's federal workforce of about 1,800 staff oversees more than 55,000 M&O contractor employees.[57] In that report, we found that NNSA officials consider the agency's federal workforce to be understaffed, leading to challenges completing work. For example, we found that, according to NNSA officials, not having enough staff has made it challenging to provide adequate contract oversight, which is critical to program success.

[57]See GAO, *National Nuclear Security Administration: Actions to Recruit and Retain Federal Staff Could Be Improved*, GAO-24-106167 (Washington, D.C.: May 29, 2024). For more information on NNSA's acquisition and contractor workforce, see *Department of Energy: Improvements Needed to Strengthen Strategic Planning for the Acquisition Workforce*, GAO-22-103854 (Washington, D.C.: Nov. 16, 2021) and *Support Service Contracts: NNSA Could Better Manage Potential Risks of Contractors Performing Inherently Governmental Functions*, GAO-19-608 (Washington, D.C.: Sept. 26, 2019).

Second, NNSA program managers must function as the integrators of all programmatic activities across the eight sites of the nuclear security enterprise. While NNSA's M&O contractors, along with their associated product realization teams, act as the technical integrators for all activities associated with a nuclear weapon acquisition program, NNSA's program managers must integrate the work of hundreds of contractors across eight sites to ensure that program goals, objectives, and schedules are met.

In some cases, the challenges of overseeing the work of multiple M&O contractors while integrating programmatic activities across sites have contributed to cost increases and schedule delays for weapon acquisitions. For example, according to an NNSA report by an independent review team, NNSA did not adequately resource two of its weapon acquisition programs to provide effective technical and programmatic oversight of its M&O contractors, which contributed to problems these programs experienced with a procured component.

NNSA is considering changes to the way it oversees M&O contractors through its Enhanced Mission Delivery Initiative, which is the subject of a separate, ongoing GAO review.[58] Through this initiative, NNSA is evaluating multiple internally generated recommendations for agency reform that it believes will increase the speed and efficiency of nuclear enterprise modernization. One of these areas of reform is to improve the efficiency of NNSA's management of its weapon modernization programs by, for example, improving its product realization process.

Conclusions

Nuclear weapon acquisitions are expensive and highly technical endeavors that bring together many specialized technologies. We found that NNSA requires its nuclear weapon acquisition programs to assess the readiness of its technologies at specific milestones throughout each program. However, we also found that NNSA programs continue to have difficulty in maturing nuclear weapon technologies to required readiness levels for critical technologies at certain milestones. In addition, we found that NNSA's weapon program managers used different methods to identify which technology elements were critical to their programs.

Two decades of our work have shown that effective TRA processes are fundamental to evaluating critical technologies' readiness to be integrated into complex system acquisitions. Correctly identifying and selecting an

[58]NNSA issued a report on this initiative in September 2022. See NNSA, *Evolving the Nuclear Security Enterprise: A Report of the Enhanced Mission Delivery Initiative* (Washington, D.C.: Sept. 2022).

acquisition program's critical technologies, using a consistent and well-documented process, is an important part of an effective TRA process because it can help prevent wasted funding and schedule resources later in the program. NNSA's directives underscore the importance of TRAs in nuclear weapon acquisitions. By formally and comprehensively documenting the process that these programs must follow to identify which technologies are critical technologies, NNSA may help ensure that the programs succeed in maturing these technologies to the recommended levels and better position the programs to manage funding and schedule resources.

Recommendation for Executive Action

The NNSA Administrator should ensure that the Office of Defense Programs documents, in a formal and comprehensive manner, the process that its nuclear weapon acquisition programs must follow to identify which of their technologies are critical technologies. (Recommendation 1)

Agency Comments

We provided a draft of this product to NNSA and DOD for review and comment. In its written comments, which are reprinted in appendix IV, NNSA agreed with our recommendation. NNSA and DOD also provided technical comments, which we incorporated as appropriate.

We are sending copies of this report to the appropriate congressional committees, the Secretaries of Defense and Energy, the Administrator of NNSA, and other interested parties. In addition, this report is available at no charge on the GAO website at http://www.gao.gov.

If you or your staff members have any questions about this report, please contact me at (202) 512-3841 or bawdena@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made significant contributions to the report are listed in appendix VI.

Allison B. Bawden
Director, Natural Resources and Environment

Appendix I: Individual Program Assessments

In the following section, we present two-page assessments of five ongoing National Nuclear Security Administration (NNSA) weapon modernization programs, as of July 2024.[1] Each assessment includes a brief description of the program, information about the weapon's delivery systems and the design laboratories involved in the program, the program's cost and schedule performance (for programs with cost and schedule baselines), a timeline identifying key milestone dates such as for the first production unit (FPU) of a weapon, and a brief narrative describing the status of the program.[2] Assessments describe the challenges we identified—such as challenges associated with the design and production of a weapon, if applicable—and include an analysis of the challenges. In addition, we outline the extent to which each program faces cost, schedule, or performance risks because of these challenges. Key technical terms are defined in the report's Background section.

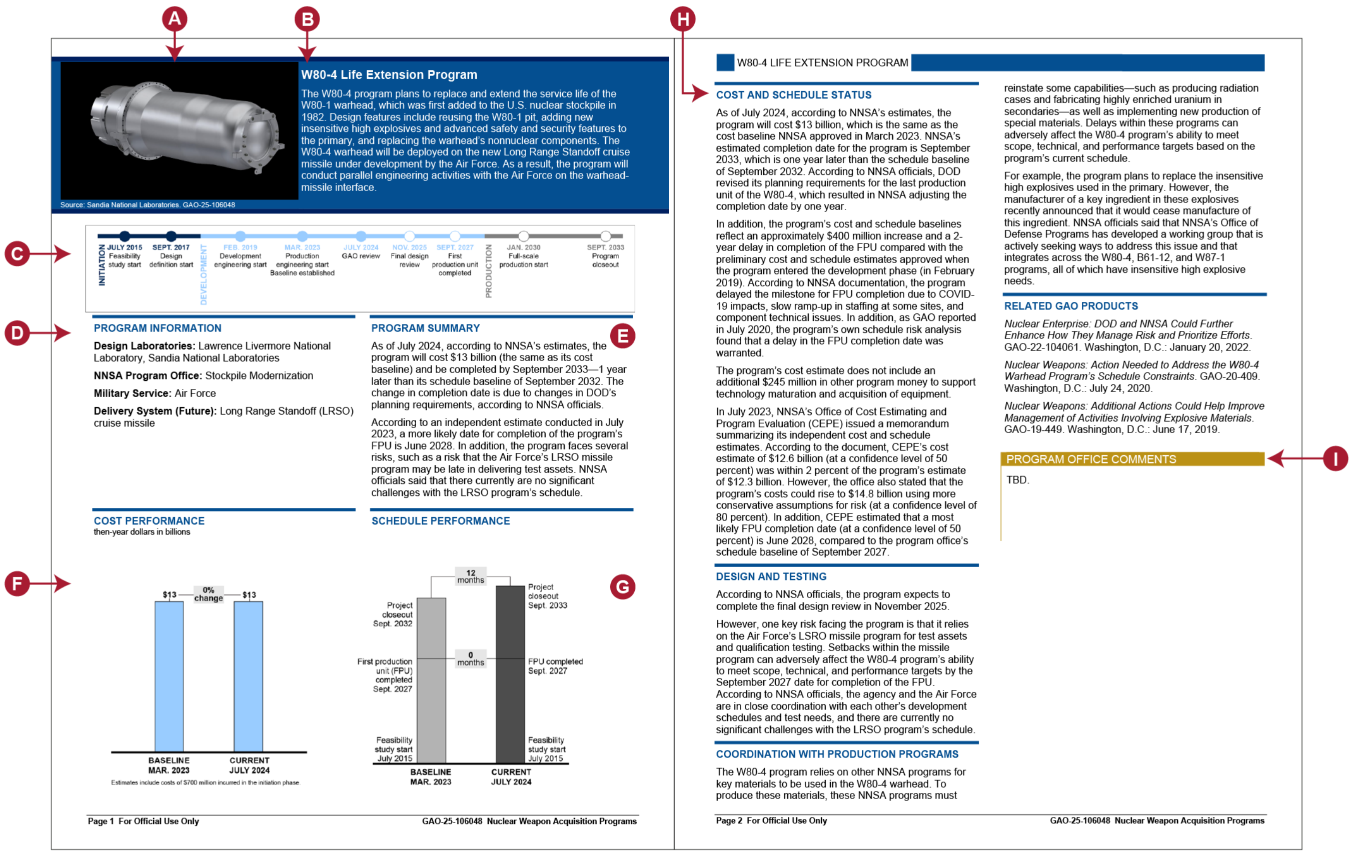
As detailed in appendix II, we obtained the information presented in these assessments from NNSA documentation, interviews with NNSA program staff, and data provided by NNSA officials in our questionnaires covering cost and schedule updates and other program details. The assessments also include our analysis of the program cost and schedule information provided. NNSA's program offices were provided an opportunity to review drafts of the assessments prior to their inclusion in this report. The program offices provided technical corrections and general comments. We integrated the technical corrections, as appropriate, and summarized

[1]In addition, the National Defense Authorization Act for fiscal year 2024 authorizes two additional nuclear weapon acquisitions, the B61-13 and a sea-launched nuclear cruise missile (National Defense Authorization Act for Fiscal Year 2024, Pub. L. No. 118-31, §§ 1640, 4701, 137 Stat. 136, 595, 924 (2023)). According to DOD, the B61-13 is intended to replace some of the B61 variants in the current stockpile, and to be substituted for some of the previously planned production quantity of the B61-12. In testimony before Congress, officials from DOD and NNSA have said that initial activities are underway to explore options for the sea-launched nuclear cruise missile, including whether to develop a variant of the W80-4 warhead for the weapon or pursue a different option. These acquisitions were authorized after our study was underway and were not included in our assessments as a result.

[2]All cost information in this report is presented in nominal then-year dollars for consistency with budget data. Then-year dollars, also sometimes called budget year dollars, include the effects of inflation (as opposed to base-year dollars, which do not). For budgeting purposes, then-year dollars are used to reflect a program's projected annual costs by appropriation. Presenting figures in terms of then-year dollars requires adjusting for inflation, based on assumptions about what inflation indexes to use, since any future inflation index is uncertain.

the general comments at the end of each program assessment. Figure 6 explains the layout of the information provided in each assessment.

Figure 6: Explanation of Program Assessment Layout



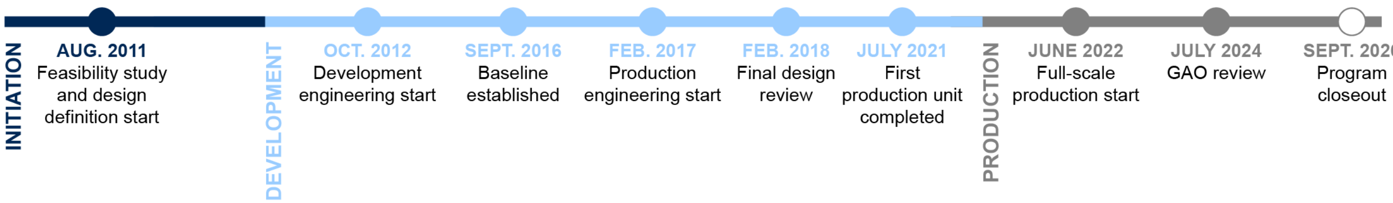
- **A** Illustration of the weapon, weapon system, or program insignia.
- **B** General description of the program's objectives.
- **C** Timeline identifying key dates for the program including when the program began, received authorization to enter each phase of development, achieved first production unit, and when the program is expected to reach closeout.
- **D** Program information: identifies the weapon design laboratories, NNSA program office and organizational code, military service customer, and delivery system or systems.
- **E** Program summary: Brief narrative describing the status of the program.
- **F** Cost: For programs in initiation or early in the development phase prior to establishing a cost baseline, the preliminary cost estimate (or range of costs) used for planning purposes. For programs later in the development phase after establishing a baseline, the approved cost baseline and latest estimate.
- **G** Schedule: For programs in initiation or early in the development phase prior to establishing a schedule baseline, the preliminary schedule estimate to complete first production unit (or range of dates) used for planning purposes. For programs later in the development phase after establishing a baseline, the approved schedule baseline and latest estimate for first production unit and closeout.
- **H** The second page of the assessment presents an analysis of program cost and schedule status, design and testing challenges, and coordination issues with production programs, to the extent relevant for each program, along with a list of related GAO products. Analyses for programs in late production may only cover cost and schedule status.
- **I** Program Office Comments: General comments provided by the cognizant program office.

Source: GAO analysis. | GAO-25-106048

Source: U.S. Navy. | GAO 25-106048

W88 Alteration 370 Program

The W88 Alteration (Alt) 370 program plans to modify the W88 warhead, first added to the U.S. nuclear stockpile in 1988. The program does not extend the life of the warhead. Design features include replacing the arming, fuzing, and firing assembly; adding a lightning arrestor connector; and refreshing the conventional high explosives in the primary. The W88 Alt 370 warhead will pair with a refurbished Mk5 reentry body developed by the Navy and deployed on existing submarine-launched ballistic missiles.



PROGRAM INFORMATION

Design Laboratories: Los Alamos National Laboratory, Sandia National Laboratories

NNSA Program Office: Stockpile Modernization

Military Service: Navy

Delivery System: Trident II D5 submarine-launched ballistic missile deployed on Ohio-class ballistic missile submarines

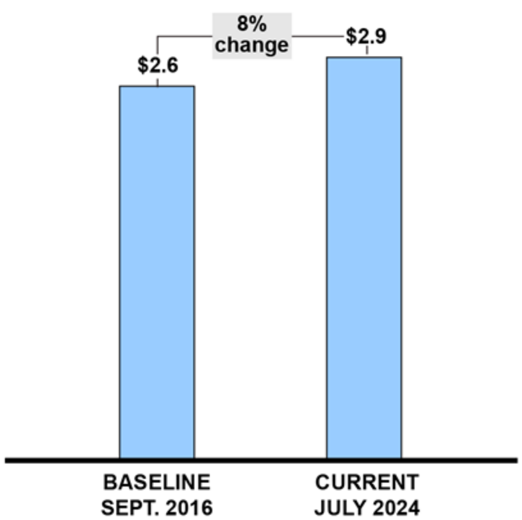
PROGRAM SUMMARY

As of July 2024, based on NNSA's estimates, the W88 Alt 370 program will cost $2.9 billion (baseline is $2.6 billion) and be completed in September 2026 (baseline is March 2025).

The program has been in full-scale production since June 2022. According to NNSA, the program met its shipment schedule to the Navy in fiscal year 2023 and expects to meet its shipment schedule in fiscal year 2024. However, the program has experienced some additional costs associated with the production schedule, as some costs (such as overtime) have been higher than expected.

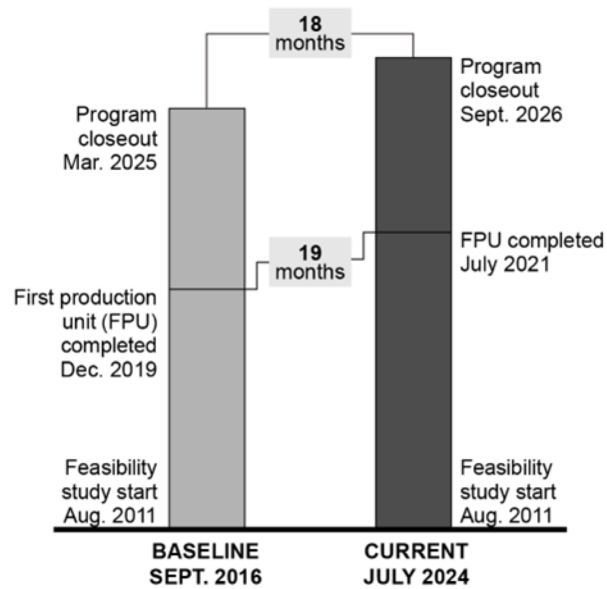
COST PERFORMANCE

then-year dollars in millions



Estimates include costs of $100 million incurred in the initiation phase.

SCHEDULE PERFORMANCE



Cost and Schedule Status

As of July 2024, based on NNSA's estimates, the program's current total cost is $2.9 billion, which is about $200 million over the baseline of $2.7 billion (approved in September 2016). NNSA currently estimates program closeout by September 2026, about 18 months later than the baseline estimate of March 2025. This cost increase and schedule delay are primarily due to an issue with a procured part in the April 2019 timeframe.

The program's cost estimate does not include an additional roughly $170 million in other program money to support technology maturation and manufacturing readiness activities, managed by other NNSA programs, that will benefit this program.

The program has been in full-scale production since June 2022. However, NNSA officials said that the program's cost estimate will increase by about $72 million due to additional costs incurred to achieve full-scale production at the Pantex Plant. Specifically, officials said that the program underestimated the costs at the Pantex Plant for meeting production requirements, and the program has seen cost growth associated with buying more tools, hiring additional production technicians, and paying for overtime for workers to maintain the production schedule.

According to NNSA officials, the program met its production schedule in fiscal year 2023 and expects to meet its production schedule in fiscal year 2024. The program is scheduled to produce its last production unit by the end of fiscal year 2025.

In addition, NNSA officials identified several technical challenges that the program experienced over the last year—such as challenges with producing enough quantities of certain parts (such as the arming, fuzing, and firing assembly), as well as facility outages. However, officials stated that the program has addressed these issues, which did not affect the production schedule at the Pantex Plant.

Related GAO Products

Nuclear Enterprise: DOD and NNSA Could Further Enhance How They Manage Risk and Prioritize Efforts. GAO-22-104061. Washington, D.C.: January 20, 2022.

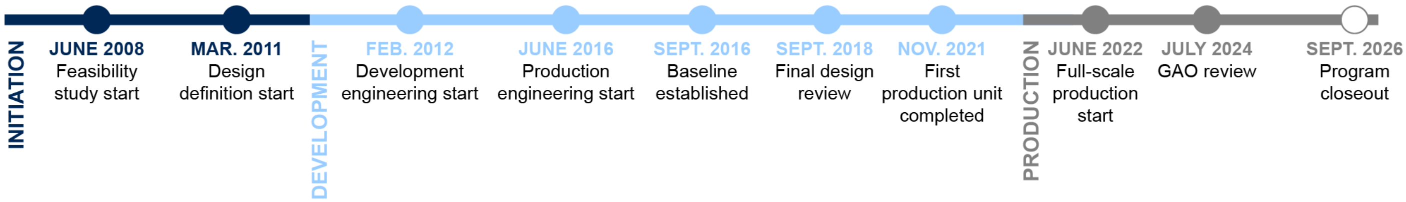
PROGRAM OFFICE COMMENTS

NNSA program officials provided technical comments on a draft of this assessment, which we incorporated as appropriate.

Source: NNSA, U.S. Air Force. | GAO 25-106048

B61-12 Life Extension Program

The B61-12 program plans to replace and extend the service life of three variants of the original B61 bomb, first added to the U.S. nuclear stockpile in 1968. Design features include reusing the pit, adding safety and security features to the primary, remanufacturing portions of the secondary, and replacing the bomb's nonnuclear components. The design also incorporates a new tail kit, provided by the Air Force, that adds guidance capability. The B61-12 bomb will be deliverable by existing and future aircraft platforms.



PROGRAM INFORMATION

Design Laboratories: Los Alamos National Laboratory, Sandia National Laboratories

NNSA Program Office: Stockpile Modernization

Military Service: Air Force

Delivery Systems (Current): B-2 bomber, F-15 aircraft, F-16 aircraft, F-35 aircraft, and certified NATO aircraft

Delivery Systems (Future): B-21 bomber

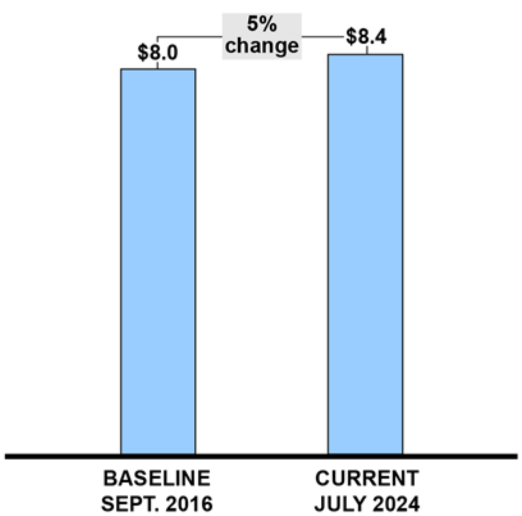
PROGRAM SUMMARY

As of July 2024, based on NNSA's estimates, the B61-12 program will cost $8.4 billion (baseline is $8.0 billion) and be completed in September 2026 (baseline is September 2025). However, DOD has announced plans to build an additional variant, the B61-13, using the B61-12 production line. As a result, NNSA plans to shorten the production run of the B61-12.

The program has been in full-scale production since June 2022. According to NNSA, the program met 100 percent of its shipment schedule to the Air Force in fiscal year 2023 and expects to meet its shipment schedule in fiscal year 2024.

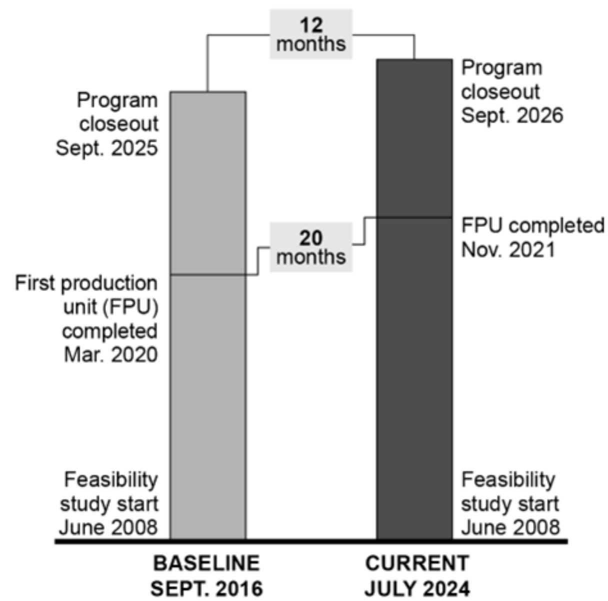
COST PERFORMANCE

then-year dollars in millions



Estimates include costs of $400 million incurred in the initiation phase.

SCHEDULE PERFORMANCE



Cost and Schedule Status

As of July 2024, based on NNSA's estimates, the total cost to complete the B61-12 program will be $8.4 billion, which is about $400 million over the baseline of $8.0 billion (approved in September 2016). NNSA estimates it will close out the program in September 2026, 1 year later than its baseline of September 2025. This cost increase and schedule delay are primarily due to an issue with a procured part in the April 2019 timeframe.

The program's cost estimate does not include an additional $648 million in other program money to support technology maturation and manufacturing readiness activities, managed by other NNSA programs.

The program has been in full-scale production since June 2022. According to NNSA, the program met its production schedule in fiscal year 2023 and is on track for the same level of performance in fiscal year 2024. In addition, the program is scheduled to produce its last production unit during fiscal year 2025 and complete program closeout in fiscal year 2026.

NNSA officials stated that the program works closely with the Pantex Plant to monitor and address potential production challenges. For example, the program monitors items such as having sufficient production technicians, facilities, and tooling to maintain the current production schedule. Officials also stated that the program currently is not facing any specific challenges or risks to the production schedule.

In October 2023, DOD announced plans to build an additional B61 variant, the B61-13, using the B61-12 production line. According to NNSA officials, NNSA will produce fewer B61-12 bombs than originally planned to accommodate the B61-13 program. Officials said that the B61-12 program will pay for the costs associated with the manufacture of nonnuclear components used for the B61-13 program.

Related GAO Products

B61-12 Nuclear Bomb: Cost Estimate for Life Extension Incorporated Best Practices, and Steps Being Taken to Manage Remaining Program Risks. GAO-18-456. Washington, D.C.: May 31, 2018.

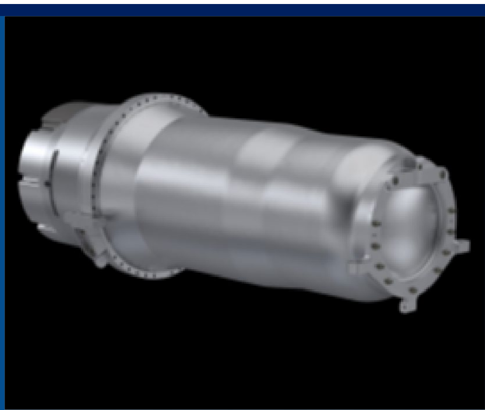
Nuclear Enterprise: DOD and NNSA Could Further Enhance How They Manage Risk and Prioritize Efforts. GAO-22-104061. Washington, D.C.: January 20, 2022.

Nuclear Weapons: NNSA Has a New Approach to Managing the B61-12 Life Extension, but a Constrained Schedule and Other Risks Remain. GAO-16-218. Washington, D.C.: February 4, 2016.

Nuclear Weapons: DOD and NNSA Need to Better Manage Scope of Future Refurbishments and Risks to Maintaining U.S. Commitments to NATO. GAO-11-387. Washington, D.C.: May 2, 2011.

PROGRAM OFFICE COMMENTS

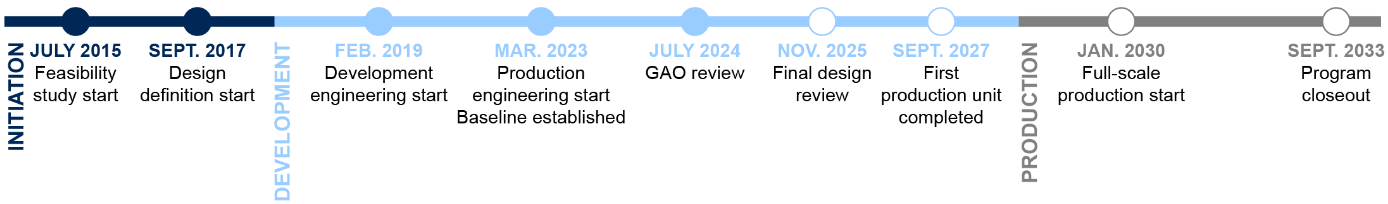
NNSA officials stated that they expect the overall cost of the B61-12 program to be reduced by approximately $100 million during fiscal year 2025. They also provided technical comments on a draft of this assessment, which we incorporated as appropriate.



Source: Sandia National Laboratories. | GAO 25-106048

W80-4 Life Extension Program

The W80-4 program plans to replace and extend the service life of the W80-1 warhead, first added to the U.S. nuclear stockpile in 1982. Design features include reusing the W80-1 pit, adding new insensitive high explosives and advanced safety and security features to the primary, and replacing the warhead's nonnuclear components. The W80-4 warhead will be deployed on the new Long Range Standoff cruise missile under development by the Air Force. As a result, the program will conduct parallel engineering activities with the Air Force on the warhead-missile interface.



PROGRAM INFORMATION

Design Laboratories: Lawrence Livermore National Laboratory, Sandia National Laboratories

NNSA Program Office: Stockpile Modernization

Military Service: Air Force

Delivery System (Future): Long Range Standoff (LRSO) cruise missile

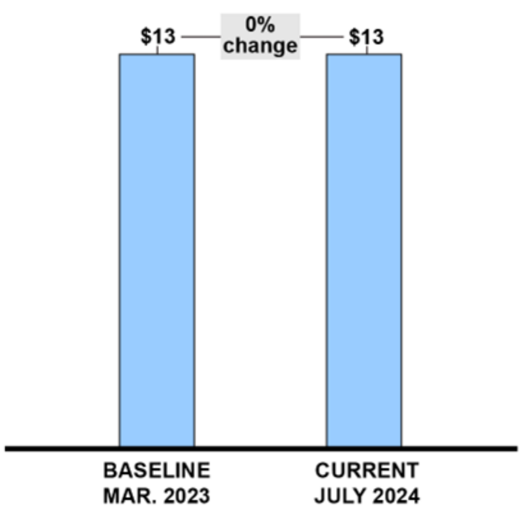
PROGRAM SUMMARY

As of July 2024, according to NNSA's estimates, the program will cost $13 billion (the same as its cost baseline) and be completed by September 2033—1 year later than its schedule baseline of September 2032. The change in completion date is due to changes in DOD's planning requirements, according to NNSA officials.

According to an independent estimate conducted in July 2023, a more likely date for completion of the program's first production unit (FPU) is June 2028. In addition, the program faces several risks, such as a risk that the Air Force's LRSO missile program may be late in delivering test assets. NNSA officials said that there currently are no significant challenges with the LRSO program's schedule.

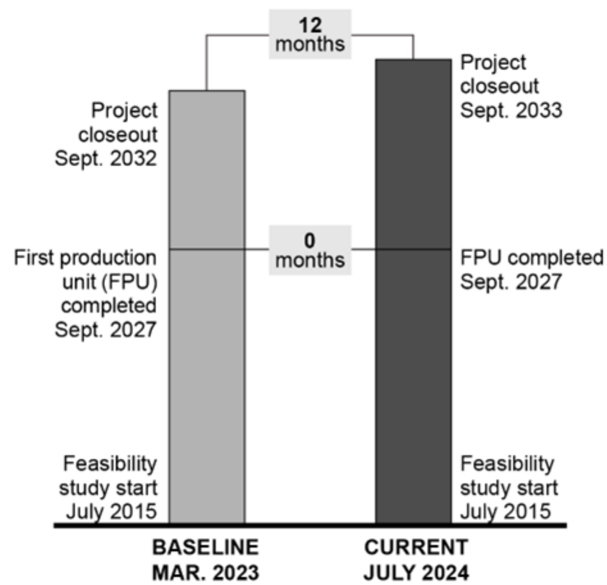
COST PERFORMANCE

then-year dollars in millions



Estimates include costs of $700 million incurred in the initiation phase.

SCHEDULE PERFORMANCE



Cost and Schedule Status

As of July 2024, according to NNSA's estimates, the program will cost $13 billion, which is the same as the cost baseline NNSA approved in March 2023. NNSA's estimated completion date for the program is September 2033, which is 1 year later than the schedule baseline of September 2032. According to NNSA officials, DOD revised its planning requirements for the last production unit of the W80-4, which resulted in NNSA adjusting the completion date by 1 year.

In addition, the program's cost and schedule baselines reflect an approximately $1.8 billion increase and a 2-year delay in completion of the FPU compared with the preliminary cost and schedule estimates approved when the program entered the development phase (in February 2019). According to NNSA documentation, the program delayed the milestone for FPU completion due to COVID-19 impacts, slow ramp-up in staffing at some sites, and component technical issues. In addition, as GAO reported in July 2020, the program's own schedule risk analysis found that a delay in the FPU completion date was warranted.

The program's cost estimate does not include an additional $245 million in other program money to support technology maturation and acquisition of equipment.

In June 2023, NNSA's Office of Cost Estimating and Program Evaluation (CEPE) issued a memorandum summarizing its independent cost and schedule estimates. According to the document, CEPE's cost estimate of $12.6 billion (at a confidence level of 50 percent) was within 2 percent of the program's estimate of $12.3 billion. However, the office also stated that the program's costs could rise to $14.8 billion using more conservative assumptions for risk (at a confidence level of 80 percent). In addition, CEPE estimated that a most likely FPU completion date (at a confidence level of 50 percent) is June 2028, compared to the program office's schedule baseline of September 2027.

Design and Testing

According to NNSA officials, the program expects to complete the final design review in November 2025.

However, one key risk facing the program is that it relies on the Air Force's LRSO missile program for test assets and qualification testing. Setbacks within the missile program can adversely affect the W80-4 program's ability to meet scope, technical, and performance targets by the September 2027 date for completion of the FPU. According to NNSA officials, the agency and the Air Force are in close coordination with each other's development schedules and test needs, and there are currently no significant challenges with the LRSO program's schedule.

Coordination with Production Programs

The W80-4 program relies on other NNSA programs for key materials to be used in the W80-4 warhead. To produce these materials, these NNSA programs must reinstate some capabilities—such as producing radiation cases and fabricating secondaries—as well as implementing new production of special materials. Delays within these programs can adversely affect the W80-4 program's ability to meet scope, technical, and performance targets based on the program's current schedule.

For example, the program plans to replace the insensitive high explosives used in the primary. However, the manufacturer of a key ingredient in these explosives recently announced that it would cease manufacture of this ingredient. NNSA officials said that NNSA's Office of Defense Programs has developed a working group that is actively seeking ways to address this issue and that integrates across the W80-4, B61-12, and W87-1 programs, all of which have insensitive high explosive needs.

Related GAO Products

Nuclear Enterprise: DOD and NNSA Could Further Enhance How They Manage Risk and Prioritize Efforts. GAO-22-104061. Washington, D.C.: January 20, 2022.

Nuclear Weapons: Action Needed to Address the W80-4 Warhead Program's Schedule Constraints. GAO-20-409. Washington, D.C.: July 24, 2020.

Nuclear Weapons: Additional Actions Could Help Improve Management of Activities Involving Explosive Materials. GAO-19-449. Washington, D.C.: June 17, 2019.

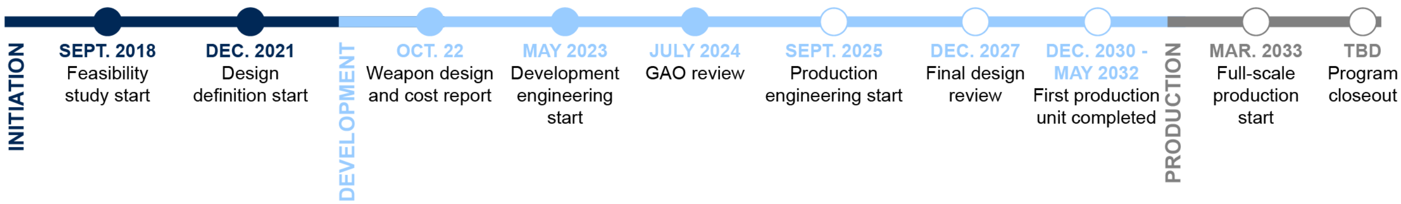
PROGRAM OFFICE COMMENTS

NNSA program officials provided technical comments on a draft of this assessment, which we incorporated as appropriate.

W87-1 Modification Program

The W87-1 program will replace the existing W78 warhead, first added to the U.S. nuclear stockpile in 1979. Design features include using a newly manufactured pit based on the design of the W87-0, adding new insensitive high explosives to the primary, enhancing safety and security features, and updating other nonnuclear components. The W87-1 warhead will be deployed on the new Mk21A reentry vehicle and Sentinel ballistic missile, both of which are under development by the Air Force. As a result, the program will conduct parallel engineering activities with the Air Force on the warhead-missile interface.

Source: NNSA. | GAO 25-106048



PROGRAM INFORMATION

Design Laboratories: Lawrence Livermore National Laboratory, Sandia National Laboratories

NNSA Program Office: Stockpile Modernization

Military Service: Air Force

Delivery System (Future): Sentinel intercontinental ballistic missile

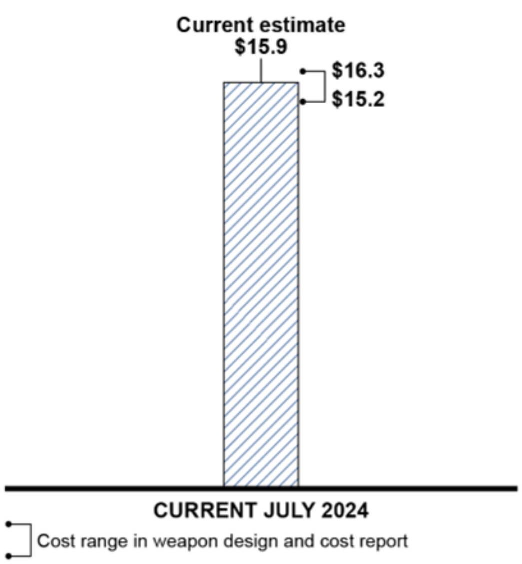
PROGRAM SUMMARY

As of July 2024, NNSA estimated that it would complete the program within the preliminary cost and schedule ranges approved in the program's weapon design and cost report.

In May 2023, the program entered the development engineering stage. The program faces several significant risks over the next 1–2 years, including the availability of testing assets from the Sentinel missile program to conduct flight testing. In addition, because the W87-1 program will rely on newly manufactured pits, another significant risk is NNSA's schedule for modernizing and constructing new pit production facilities.

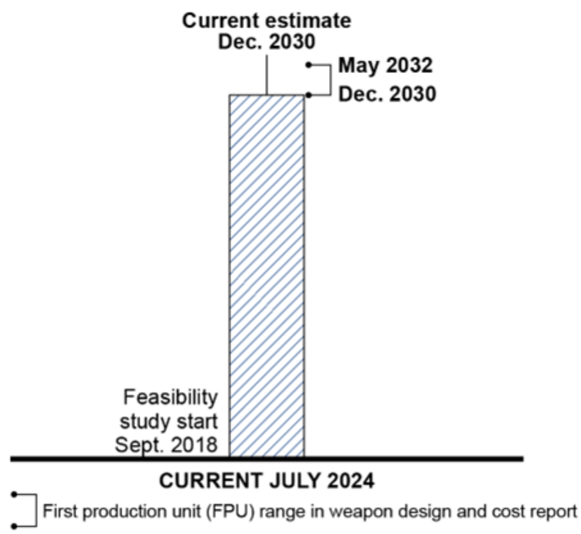
PRELIMINARY COST[a]

then-year dollars in millions



[a]These estimates are preliminary as the program is in the development phase and its design is not complete. NNSA uses these estimates for planning purposes.

PRELIMINARY SCHEDULE[a]



[a]These estimates are preliminary as the program is in the development phase and its design is not complete. NNSA uses these estimates for planning purposes.

Cost and Schedule Status

As of March 2024, NNSA estimated the program's cost at between $15.2 billion to $16.3 billion, which is the same as the preliminary cost ranges NNSA approved in the program's weapon design and cost report. NNSA's preliminary estimate of the date for first production unit (FPU) completion remains within the December 2030 to June 2032 time frame.

In November 2022, NNSA's Office of Cost Estimating and Program Evaluation (CEPE) issued a memorandum summarizing its independent cost and schedule estimates. According to the document, CEPE's cost estimate of $14.5 billion (at a confidence level of 50 percent) was within 10 percent of the program's estimate of $16.0 billion. However, the office also stated that the program's costs could rise to $17.1 billion using more conservative assumptions for risk (at a confidence level of 80 percent). The office also estimated a roughly similar amount of time for the program to complete its FPU, compared to the program's estimate.

In May 2023, the W87-1 program entered the development engineering stage. According to NNSA officials, the program expects to issue its baseline cost report in the first quarter of fiscal year 2026, at which time the program will establish its performance baseline.

However, NNSA officials said that the issuance of the baseline cost report, and the approval to enter the production engineering stage, will be affected by two related Air Force acquisition programs. Specifically, the Sentinel missile program announced in January 2024 that it would cost almost 40 percent more (or at least $130 billion) than originally estimated and take 2 years longer to complete. In addition, the Air Force is conducting an integrated baseline review of the Mk21A reentry vehicle program. As a result, officials said that they are still evaluating the effects that delays in these programs may have on the overall schedule of the W87-1 program. DOD and NNSA will submit a report to Congress on their joint schedule for the program no later than February 2025.

Design and Testing

According to NNSA officials, the program completed its conceptual design review in December 2022. The program found that the design of certain components—such as system cables—had not met the program's design schedule for maturity. As a result, some components had to be significantly redesigned. The program expects to complete its baseline design review during the third quarter of fiscal year 2025.

According to NNSA officials, the program has not completed the first phase of flight testing. The program is reliant on the Sentinel missile program and the Mk 21A reentry vehicle program for testing assets to conduct flight testing and other qualification testing. However, officials said that they expect both Air Force programs to announce delays in the availability of hardware and flight-testing dates that could result in delays of up to a year or longer for flight tests. Officials said that they will update the schedule for flight testing once the Sentinel program approves changes to its schedule and the Mk21A program finishes its integrated baseline review.

Coordination with Production Programs

The W87-1 will be the first weapon that NNSA produces using entirely new or remanufactured nuclear and nonnuclear components since the end of the Cold War. As a result, the program is reliant on multiple NNSA production programs, including programs to reinstate capabilities for radiation case production and uranium fabrication, new production of plutonium pits, new production of special materials within the secondary, and existing efforts to improve lithium and high explosives sourcing and production.

Moreover, NNSA is modernizing many of the production facilities that will be needed to provide components for the W87-1 by building new facilities or repairing existing facilities and capabilities. For example, NNSA is currently overseeing multiple projects to upgrade existing facilities at Los Alamos National Laboratory for pit manufacturing. These projects are part of the overall Los Alamos Plutonium Pit Production Project. Delays in these projects may adversely affect the W87-1 program's schedule.

Related GAO Products

National Nuclear Security Administration: Actions Needed to Improve Integration of Production Modernization Programs and Projects. GAO-24-106342. Washington, D.C.: July 9, 2024.

National Nuclear Security Administration: Assessments of Major Projects. GAO-23-104402. Washington, D.C.: August 17, 2023.

Nuclear Weapons: NNSA Does Not Have a Comprehensive Schedule or Cost Estimate for Pit Production Capability. GAO-23-104661. Washington, D.C.: January 12, 2023.

Nuclear Weapons: Actions Needed to Improve Management of NNSA's Lithium Activities. GAO-21-244. Washington, D.C.: August 12, 2021.

Nuclear Weapons: NNSA Should Further Develop Cost, Schedule, and Risk Information for the W87-1 Warhead Program. GAO-20-703. Washington, D.C.: September 9, 2020.

Nuclear Weapons: Additional Actions Could Help Improve Management of Activities Involving Explosive Materials. GAO-19-449. Washington, D.C.: June 17, 2019.

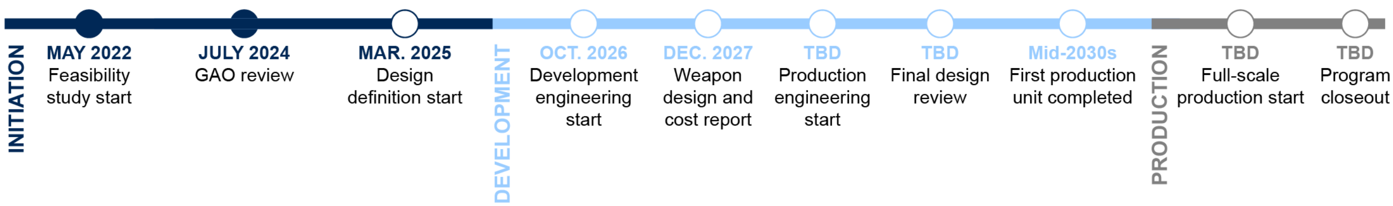
PROGRAM OFFICE COMMENTS

NNSA program officials provided technical comments on a draft of this assessment, which we incorporated as appropriate.

Source: Los Alamos National Laboratory. | GAO 25-106048

W93 Program

The W93 program plans to design and produce a new warhead to provide flexibility and adaptability to meet future warfighter needs. Design features may include using newly manufactured pits, as well as incorporating advanced safety and security features and using newly manufactured secondaries. The W93 warhead program is managed jointly with the Navy program to develop a new reentry body for the warhead, known as the Mk7.



PROGRAM INFORMATION

Design Laboratories: Los Alamos National Laboratory, Sandia National Laboratories

NNSA Program Office: Stockpile Modernization

Military Service: Navy

Delivery System: Submarine-launched ballistic missiles on Ohio-class and (future) Columbia-class submarines

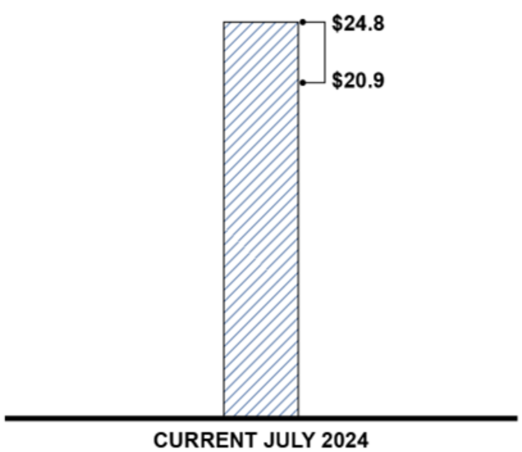
PROGRAM SUMMARY

As of July 2024, NNSA estimated that the program may cost between $20.9 billion to $24.8 billion and deliver its first production unit (FPU) by the mid-2030s. The program plans to enter the next acquisition stage in March 2025.

The joint W93/Mk7 program is reliant on testing assets and will not be able to obtain flight testing data until March 2027. In addition, the program faces several challenges with manufacturing certain components. The program is also reliant on multiple NNSA production programs to reinstate capabilities to produce new plutonium pits, fabricate new secondaries, and improve lithium and high explosives sourcing and production.

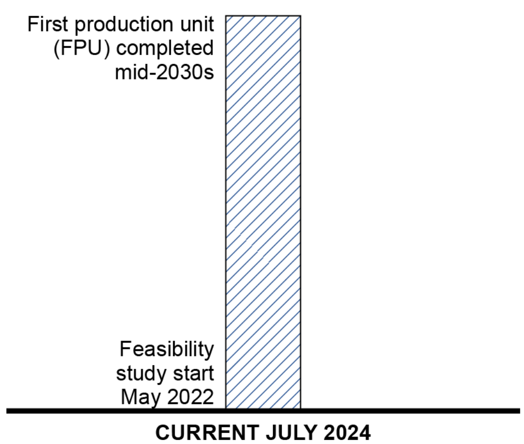
INITIAL COST[a]

then-year dollars in millions



[a]These estimates are preliminary as the program is in the development phase and its design is not complete. NNSA uses these estimates for planning purposes.

INITIAL SCHEDULE[a]



[a]These estimates are preliminary as the program is in the development phase and its design is not complete. NNSA uses these estimates for planning purposes.

Cost and Schedule Status

As of July 2024, NNSA estimated that the program may cost between $20.9 billion to $24.8 billion. NNSA's initial estimate of the date for FPU completion is in the mid-2030s.

In May 2022, the program entered the feasibility study stage. According to NNSA officials, the program expects to complete the feasibility study stage by March 2025, at which time it plans to proceed to the start of the design definition stage. In addition, the program plans to issue its weapon design and cost report by December 2026.

NNSA officials identified several manufacturing risks that may affect the program's overall schedule. For example, some of the warhead components must be manufactured in very thin layers, and the ability of NNSA's contractors to manufacture this material and handle it during assembly operations poses risks to the program.

Another risk is the manufacturing of certain components using special materials. According to NNSA officials, there is currently no capability within the nuclear security enterprise to manufacture these components, and NNSA is reviewing a path forward for producing them.

Design and Testing

According to NNSA officials, the program plans to complete its conceptual design review during fiscal year 2027 and its baseline design review during fiscal year 2030.

According to NNSA officials, the Mk7 reentry body will present new mechanical stresses on the W93 warhead, and the W93 program will not be able to obtain flight testing data based on the new Mk7 design until March 2027. In the meantime, according to officials, the program will have to rely on model-based estimates of the Mk7 to advance the design of the W93 warhead.

Coordination with Production Programs

The program is reliant on multiple NNSA production programs, including programs to reinstate capabilities for radiation case production and uranium fabrication, new production of plutonium pits, new production of special materials within the secondary, and existing efforts to improve lithium and high explosives sourcing and production.

Moreover, NNSA is modernizing many of the production facilities that will be needed to provide components for the W93 by building new facilities or repairing existing facilities and capabilities. For example, NNSA is currently overseeing multiple projects to build new facilities for pit manufacturing at the Savannah River Site. These projects are part of the overall Savannah River Plutonium Processing Facility project. Delays in these projects may adversely affect the W93 program's schedule.

RELATED GAO PRODUCTS

National Nuclear Security Administration: Actions Needed to Improve Integration of Production Modernization Programs and Projects. GAO-24-106342. Washington, D.C.: July 9, 2024.

National Nuclear Security Administration: Assessments of Major Projects. GAO-23-104402. Washington, D.C.: August 17, 2023.

Nuclear Weapons: NNSA Does Not Have a Comprehensive Schedule or Cost Estimate for Pit Production Capability. GAO-23-104661. Washington, D.C.: January 12, 2023.

Nuclear Enterprise: DOD and NNSA Could Further Enhance How They Manage Risk and Prioritize Efforts. GAO-22-104061. Washington, D.C.: January 20, 2022.

Nuclear Weapons: Actions Needed to Improve Management of NNSA's Lithium Activities. GAO-21-244. Washington, D.C.: August 12, 2021.

PROGRAM OFFICE COMMENTS

NNSA program officials provided technical comments on a draft of this assessment, which we incorporated as appropriate.

Appendix II: Objectives, Scope, and Methodology

This is our first biennial report assessing the National Nuclear Security Administration's (NNSA) nuclear weapon acquisition programs. We included the five NNSA programs under way as of June 2022, when we began our review. We did not conduct a detailed review of the program to acquire the B61-13 bomb, a variant of the B61 bomb, because the B61-13 program had not been authorized when our work started and because NNSA is managing the program under the management structure of the B61-12 Life Extension Program, which was included in our review.

We described the status and assessed the challenges faced by the five NNSA programs in individual assessments. We divided these programs into those with approved cost and schedule baselines and those without because we consider them to be in different acquisition phases. Specifically, programs with cost and schedule baselines have issued their baseline cost reports, which provide detailed design descriptions and formal cost and schedule estimates.

In addition to the individual assessments, the objectives of our review were to assess the processes NNSA uses and the challenges it faces in managing its nuclear weapon acquisition programs.

Individual Program Assessments

We developed individual program assessments for five programs (see app. I). For each assessment, we included a description and image of the program; information concerning the NNSA design laboratories and program offices involved in the program; the program's cost and schedule performance, when available; key program milestones; and a brief narrative describing the current status of the program.[1] We also provided a detailed discussion of key challenges for each program.

To obtain this information, we reviewed NNSA documents containing information on the programs' cost and schedule performance, including the Fiscal Year 2024 Stockpile Stewardship and Management Plan, Selected Acquisition Reports for fiscal years 2023 and 2024, independent cost estimates and independent cost reviews from NNSA's Office of Cost Estimating and Program Evaluation, NNSA and Nuclear Weapons Council memorandums, and program fact sheets. We also reviewed

[1]All cost information in this report is presented in nominal then-year dollars for consistency with budget data. Then-year dollars, also sometimes called budget year dollars, include the effects of inflation (as opposed to base-year dollars, which do not). For budgeting purposes, then-year dollars are used to reflect a program's projected annual costs by appropriation. Presenting figures in terms of then-year dollars requires adjusting for inflation, based on assumptions about what inflation indexes to use, since any future inflation index is uncertain.

documentary and testimonial information collected through site visits, questionnaires, and interviews. More specifically:

- **Site visits.** We conducted visits to Sandia National Laboratories in Albuquerque, New Mexico; Los Alamos National Laboratory in Los Alamos, New Mexico; and the Kansas City National Security Campus in Kansas City, Missouri. During the site visits, we viewed design, production, and testing equipment, as well as nuclear weapon components. We also interviewed NNSA officials and contractor representatives responsible for managing design and production activities in the programs and heard presentations about the programs.
- **Questionnaires.** After completing the site visits, we developed a questionnaire to collect additional information on all five programs and to confirm information from the documents we collected. The questionnaires included questions sent to all programs, as well as program-specific questions. We provided the questionnaires to officials in the NNSA federal program offices for each of the five programs. After reviewing the officials' responses, we submitted follow-up questions to the same federal program office officials and met with the officials to discuss their responses.
- **Interviews.** To gather additional information on the programs, the team conducted interviews with NNSA officials in offices with management responsibilities under the programs. Specifically, we interviewed officials from the Office of Cost Estimating and Program Evaluation; the Office of Systems Engineering and Integration; the Office of Research, Development, Testing, and Evaluation; and the Office of Stockpile Management, including the federal program managers, other NNSA federal officials, and contractor representatives for each of the five programs.

To assess the programs' performance with respect to cost and schedule goals, we compared NNSA's cost and schedule estimates for its programs as of July 2024 to its baseline estimates. For baselines, we used the cost and schedule estimates in programs' Baseline Cost Reports. Because these reports are classified, we used citations of these estimates provided in unclassified documents, such as independent cost estimates issued by the Office of Cost Estimating and Program Evaluation.

As of July 2024, three of the five programs under review had established baselines: the B61-12 Life Extension Program, the W88 Alteration 370 Program, and the W80-4 Life Extension Program. For these three programs, we assessed performance against their cost baselines by using cost information reported by NNSA for each program as of July 2024. We included sunk costs as described in the Fiscal Year 2024 Stockpile Stewardship and Management Plan for each program. We did not include shared moneys—such as funds used to develop components used in multiple weapon systems—in the total current costs; however, we did note where such funds were used in our program assessments.

To assess these three programs' performance against their schedule baselines, we referred to schedule estimates reported in the Selected Acquisition Reports for each program and, in our questionnaires and interviews, confirmed that the dates reported were current as of July 2024.

For the 2 programs that had not established baselines as of July 2024—the W87-1 Modernization Program and the W93 Program—we reported current cost and schedule estimates published in NNSA's Fiscal Year 2024 Stockpile Stewardship and Management Plan. We reported costs in then-year dollars, which include the effects of inflation or escalation or reflect the price levels expected to prevail during the year of issue.

Report Objectives

To assess the processes NNSA uses to manage its nuclear weapon acquisition programs, we reviewed documents that establish the framework for joint activities between NNSA and the Department of Defense (DOD) in conducing these programs. The documents we reviewed included both DOD and Department of Energy (DOE) directives on the Phase X and Phase 6.X processes, such as the DOD instruction on procedures for joint DOD-DOE nuclear weapons activities and the NNSA supplemental directive on the Phase X and Phase 6.X processes.[2] We also reviewed other NNSA directives that provide implementation guidance related to these processes, including NNSA's program execution instruction for defense programs.[3]

[2]Department of Defense Instruction 5030.55, *DoD Procedures for Joint DoD-DOE Nuclear Weapons Life-Cycle Activities* (Jan. 25, 2001); NNSA Supplemental Directive 452.3-2A, *Phase X / Phase 6.X Processes* (Nov. 8, 2022).

[3]DOE/NNSA, *Department of Energy National Nuclear Security Administration Office of Defense Programs Program Execution Instruction*, Revision 3 (Sept. 2021).

In addition, we compared DOD's and NNSA's processes to those described in GAO's body of work on knowledge-based acquisition practices.[4]

To assess the processes NNSA uses to identify critical technologies used in weapons programs and assess their readiness, we conducted an abridged analysis of NNSA's guidance on technology readiness assessments (TRA). Our abridged analysis focused on NNSA directives that prescribe practices for NNSA's TRAs—specifically DOE's TRA guide and six NNSA directives related to the TRA process.[5] We also reviewed and applied applicable federal control standards.[6]

To describe the challenges NNSA faces in managing nuclear weapon acquisitions, we reviewed NNSA documents, conducted site visits, reviewed NNSA officials' responses to questionnaires, and conducted interviews with NNSA officials and contractor representatives, as described in detail above. Based on our review, we identified technology maturation and readiness, producing and procuring components, and overseeing contractors as three key challenges for NNSA. The challenges discussed in this report do not represent an exhaustive or exclusive list and are based on our assessments, not those of NNSA.

We conducted this performance audit from June 2022 to December 2024 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain

[4]Our original work on leading product development practices, initiated in the 1990s and updated in subsequent decades, found that successful programs take steps to gather knowledge that confirms their technologies are mature, their designs stable, and that their production processes are in control. These programs ensure a high level of knowledge is achieved at key junctures in development. We characterize these junctures as knowledge points. See, for example, GAO, *Weapon Systems Annual Assessment: Programs Are Not Consistently Implementing Practices That Can Help Accelerate Acquisitions*, GAO-23-106059 (Washington, D.C.: June 8, 2023).

[5]DOE, *Technology Readiness Assessment Guide*, DOE G 413.4A Chg. 1 (Oct. 2015); and NNSA, *Technology Readiness Assessments*, NAP 413.4 (Apr. 2020); *Defense Programs Technology Readiness Assessment (TRA) Implementation Guide* (Jan. 2018); *Department of Energy National Nuclear Security Administration Office of Defense Programs Program Execution Instruction*, Revision 3 (Sept. 2021); *Product Realization*, Defense Programs Business Process System R001, Issue D (May 2018); *Implement Phase 6.X Process*, Defense Programs Business Process System R006 (Oct. 2019); and *Conduct Technology Readiness Level (TRL) Assessment*, Defense Programs Business Process System C018 (Jan. 2017).

[6]GAO, *Standards for Internal Control in the Federal Government*, GAO-14-704G (Washington, D.C.: Sept. 10, 2014).

sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Appendix III: Technology Readiness Levels as Defined by the National Nuclear Security Administration's Office of Defense Programs

Table 5: Technology Readiness Levels as Defined by the National Nuclear Security Administration's Office of Defense Programs

Technology readiness level (TRL)	TRL title	TRL description
1	Basic principles observed and reported	This is the first level of technology readiness and includes fundamental scientific research. At this level, basic scientific principles are being studied analytically or experimentally. Examples might include paper studies of a technology's basic properties.
2	Concept and application formulated	Practical applications are beginning to be invented or identified. Applications are still speculative and there is no proof or detailed analysis to support assumptions. Examples might include applied research in a field of potential interest.
3	Concepts demonstrated analytically or experimentally	Active research and development is initiated. This includes analytical and laboratory-based studies to physically validate analytical predictions of key elements of the technology. These studies and experiments should constitute "proof-of-concept" validation of the applications/concepts formulated at TRL 2. Examples include the study of separate elements of the technology that are not yet integrated or representative.
4	Key elements demonstrated in laboratory environment	The key elements must be integrated to establish that the pieces will work together. The validation should be consistent with the requirements of potential applications, but it is relatively low-fidelity when compared to a final product. Examples include integration of ad hoc hardware or software with mock material in the laboratory such as breadboards, low-fidelity development components, and rapid prototypes.
5	Key elements demonstrated in relevant environment	Fidelity of the key elements increases significantly. Key elements are integrated with realistic supporting elements so that the technology can be tested and demonstrated in simulated or actual environments.
6	Representatives of the deliverable demonstrated in relevant environment	Represents a major step in a technology's demonstrated readiness. Examples include testing a prototype or representative of a deliverable in a high-fidelity, simulated environment or actual environment.
7	Final development deliverable demonstrated in an operational environment	Development version of the deliverable is near or at the planned operational system. This represents a significant step beyond TRL 6 and requires the demonstration of an actual development version of the deliverable in the operational environment. In almost all cases, this TRL coincides with the end of development. Examples include integration and demonstration within the next assembly, and advanced concept technology demonstrations of integrated systems such as flight testing.
8	Deliverable qualified through test and demonstration	The technology has been proven to work in its final form under expected conditions based on certification and qualification activities. Examples include developmental test and evaluation of the actual deliverable in its intended application to validate that it meets design requirements and product definition requirements, and that the first production unit was accepted per a qualified process or as a qualified product.
9	Operational use of deliverable	Application of the technology in its final form and under mission conditions such as those encountered in operational test and evaluation. An example includes using the deliverable under operational mission conditions. This TRL does not include ongoing or planned product improvement of reusable systems.

Source: National Nuclear Security Administration (NNSA) documentation. | GAO-25-106048

Appendix IV: Comments from the National Nuclear Security Administration

Department of Energy
Under Secretary for Nuclear Security
Administrator, National Nuclear Security Administration
Washington, DC 20585

National Nuclear Security Administration

November 20, 2024

Ms. Allison B. Bawden
Director, Natural Resources
and Environment
U.S. Government Accountability Office
Washington, DC 20548

Dear Ms. Bawden:

Thank you for the opportunity to review the Government Accountability Office (GAO) draft report "National Nuclear Security Administration: Assessments of Nuclear Weapon Acquisitions" (GAO-25-106048). The Department of Energy's National Nuclear Security Administration (NNSA) appreciates GAO's recognition of some of the challenges we face with managing our nuclear weapon acquisitions and for acknowledging that NNSA and its contractors have taken steps to address those challenges.

As the draft report notes, NNSA's management of nuclear weapon acquisition programs follows an incremental approach to building knowledge, much like GAO's knowledge-based acquisition practices and consistent with how the Department of Defense has structured its acquisition process. NNSA's Technology Readiness Assessment policy provides high-level requirements, as well as a general definition of critical technology elements. NNSA also provides guidance for Manufacturing Readiness Levels (MRLs), a similar scale to provide consistent assessments for manufacturing maturity and risks of a particular technology or process during the acquisition life cycle. Related directives for both provide supplemental guidance while affording latitude to Federal program managers and project teams in identifying technologies that may require greater focus in evaluating their maturity. For technologies selected, minimum TRL and MRL levels must be demonstrated and any associated program risk approved by NNSA's Defense Programs prior to authorization to proceed.

We agree with the auditors' recommendation for further enhancing our existing practices by documenting, in a formal and comprehensive manner, the process that our nuclear weapon acquisition programs must follow to identify which of their technologies are critical technologies. The estimated date for defining this process and incorporating it into existing guidance is October 31, 2025. NNSA also appreciates GAO's recognition that NNSA programs rely on a relatively small number of dedicated federal staff to manage our nuclear weapons acquisition programs. While NNSA does not need to vastly expand its cadre of Federal Program Managers, additional staff are necessary to support existing and expanding Defense Programs scope. Activities are ongoing to recruit and retain the appropriate number of personnel necessary to support our modernization programs, as informed by NNSA's Strategic Workforce Planning analysis.

Our subject matter experts have also provided technical and general comments under separate cover for your consideration to enhance the clarity and accuracy of the report. If you have any questions about this response, please contact Dean Childs, Director, Audits and Internal Affairs, at (202) 836-3327.

Sincerely,

Jill Hruby

Appendix V: Additional Source Information for Images and Figures

This appendix contains credit, copyright, and other source information for images, tables, or figures in this product when that information was not listed adjacent to the image, table, or figure.

Appendix I:

GAO analysis of NNSA documents (all timeline figures)

GAO analysis of NNSA data (all preliminary cost figures and cost performance figures)

GAO analysis of NNSA data (all preliminary schedule figures and schedule performance figures)

Appendix VI: GAO Contact and Staff Acknowledgments

GAO Contact

Allison B. Bawden, (202) 512-3841 or bawdena@gao.gov

Staff Acknowledgments

In addition to the contact named above, Jason Holliday (Assistant Director), Rob Grace (Analyst in Charge), Adrian Apodaca, Paul Bauer, Bethany Benitez, Antoinette C. Capaccio, Ellen Fried, Frank Garro, Matt McLaughlin, Cynthia Norris, John Ortiz, Cami Pease, Marshal Pennock, and Dan Will made key contributions to this report. Also contributing to this report were Penney Harwell Caramia, Erin Carson, Pamela Davidson, Chris Durbin, Joe Kirschbaum, Jennifer Leotta, Travis Masters, Anne McDonough, Brian Smith, Don Springman, and Ben Wilder.

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