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Report to Congressional Committees

July 2020

NUCLEAR WEAPONS

Action Needed to Address the W80-4 Warhead Program's Schedule Constraints

GAO-20-409

GAO Highlights

Highlights of GAO-20-409, a report to congressional committees

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Why GAO Did This Study

To maintain and modernize the U.S. nuclear arsenal, NNSA and DOD conduct LEPs. In 2014, they began an LEP to produce a warhead, the W80-4, to be carried on the LRSO missile. In February 2019, NNSA adopted an FPU delivery date of fiscal year 2025 for the W80-4 LEP, at an estimated cost of about $11.2 billion over the life of the program.

The explanatory statement accompanying the 2018 appropriation included a provision for GAO to review the W80-4 LEP. This report examines, among other objectives, (1) the risks NNSA has identified for the W80-4 LEP, and processes it has established to manage them, and (2) the extent to which NNSA's lifecycle cost estimate for the LEP aligned with best practices. GAO reviewed NNSA's risk management database and other program information; visited four NNSA sites; interviewed NNSA and DOD officials; and assessed the program's cost estimate using best practices established in prior GAO work.

What GAO Recommends

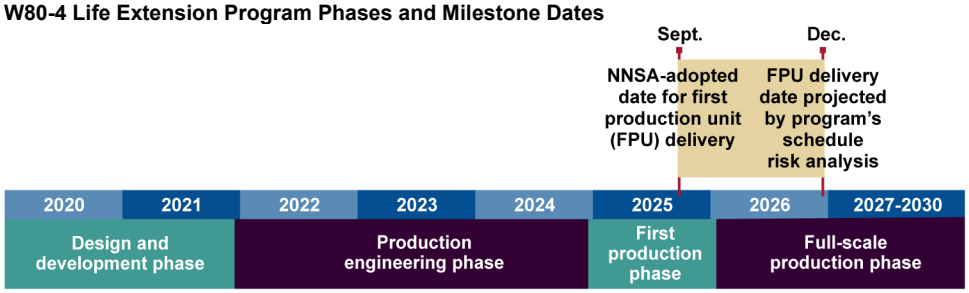
GAO is making two recommendations, including that NNSA adopt a W80-4 program FPU delivery date based on the program's schedule risk analysis, or document its justification for not doing so. NNSA generally disagreed with GAO's recommendations. GAO continues to believe that its recommendations are valid, as discussed in the report.

View GAO-20-409. For more information, contact Allison B. Bawden at (202) 512-3841 or bawdena@gao.gov

What GAO Found

The National Nuclear Security Administration (NNSA), a separately organized agency within the Department of Energy (DOE), has identified a range of risks facing the W80-4 nuclear warhead life extension program (LEP)—including risks related to developing new technologies and manufacturing processes as well as reestablishing dormant production capabilities. NNSA is managing these risks using a variety of processes and tools, such as a classified risk database. However, NNSA has introduced potential risk to the program by adopting a date (September 2025) for the delivery of the program's first production unit (FPU) that is more than 1 year earlier than the date projected by the program's own schedule risk analysis process (see figure). NNSA and Department of Defense (DOD) officials said that they adopted the September 2025 date partly because the National Defense Authorization Act for fiscal year 2015 specifies that NNSA must deliver the first warhead unit by the end of fiscal year 2025, as well as to free up resources for future LEPs. However, the statute allows DOE to obtain an extension, and, according to best practices identified in GAO's prior work, program schedules should avoid date constraints that do not reflect program realities. Adopting an FPU date more consistent with the date range identified as realistic in the W80-4 program's schedule risk analysis, or justifying an alternative date based on other factors, would allow NNSA to better inform decision makers and improve alignment between schedules for the W80-4 program and DOD's long-range standoff missile (LRSO) program.

W80-4 Life Extension Program Phases and Milestone Dates



Source: GAO analysis of National Nuclear Security Administration (NNSA) data. | GAO-20-409

NNSA substantially incorporated best practices in developing the preliminary lifecycle cost estimate for the W80-4 LEP, as reflected in the LEP's weapon design and cost report. GAO assessed the W80-4 program's cost estimate of $11.2 billion against the four characteristics of a high quality, reliable cost estimate: comprehensive, well-documented, accurate, and credible. To develop a comprehensive cost estimate, NNSA instituted processes to help ensure consistency across the program. The program also provided detailed documentation to substantiate its estimate and assumptions. To help ensure accuracy, the cost estimate drew on historic data from prior LEPs. Finally, to support a credible estimate, NNSA reconciled the program estimate with an independent cost estimate. GAO considers a cost estimate to be reliable if the overall assessment ratings for each of the four characteristics are substantially or fully met—as was the case with the W80-4 program's cost estimate in its weapon design and cost report, which substantially met each characteristic.

Contents

Abbreviations

AoA	analysis of alternatives
BOE	basis of estimate
DOD	Department of Defense
DOE	Department of Energy
FPU	first production unit
LEP	Life Extension Program
LRSO	long range stand-off missile
NNSA	National Nuclear Security Administration
USSTRATCOM	U.S. Strategic Command
WDCR	weapon design and cost report

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Congressional Committees

The United States' current efforts to modernize the nuclear weapons stockpile are more extensive than at any time since the Cold War era. The Department of Defense (DOD) and the National Nuclear Security Administration (NNSA) are undertaking multiple nuclear weapon modernization programs and related projects that are expected to cost hundreds of billions of dollars over the next decade.[1] These programs include the W80-4 Life Extension Program (LEP)[2], which began in 2014, and the related long range stand-off missile (LRSO) program. The W80-4 LEP is intended to develop a replacement for the W80-1 warhead, which was added to the stockpile in 1982.[3] The LRSO program is intended to replace the Air Force's air-launched cruise missile, which also entered service in 1982.[4] The W80-1 warhead and the air-launched cruise missile both have been in service well past their originally intended design lives. The National Defense Authorization Act for fiscal year 2015 establishes that the Secretary of Energy must deliver the first production unit (FPU) of the W80-4 by the end of fiscal year 2025.[5] Though an extension may be

[1]NNSA is a separately organized agency within the Department of Energy (DOE) responsible for the nation's nuclear weapons, nonproliferation, and naval reactor programs. Among other things, NNSA's mission is to maintain and enhance the safety, security, reliability, and performance of the U.S. nuclear weapons stockpile.

[2]NNSA and DOD undertake LEPs to refurbish or replace nuclear weapons' components to extend their lives, enhance their safety and security characteristics, and consolidate the U.S. nuclear stockpile into fewer weapon types in order to minimize maintenance and testing costs, while preserving needed military capabilities, as established by the Commander of U.S. Strategic Command (USSTRATCOM).

[3]All nuclear weapons in the U.S. stockpile are designated as either a warhead or a bomb. Warheads are weapons that have certain engineering requirements because they must interface with a launch or delivery system. Bombs are weapons that do not have these interface requirements, such as gravity bombs and atomic demolition munitions (now retired and dismantled).

[4]We are separately reviewing the Air Force's acquisition of the LRSO.

[5]The FPU milestone occurs when DOD accepts the weapon's design and NNSA verifies that the first produced weapon or weapons meets the design.

granted, the Secretary must justify any delay.[6] The W80-4 LEP's weapon design and cost report (WDCR), completed in January 2019, stated that NNSA will produce the FPU of the W80-4 in fiscal year 2025 and complete production by 2031 at an estimated total cost of about $11.2 billion.[7]

We have previously reported on the difficulties that NNSA has faced in managing its portfolio of nuclear weapon modernization programs and related projects to improve the facilities it uses for these programs. For example:

- In December 2018, NNSA completed the last production unit for the W76-1 LEP, which began in 2000 and was the first LEP in which NNSA undertook full-scale design activities for a weapon system since 1982.[8] As we reported in March 2009, NNSA had to delay first production of the W76-1 by about 1 year, in part because the agency encountered difficulties resuming the manufacture of an important

[6]Carl Levin and Howard P. "Buck" McKeon National Defense Authorization Act for Fiscal Year 2015, Pub. L. No. 113-291, §3119, 128 Stat. 3292, 3890. Specifically, the act allows the Secretary of Energy to request a one-year delay if the Commander of USSTRATCOM certifies to the Chairman of the Nuclear Weapons Council and congressional defense committees that the delay is in the interest of national security and does not negatively affect the Commander's ability to meet nuclear deterrence and assurance requirements. If the Secretary determines that the FPU will not be delivered by the original or extended deadline, the Secretary must notify, and explain the delay to, the congressional defense committees, the Secretary of Defense and the Commander. In turn, the Commander must assess the delay for its effects on national security and nuclear deterrence and assurance and any mitigation options available.

[7]The WDCR reflects the program's preliminary cost and schedule estimates for design, qualification, production, and lifecycle activities. According to NNSA officials, the 2031 completion date for production includes production of components for surveillance activities, which provide data to evaluate the safety, security, reliability, and performance of the nuclear weapons stockpile. These data support NNSA's and DOD's annual assessments of the state of each warhead type in the stockpile.

[8]The W76 warhead was first introduced into the stockpile in 1978 and is deployed with the Trident II D5 missile on the Ohio-class nuclear ballistic missile submarines. Since the LEP process began in 1996, NNSA has undertaken other nuclear modernization efforts, including one that involved an alteration of the W87 warhead and that NNSA program officials characterized as having significant design activities; this effort was completed in 2005.

material known as Fogbank.[9] According to an NNSA report on lessons learned from the W76-1 LEP, problems in planning and execution resulted in significant changes to the program baseline and significant cost increases.[10]

- More recently, we reported that NNSA is experiencing challenges in current projects related to nuclear weapon modernization programs, including restarting the production of specialized explosives and upgrading facilities that produce key materials and components used in weapons, including plutonium, uranium, lithium, and specialized microelectronics.[11]

The explanatory statement accompanying the Consolidated Appropriations Act, 2018, included a provision for GAO to review the W80-4 LEP.[12] This report examines (1) the risks NNSA has identified for the W80-4 LEP and processes the agency has established to manage risks; (2) the extent to which NNSA's lifecycle cost estimate for the design option selected for the LEP aligned with best practices; and (3) the steps NNSA took to evaluate design options for the W80-4 LEP.

To assess the risks NNSA has identified for the W80-4 LEP and the processes the agency has established to manage those risks, we reviewed NNSA documentation and data on identified risks to the W80-4

[9]GAO, *Nuclear Weapons: NNSA and DOD Need to More Effectively Manage the Stockpile Life Extension Program*, GAO-09-385 (Washington, D.C.: Mar. 2, 2009). According to our report, NNSA had lost knowledge of how to manufacture the material because it kept few records of the process when the material was made in the 1980s, and almost all staff with expertise on production had retired or left the agency, leaving the production process for Fogbank dormant for about 25 years.

[10]National Nuclear Security Administration, *Defense Programs W76-1 Life Extension Program Lessons Learned Study* (Washington, D.C.: Aug. 3, 2017). The report does not quantify what is meant by "significant cost increases." However, according to the report, the W76-1 LEP did not establish a "true" cost baseline; instead, it used an annual budget estimate for cost, which included costs within the 5-year Future Years Nuclear Security Program and general cost projections beyond this period.

[11]See GAO, *Nuclear Weapons: Additional Actions Could Help Improve Management of Activities Involving Explosive Materials*, GAO-19-449 (Washington, D.C.: June 17, 2019); *Nuclear Weapons: NNSA's Modernization Efforts Would Benefit from a Portfolio Management Approach*, GAO-20-443T (Washington, D.C.: Mar. 3, 2020); and *Nuclear Weapons: NNSA Needs to Establish Stronger Management Controls over Its Microelectronics Activities*, GAO-20-357 (Washington, D.C.: June 9, 2020).

[12]164 Cong. Rec. H2045 (daily ed. Mar. 22, 2018) (explanation of Consolidated Appropriations Act, 2018); Consolidated Appropriations Act, 2018, Pub. L. No. 115-141, 132 Stat. 348 (2018).

program. We also reviewed applicable NNSA directives (such as policies, operating procedures, and NNSA's DP Program Execution Instruction) as they relate to cost and schedule estimating.[13] We compared these directives and agency actions with best practices outlined in GAO's cost estimating and schedule assessment guides.[14] In addition, we visited and interviewed program officials and contractor representatives at the Lawrence Livermore and Sandia National Laboratories in Livermore, California; the Kansas City National Security Campus near Kansas City, Missouri; the Y-12 National Security Complex in Oak Ridge, Tennessee; and the W80-4 program office in Albuquerque, New Mexico.[15] We selected these sites because they are responsible for conducting a range of the design and production activities for the program. During these site visits, we discussed program risks and the steps NNSA is taking to manage them, reviewed information in the program's classified Active Risk Manager database, and viewed weapon components and facilities to better understand the items and functions described in the documentation under review. We also interviewed officials from U.S. Strategic Command (USSTRATCOM), the Air Force Nuclear Weapons Center, and NNSA's program office for LEPs regarding their views on the management of the W80-4 LEP and any risks involved with the program.

To assess the extent to which NNSA's lifecycle cost estimate for the W80-4 LEP aligned with best practices, we reviewed program documentation and data and interviewed program officials responsible for producing the cost estimate to understand the methods, assumptions, information, and data NNSA used to produce the estimate. Specifically, we reviewed NNSA's WDCR, the report that provided the preliminary cost estimate for the design, qualification, production, and lifecycle activities for the W80-4 LEP. Further, we reviewed applicable NNSA directives as they relate to cost and schedule estimating. We also reviewed documentation that contractor representatives responsible for developing the cost estimate at NNSA sites participating in the LEP provided to the

[13]NNSA, Office of Defense Programs, *DP Program Execution Instruction* (Washington, D.C.: June 2019).

[14]GAO, *GAO Schedule Assessment Guide: Best Practices for Project Schedules.* GAO-16-89G (Washington, D.C.: December 2015); and *GAO Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program Costs,* GAO-09-3SP (Washington, D.C.: March 2009). GAO revised this guide in March 2020 to, among other things, clarify some of the best practices and their related criteria.

[15]While visiting Lawrence Livermore National Laboratory, we also interviewed program officials and contractor representatives from Sandia National Laboratories in Livermore, California.

W80-4 program office to assist in compiling the WDCR. During the interviews and site visits described above, we also interviewed program officials and contractor representatives to discuss their cost estimating methods, and we viewed classified and unclassified systems and documents used in compiling the WDCR. We also interviewed officials from NNSA's Office of Cost Estimating and Program Evaluation to discuss the independent cost estimate they conducted for the W80-4 LEP. GAO cost estimating specialists then assessed this information against the cost estimating best practices outlined in GAO's cost estimating guide, which establishes a consistent methodology that can be used across the federal government to develop, manage, and evaluate program cost estimates.[16] We describe these best practices in further detail in the body of this report.

To assess the steps NNSA took to evaluate the design options for the W80-4 LEP, we reviewed documentation related to the W80-4 program's decision-making process for the selected warhead modification design options. In addition, during the site visits described above, we interviewed W80-4 program officials and contractor representatives involved in developing design options. We reviewed the documentary and interview-based evidence to identify the steps NNSA took, including whether NNSA defined its mission need and requirements, established a list of design options and assessed their viability, and considered the lifecycle costs of the different design options. As identified in our past work, an analysis of alternatives (AoA) is a key first step in the acquisition process and is intended to assess alternative solutions for addressing a validated need.[17] AoAs are done or updated to support key acquisition decision points. We focused on the best practices for a comprehensive AoA, narrowing our focus to this characteristic because our review of the program's cost estimating practices addressed the other areas related to the AoA.

We conducted this work from January 2019 to July 2020, 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

[16]GAO-09-3SP.

[17]GAO, *Amphibious Combat Vehicle: Some Acquisition Activities Demonstrate Best Practices; Attainment of Amphibious Capability to be Determined*, GAO-16-22 (Washington, D.C.: Oct. 28, 2015).

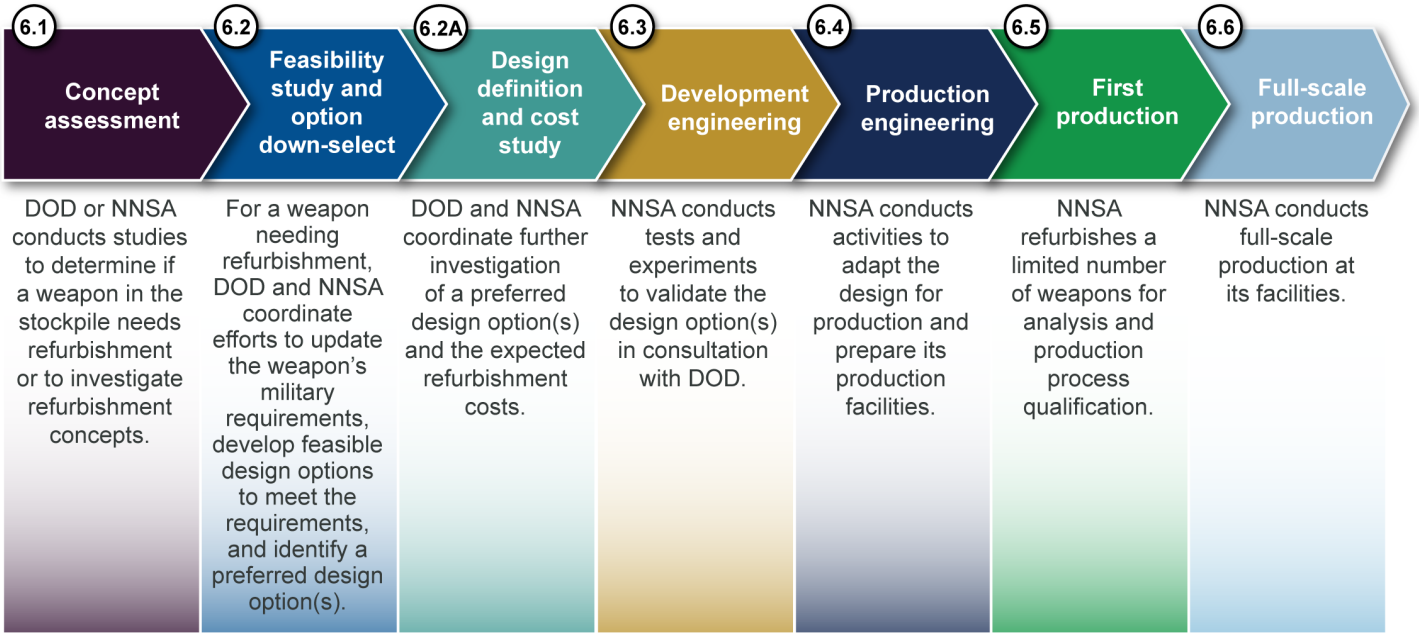
provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

Joint NNSA and DOD Process for Managing LEPs

NNSA and DOD jointly manage LEPs under a multistep process known as the phase 6.X process. Figure 1 illustrates the phase 6.X process. The W80-4 LEP is currently in phase 6.3 (development engineering) of this process.

Figure 1: The Phase 6.X Process as Jointly Managed by DOD and NNSA



Abbreviations
DOD Department of Defense
NNSA National Nuclear Security Administration

Source: Nuclear Weapons Council. | GAO-20-409

Note: Refurbishment life extension programs, which have been conducted since the 1990s, involve the use of existing or newly manufactured components that are based on the original designs specific to that weapon. Additionally, nuclear and non-nuclear components are produced as closely as possible to the original designs for a specific warhead. Deviations from original designs are often the result of "sunset" technologies (when technologies no longer exist to produce items) or manufacturing processes that cannot be replicated because of environmental or health hazards.

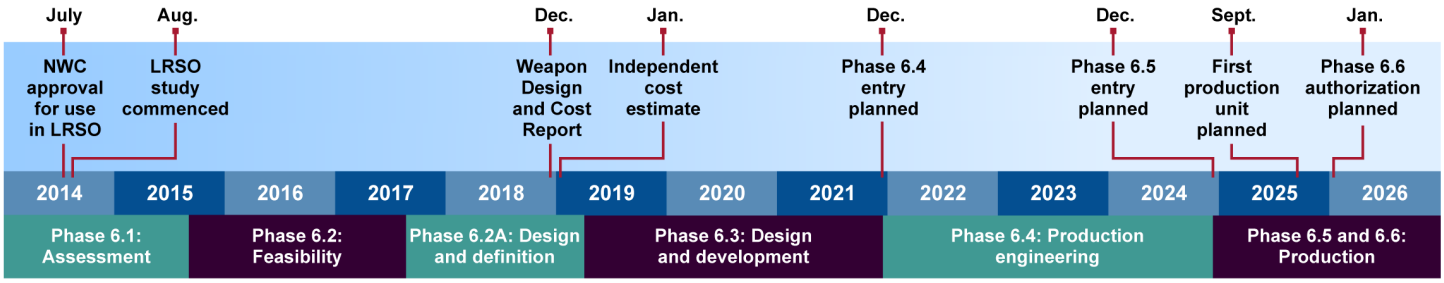
The phase 6.X process and the various roles and functions of DOD, the Department of Energy (DOE), and NNSA in nuclear weapon refurbishment activities are described in a guidance document known as

the Procedural Guideline for the Phase 6.X Process.[18] The document describes key tasks and deliverables expected to be completed by the end of each phase. For example:

- The phase 6.2 study report should include a summary of all refurbishment options considered, along with associated analyses.
- In phase 6.2A, NNSA is to develop the WDCR to reflect preliminary cost estimates for design, qualification, production, and lifecycle activities. In addition, a preliminary project schedule with major milestones should be established.
- During phase 6.3, NNSA is to formally update the WDCR based on late development and preproduction activities and reissue it as the baseline cost report, which is then used to establish a program cost baseline.

Figure 2 shows NNSA's reported schedule for the W80-4 LEP.

Figure 2: The W80-4 Nuclear Warhead Life Extension Program's Reported Schedule



LRSO Long Range Standoff Missile
NWC Nuclear Weapons Council

Source: National Nuclear Security Administration. | GAO-20-409

The Procedural Guideline for the Phase 6.X Process also describes the roles and functions of two joint bodies that provide oversight and approval functions to LEPs and other nuclear weapons-related activities: the Nuclear Weapons Council and its Standing and Safety Committee.[19] The

[18]Nuclear Weapons Council, *Procedural Guideline for the Phase 6.X Process* (Washington, D.C.: Jan. 5, 2015).

[19]For more information on the Nuclear Weapons Council's structure and activities, see, for example, GAO, *Nuclear Weapons Council: Enhancing Interagency Collaboration Could Help with Implementation of Expanded Responsibilities,* GAO-15-446 (Washington, D.C., May 21, 2015).

Nuclear Weapons Council is the joint DOD and DOE activity that serves as the focal point for interagency activities to maintain the nuclear weapons stockpile. Its membership includes the Under Secretary of Defense for Acquisition and Sustainment (generally the Chair); the Under Secretary of Defense for Policy; the Vice Chairman of the Joint Chiefs of Staff; the Commander of USSTRATCOM; and DOE's Under Secretary for Nuclear Security, who also serves as the Administrator of NNSA.[20]

NNSA's Internal Management of the W80-4 Program

In addition to the joint phase 6.X process described above, NNSA's Office of Defense Programs, which is responsible for managing NNSA's nuclear weapon modernization programs, and the W80-4 program office have issued additional directives that apply to the program's management. Specifically:

- **NNSA's Office of Defense Programs**. NNSA's Office of Defense Programs has issued a program management directive, the DP Program Execution Instruction, which establishes requirements and processes specific to LEPs and other nuclear weapon modernization programs.[21] The Program Execution Instruction requires such programs to develop integrated master schedules, which aid in defining and documenting the tasks required to develop and deliver a system such as a warhead or bomb. The instruction notes that only by maintaining the integrity of the schedule will it be a useful tool to forecast and manage a program. In addition, the Program Execution Instruction requires LEPs and other nuclear weapon modernization programs to develop detailed program cost estimates and provide information in support of independent cost estimates, among other requirements.
- **The W80-4 program office**. Within NNSA's Office of Defense Programs, the W80-4 program office has established its own program-specific directives related to planning and requirements, such as the WDCR requirements document, which defines the criteria and primary processes for completing the initial program schedule

[20]10 U.S.C. § 179; 42 U.S.C. § 7132.

[21]National Nuclear Security Administration, Office of Defense Programs, *DP Program Execution Instruction*.

and cost estimate for the W80-4 LEP, and the program's risk management plan.[22]

Further, NNSA has established procedures and policies that broadly apply to its programs, including those managed by NNSA's Office of Defense Programs, such as LEPs. Specifically, NNSA has established a business operating procedure that reflects requirements, responsibilities, and expectations related to cost analysis for all its programs and projects.[23] This procedure outlines the process the NNSA programs are to follow to develop a detailed cost estimate. In addition, NNSA has issued a policy to establish the roles and responsibilities for conducting independent cost estimates.[24] This policy describes the process for independently verifying and validating program estimates.

NNSA's federal W80-4 program office is located in NNSA facilities on Kirtland Air Force Base in Albuquerque, New Mexico, under the direction of a federal program manager. The program office directs the work of seven government-owned, contractor-operated NNSA laboratories and sites that serve as design and production agencies for the LEP.[25] Figure 3 shows the sites participating in the W80-4 LEP and their respective roles.

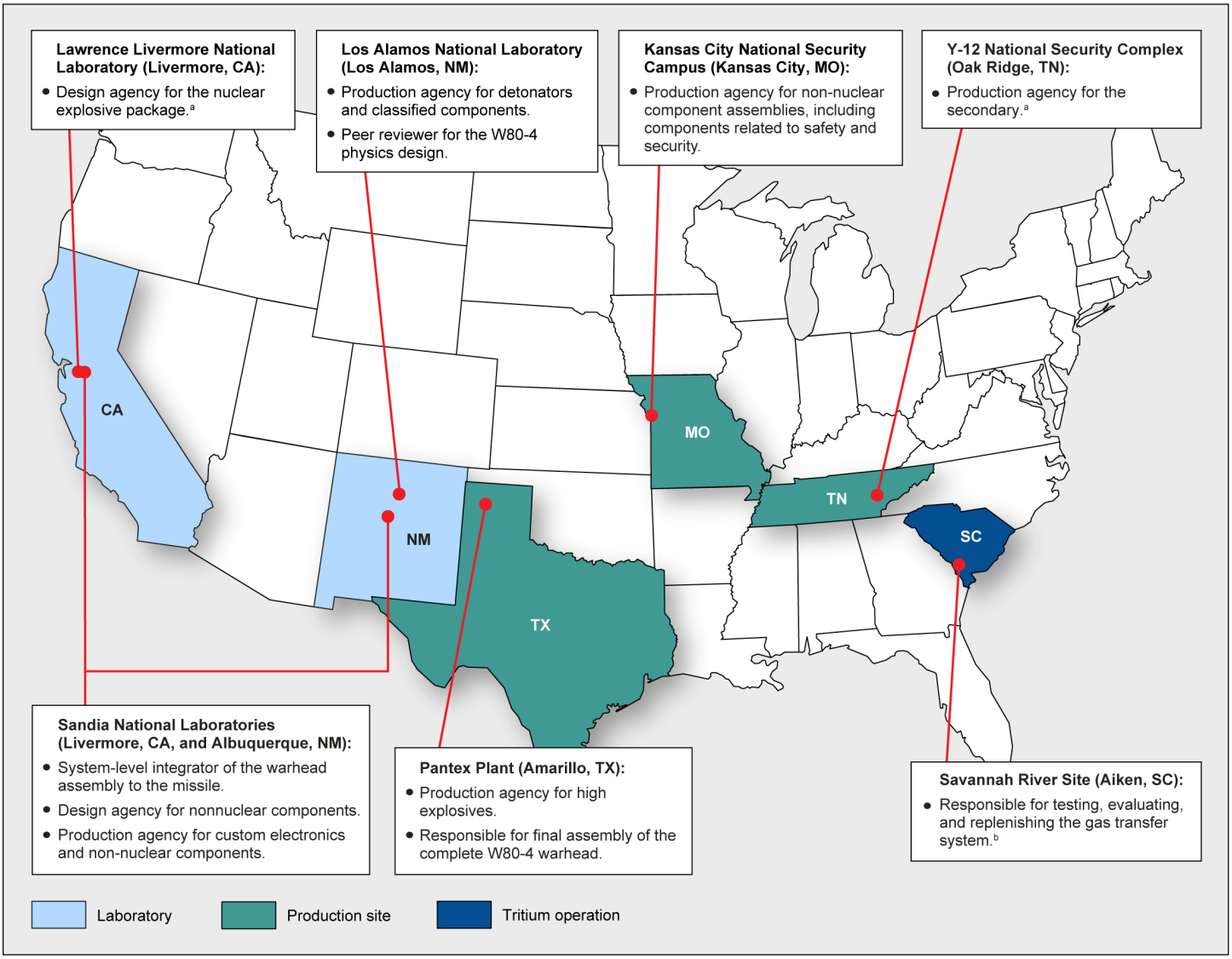
[22]National Nuclear Security Administration, *W80-4 Life Extension Program Weapon Design and Cost Report Requirements* (Washington, D.C.: July 30, 2018); National Nuclear Security Administration, *W80-4 Life Extension Program Risk Management Plan* (Washington, D.C.: July 7, 2016).

[23]National Nuclear Security Administration, *Cost Analysis Requirements Description,* BOP-413.9 (Washington, D.C.: Jan. 22, 2018).

[24]National Nuclear Security Administration, *Responsibilities for Independent Cost Estimates,* NAP-413.3 (Washington, D.C.: Feb. 13, 2019).

[25]The design agency is the organization responsible for the design of NNSA weapon material and the integrity of the design through stockpile life. The production agencies are contractors responsible for the procurement or production of weapon and weapon-related material or components in conformance with design agency specifications.

Figure 3: National Nuclear Security Administration Sites and Laboratories Participating in the W80-4 Nuclear Warhead Life Extension Program



Sources: National Nuclear Security Administration; Map Resources (map). | GAO-20-409

[a]The first stage of a nuclear weapon, known as the primary, is a fission device that is the initial source of nuclear energy. The primary includes the nuclear weapon's central core, known as the pit. The second stage, or secondary, is a nuclear stage physically separate from the primary. The primary and the secondary are referred to as the weapon's nuclear explosive package.

[b]A gas transfer system injects gases into a nuclear weapon's central core, or pit, to boost the nuclear reaction during detonation.

Ongoing and Planned Weapon Modernization Programs and Related Efforts

In addition to the W80-4 LEP, NNSA is currently managing three other weapon modernization programs. Table 1 provides more information on these programs.

Table 1: Ongoing National Nuclear Security Administration (NNSA) Weapon Modernization Programs

Program	Description
B61-12 Life Extension Program (LEP)	The B61 bomb is the oldest nuclear weapon in the stockpile. It was first fielded in 1968, with current modifications fielded from 1979 through 1991.[a] The B61-12 LEP is to consolidate and replace the B61-3, B61-4, B61-7, and B61-10 modifications of the bomb.[b] NNSA formally estimated in October 2016 that it would incur a total cost of about $7.6 billion for the program and that it would complete the first production unit (FPU) in March 2020.[c] However, in September 2019, due to problems with an electrical part, NNSA revised its estimated FPU delivery date for the program to the first quarter of fiscal year 2022. According to September 2019 congressional testimony by NNSA's Deputy Administrator for Defense Programs, the electrical part problem and resulting delay will increase the cost of the program by about $600 million to $700 million.
W88 Alteration 370 program[d]	The W88 Alteration 370 program is to replace the arming, fuzing, and firing subsystem and high explosive main charge for the W88 warhead, which is deployed on the Navy's Trident II D5 submarine-launched ballistic missile system. As of 2017, NNSA formally estimated the program would cost about $2.6 billion and would complete the FPU in December 2020.[c] However, in September 2019, due to problems with an electrical part—the same part affecting the B61-12 LEP—NNSA revised its estimated FPU delivery date for the program to the fourth quarter of fiscal year 2021. According to September 2019 congressional testimony by NNSA's Deputy Administrator for Defense Programs, the electrical part problem and resulting delay will increase the cost of the program by about $120 million to $150 million.
W80-4 LEP	The W80-4 LEP is intended to provide a warhead for a future long-range standoff missile to replace the Air Force's current air-launched cruise missile. As of January 2019, according to NNSA's preliminary estimates, the program will cost about $12 billion and will complete the FPU by fiscal year 2025.[c,e]
W87-1 Modification program[b]	In fiscal year 2019, NNSA restarted a program to replace the capabilities of the W78 warhead, used on Air Force intercontinental ballistic missiles. As of July 2019, NNSA preliminarily estimated that the program would cost about $11.7 billion to $14.8 billion. NNSA plans to produce the FPU by the beginning of the second quarter of fiscal year 2030 to field on the Air Force's Ground Based Strategic Deterrent, which is also in development.[c, f]

Source: GAO analysis of NNSA information. | GAO-20-409

[a]All nuclear weapons in the U.S. stockpile are designated either as warheads or as bombs. Weapons that have certain engineering requirements because they must interface with a launch or delivery system are called warheads. Weapons that do not have these interface requirements, such as gravity bombs and atomic demolition munitions (now retired and dismantled), are called bombs.

[b]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 12 variations over time, each designated as a different modification.

[c]The FPU milestone occurs when the Department of Defense (DOD) accepts the weapon's design and NNSA verifies that the first produced weapon or weapons meets the design.

[d]The W88 Alteration 370 program is an alteration, not an LEP. An alteration is usually a replacement of an older component with a newer component that does not affect military operations, logistics, or maintenance, according to DOD documentation. NNSA manages significant alterations as LEPs.

[e]The estimated cost of about $12 billion for the W80-4 program includes about $800 million in sunk costs, which are not factored into the $11.2 billion estimate given in the program's Weapon Design and Cost Report.

[f]The Ground Based Strategic Deterrent is intended to replace the Minuteman III intercontinental ballistic missile.

In addition to these ongoing weapons programs, the 2018 *Nuclear Posture Review* called for NNSA and DOD to consider additional programs such as a program to develop a modern nuclear-armed sea-launched cruise missile and another to develop a new submarine-launched ballistic missile warhead (now referred to as the W93).[26] Moreover, to support and enable ongoing and planned weapon programs, NNSA also plans to spend billions of dollars over the next 2 decades on capital asset projects and other infrastructure risk reduction and recapitalization efforts to modernize the infrastructure NNSA uses to produce components and materials needed for its weapon programs. We reported additional information about these interrelated efforts and their management and costs in March 2020.[27]

NNSA Has Identified Risks to the W80-4 Program and Established Processes to Manage Them, but Has Also Introduced Potential Risks by Adopting an Unrealistic Schedule

NNSA has identified a range of risks facing the W80-4 LEP, including risks related to developing new technologies and manufacturing processes and reestablishing dormant production capabilities. NNSA is managing these risks using a variety of processes and tools, such as the use of a classified risk database. However, NNSA has introduced potential risks to the W80-4 program by adopting an unrealistic date for the program's FPU delivery—a date that is more than 1 year earlier than the date projected by the program's own schedule risk analysis.

[26]DOD, *Nuclear Posture Review*, February 2018. Through its nuclear posture reviews, DOD assesses the global threat environment and establishes U.S. policy on nuclear forces. The previous review took place in 2010.

[27]GAO-20-443T.

NNSA Has Identified and Is Managing Program Risks Related to Developing New Technologies and Reestablishing Production Capabilities

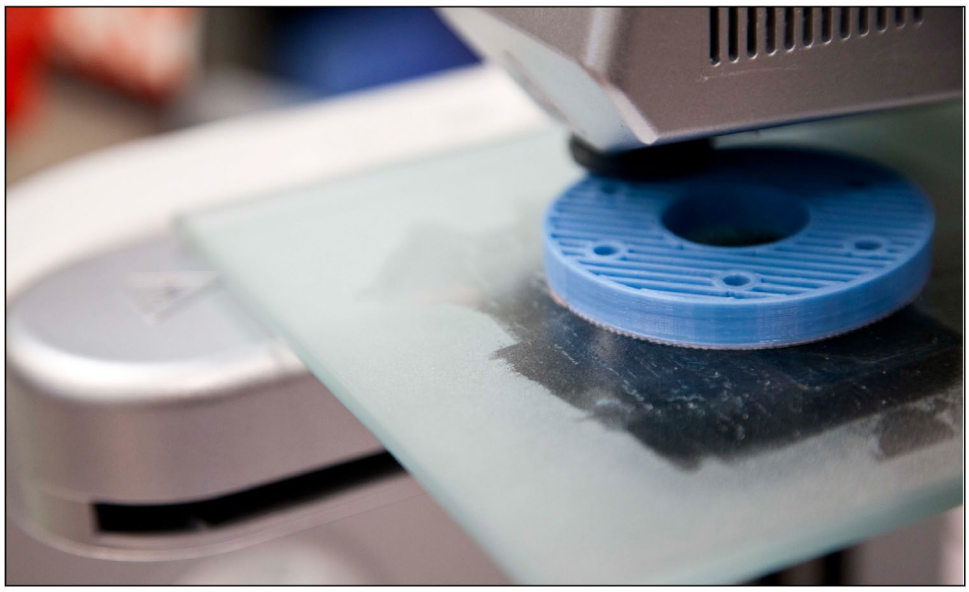
NNSA has identified and has processes in place to manage a range of risks in the W80-4 program, including risks related to developing new technologies and manufacturing processes and reestablishing dormant production capabilities. First, program officials have identified risks associated with developing new technologies and processes used in the W80-4 program, such as additive manufacturing.[28] According to program officials we interviewed, NNSA is developing additive manufacturing capabilities to produce certain W80-4 replacement components, which these officials expect to provide significant benefits. Specifically, by using additive manufacturing, NNSA expects to produce parts qualified for use in nuclear weapons at a higher rate than production agencies can achieve through traditional manufacturing techniques.[29] For example, during our site visits, NNSA officials and contractor representatives showed us additive manufacturing processes that they said eliminated the need for complicated manual labor, such as complex welds, and reduced waste and error.

Moreover, additive manufacturing processes should allow NNSA to incorporate design features that, according to NNSA officials and contractor representatives, will substantially help the W80-4 program meet USSTRATCOM's military requirements while yielding significant cost savings. However, according to NNSA officials and contractor representatives we interviewed, certain processes for producing additively manufactured parts are still under development, and inherent risks exist because of the unknowns associated with the process, including whether parts produced in this manner will meet qualification standards for use in nuclear weapons. Figure 4 shows an example of additively manufactured material.

[28]Additive manufacturing, also called 3D printing, involves a suite of technologies to fabricate metallic, plastic, ceramic, and electronic parts, using a technique in which material is precisely placed layer-by-layer as directed from a digital file. Since the inception of additive manufacturing in the 1980s, when private industry used it as a tool for design and prototyping, its use has expanded to include the production of finished parts. See GAO, *Advanced Manufacturing: Innovation Institutes Have Demonstrated Initial Accomplishments, but Challenges Remain in Measuring Performance and Ensuring Sustainability*, GAO-19-409 (Washington, D.C.: May 23, 2019); *Defense Additive Manufacturing: DOD Needs to Systematically Track Department-wide 3D Printing Efforts*, GAO-16-56 (Washington, D.C.: Oct. 14, 2015); and *3D Printing: Opportunities, Challenges, and Policy Implications of Additive Manufacturing*, GAO-15-505SP (Washington, D.C.: June 24, 2015).

[29]Qualification is the process of ensuring that design, product, and all associated processes are capable of meeting DOD requirements. A qualified item is authorized for an intended use, such as for use in the event of war, or for training or evaluation.

Figure 4: Example of Additively Manufactured Material



Source: Department of Energy. | GAO-20-409

In addition to developing additive manufacturing capabilities, W80-4 program officials said they are monitoring issues associated with the use of commercial off-the-shelf parts, which have caused delays in earlier programs. Specifically, the B61-12 LEP and the W88 Alt 370 program face FPU delivery delays of 20 months and 19 months, respectively, resulting from the use of a commercial off-the-shelf part that did not pass aging tests. Nuclear weapons parts must be capable of reliably operating long enough to last the lifetime, and in the harsh environment, of the nuclear weapon. Similar issues also create risks for the W80-4 program. For example, late design changes and qualification requirements for commercial parts could result in program delays, according to program officials we interviewed.

Program officials and contractor representatives we interviewed also identified several risks associated with manufacturing processes. Representatives from design and production agencies responsible for integrating weapon components said that they are relying on other sites to produce parts, such as microelectronic parts, cables, and detonators, that they need to complete component-level development builds. Late design changes or delays in delivering parts could present risks to the program. Specifically, late design changes may require retooling

production equipment or requalifying new parts. As we have previously reported, design changes have contributed to cost and schedule delays for the W76-1 LEP, and design changes intended to make parts easier to produce can exacerbate schedule delays by compressing the overall weapons refurbishment schedule.[30] Further, delays in delivering microelectronic parts could affect the entire W80-4 program due to a planned temporary shutdown at NNSA's microelectronics production facility at Sandia National Laboratories in New Mexico.[31]

The W80-4 program also faces risks related to reestablishing long-dormant material production capabilities. For example, contractor representatives from Lawrence Livermore National Laboratory said that one of the biggest risks they face in meeting their expected time frames involves the manufacturing of high explosives. We have previously reported that NNSA began work in 2007 to reestablish the facilities and methods used to produce the insensitive high explosives used in the implosion of the W80-4's pit.[32] DOE had not produced these insensitive high explosives since the 1990s. NNSA officials and contractor representatives we interviewed told us in October 2019 that they had made progress in scaling up explosives production in support of their LEP programs, but that significant risks continue to exist because full-scale production has not been prioritized. Additionally, these officials stated that key capabilities, including lithium recycling and production, also pose a risk to the success of the W80-4 program. As we have previously reported, NNSA needed to develop a lithium production strategy to address this risk and has made progress in doing so.[33] Lastly, other risks include a classified material needed to modernize the weapon system that, according to officials, NNSA has not produced since 2000.

NNSA monitors risks and their potential effects on the program using a classified database known as the Active Risk Manager. According to W80-4 program officials, the LEP's 46 product realization teams, which execute the ground-level project work on W80-4 components and

[30]GAO, *Modernizing the Nuclear Security Enterprise: NNSA is Taking Actions to Manage Increased Workload at Kansas City National Security Campus,* GAO-19-126 (Washington, D.C., Apr. 12, 2019).

[31]We recently evaluated NNSA's microelectronics capabilities. See GAO-20-357.

[32]GAO-19-449.

[33]GAO, *DOE Project Management: NNSA Should Ensure Equal Consideration of Alternatives for Lithium Production,* GAO-15-525 (Washington, D.C.: July 13, 2015). We initiated a follow-up review on NNSA's lithium capabilities in January 2020.

subassemblies, are responsible for identifying risks. Product realization teams are responsible for managing most of the risks they identify. The W80-4 program includes higher-level risks—that is, risks that have the potential to affect top-level schedule milestones or the program's ability to deliver a weapon that meets requirements—which are presented to DOD and NNSA for joint review and inclusion in the Active Risk Manager database. Program officials said that these risks are categorized according to the likelihood of their occurrence and the consequences should they occur. Risks with the highest likelihood and consequence are color coded as red risks, with successively lower-likelihood and lower-consequence risks labeled as yellow and green, respectively.

In particular, the W80-4 program has identified and is managing over 70 red risks in the Active Risk Manager database. According to program officials, they have developed risk management strategies and mitigation steps for each risk. We observed these documented steps in the Active Risk Manager database. These officials told us that they have been able to reduce some of the risks identified in the database by implementing risk mitigation strategies. Additionally, they said that they have identified and documented opportunities—that is, program areas with the potential to achieve time and cost savings. According to program officials, they have closed approximately 25 percent of the W80-4 program's risks over the life of the program. In addition, they said that since April 2019 they have mitigated risk levels associated with 45 risks from red to yellow, and they have mitigated risk levels associated with 11 risks from red to green.

NNSA officials and contractor representatives we interviewed cited several strategies that they said were being used to manage W80-4 program risks. For example, officials said that they have made life-of-program purchases of certain parts in order to facilitate earlier testing and to mitigate supply chain risks. Officials also said that they have negotiated design requirements needed in early development builds. These officials told us that the new requirements should help the program meet its need to build certain components early to fit within the planned time frames for the overall program, with an opportunity to make production improvements in subsequent builds.

In addition, program officials said that they have emphasized regular coordination between the program's design agencies and production agencies throughout the program. For example, the design agencies and production agencies have ensured that they are using the same type of additive manufacturing printers so that they can directly transfer software, hardware materials, and tooling. According to program officials, this

improved coordination has been in response to lessons learned from prior LEPs, including the W76-1 program. For example, the production agencies have been involved in the design process to ensure that parts procurement and production are feasible. According to program officials, this should allow for earlier qualification of parts and reduce the need for late design changes.

NNSA Introduced Potential Risks to the W80-4 Program by Adopting an Unrealistic Schedule

Based on the W80-4 program's own analysis, NNSA has introduced potential risks to the program by adopting an unrealistic delivery date for the FPU. Following NNSA requirements for LEPs—as described in NNSA's Program Execution Instruction—W80-4 program officials said that they began developing an integrated master schedule in 2018. In putting together the program's integrated master schedule, program officials said that they instructed contractor representatives at each participating site to develop their own site-specific schedule. Although not required to do so by an NNSA directive, program officials said that they also instructed contractors to conduct a formal schedule risk analysis, which is consistent with best practices identified in our cost estimating guide.[34] W80-4 program office officials we interviewed said they then reviewed and discussed the site-level analyses with the contractor representatives who developed them, and then conducted an integrated program schedule risk analysis for the entire program.

Based on this integrated schedule risk analysis, the W80-4 program projected an FPU delivery in December 2026, with a 70 percent confidence level.[35] According to program officials, they proposed this date as being reasonably achievable to NNSA management and the Nuclear Weapons Council in February 2019. The program's analysis included assumptions about the likelihood that program risks and other uncertainties might occur, as well as their potential effects on key

[34]GAO-09-3SP. Schedule risk analysis examines the effect of program activity delays. A program schedule delay can have cost effects for all aspects of a program.

[35]The W80-4 program established a baseline confidence level of 70 percent, meaning that the FPU has a 70 percent probability that it will finish on or before that date, leaving a 30 percent probability that the program will take longer than projected.

milestone dates.[36] This result was similar to the projection developed by the Office of Cost Estimating and Program Evaluation, NNSA's independent cost estimating office, which reported in a January 2019 memorandum to the NNSA Administrator that an FPU delivery date by the end of fiscal year 2026 was realistic.[37]

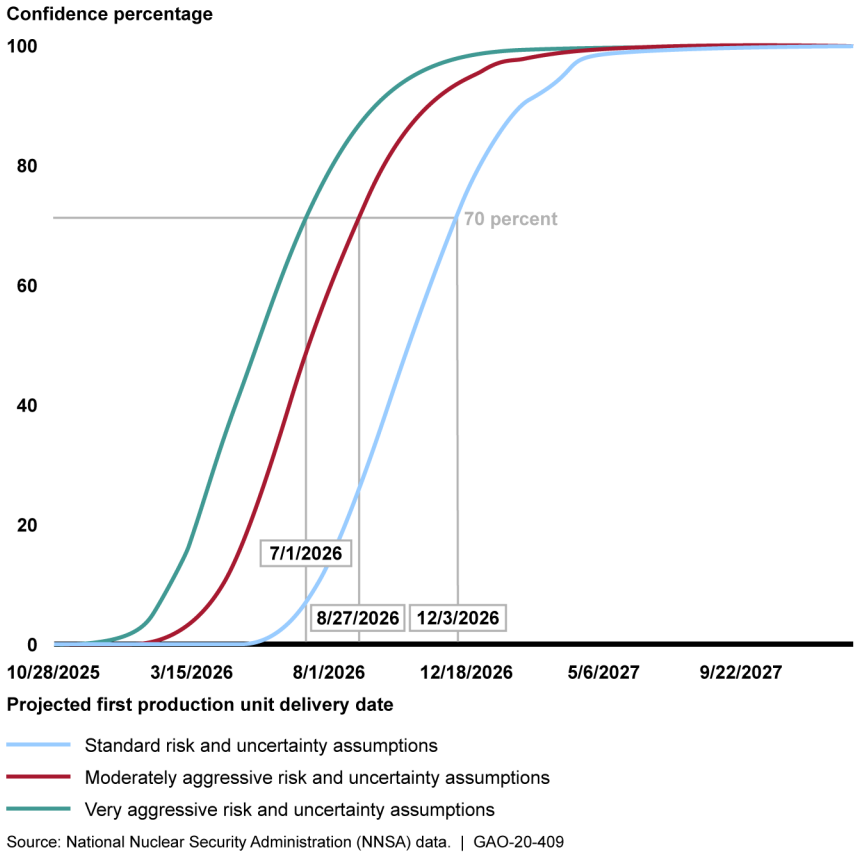
The program office also performed additional iterations of its analysis that included more aggressive assumptions regarding risk and uncertainty.[38] According to the most aggressive iteration of the analysis the W80-4 program office shared with us, the W80-4 program projected an FPU delivery in July 2026, with a 70 percent confidence level. Figure 5, below, shows the results of three iterations of the W80-4 program office's schedule risk analysis (depicted graphically in shapes referred to as S-curves) that illustrate increasing confidence over time that the program can achieve FPU delivery by a given date.

[36]Risk is a potential event that could affect the program positively or negatively. Uncertainty refers to a situation in which little to no information is known about the outcome. Assumptions regarding resource availability and productivity, required effort, and availability of materials, among other things, allow for the determination of the program estimate. Program officials said they can adjust their assumptions about the likelihood of risks and uncertainties materializing, thereby affecting the projected program costs and completion date.

[37]In January 2017, NNSA issued a supplemental directive that directed the Office of Cost Estimating and Program Evaluations to prepare an independent cost estimate at the completion of Phase 6.2A for each nuclear weapon system undergoing life extension. National Nuclear Security Administration, *Phase 6.X Process,* NNSA Supplemental Directive 452.3-2 (Washington, D.C.: Jan. 19, 2017).

[38]According to program officials, each site rated the likelihood that risks and uncertainties would be realized on a five-point scale from very aggressive to very conservative. An aggressive rating assumes risks and uncertainties will be mitigated, resulting in a shorter program schedule. A conservative rating assumes risks and uncertainties are likely to be realized, resulting in a longer program schedule.

Figure 5: Projected Delivery Dates for the W80-4 Nuclear Warhead First Production Unit (FPU), Based on the Program's Schedule Risk Analysis



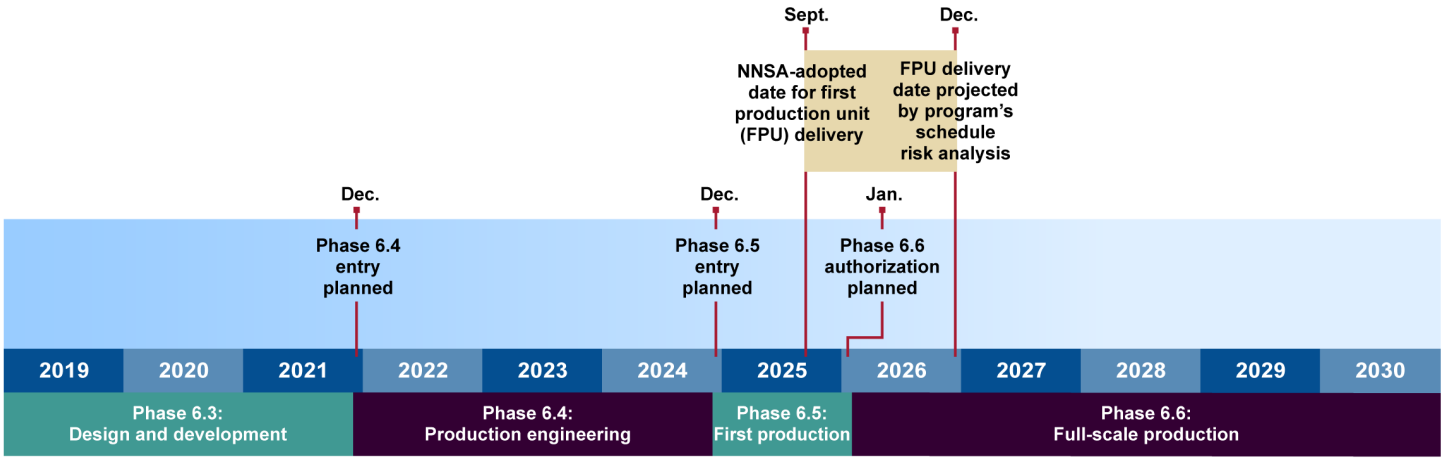
Source: National Nuclear Security Administration (NNSA) data. | GAO-20-409

Note: The FPU milestone occurs when the Department of Defense accepts the weapon's design and NNSA verifies that the first produced weapon or weapons meets the design. The W80-4 program established a baseline confidence level of 70 percent, meaning that the FPU has a 70 percent probability that it will finish on or before that date.

Nevertheless, in the program's January 2019 WDCR, NNSA adopted an FPU delivery date of September 2025, and the Nuclear Weapons Council subsequently affirmed this date during deliberations in February and April of the same year. None of the iterations of the program's schedule risk analysis suggested that this date was achievable at a level of confidence of more than 1 percent, as illustrated in figure 5 above. The Office of Cost Estimating and Program Evaluation similarly found that a fiscal year 2025 FPU delivery date was unlikely. NNSA was able to adopt the September 2025 FPU delivery date in the program's WDCR partly because NNSA's Program Execution Instruction does not require LEPs to conduct or consider a schedule risk analysis when establishing the dates of key

program milestones, such as the FPU delivery date. Figure 6 depicts the FPU delivery date approved by NNSA in the WDCR compared to the FPU delivery date projected by the W80-4 program's schedule risk analysis.

Figure 6: W80-4 Life Extension Program Phases and Milestone Dates



Source: GAO analysis of National Nuclear Security Administration (NNSA) data. | GAO-20-409

Note: The W80-4 program office conducted a series of schedule risk analyses with a range of assumptions. The December 2026 FPU delivery date represents the date the W80-4 program office proposed to NNSA and the Nuclear Weapons Council as being reasonably achievable. NNSA adopted an FPU delivery date of September 2025 in the W80-4 Weapon Design and Cost Report based on other factors, such as freeing up resources for future programs.

According to NNSA and DOD officials we interviewed, NNSA adopted and the Nuclear Weapons Council affirmed an early delivery date for the W80-4 FPU in the WDCR for three main reasons.

- First, according to NNSA program officials, the National Defense Authorization Act for fiscal year 2015 specifies that the program must deliver the FPU by the end of fiscal year 2025.[39]
- Second, according to NNSA and USSTRATCOM officials, both NNSA and DOD wanted to push the nuclear security enterprise to meet the September 2025 FPU delivery date in the interest of freeing up resources for future LEPs and getting the W80-4 warhead ready in case other nuclear weapon programs experience delays. For

[39]Carl Levin and Howard P. "Buck" McKeon National Defense Authorization Act for Fiscal Year 2015, Pub. L. No. 113-291, §3119, 128 Stat. 3292, 3890. Though an extension may be granted, the Secretary of Energy must justify any delay.

example, USSTRATCOM officials told us that the FPU delivery date was adopted with future weapon programs in mind, expressing concern that a delay in the delivery of the W80-4 FPU would have a cascading effect on future LEPs.[40] In addition, according to officials we interviewed in NNSA's Office of Defense Programs, delaying the FPU milestone to a later date would present challenges to NNSA in scaling up to full-quantity production, which NNSA has planned to begin in 2026.

- Third, according to a senior NNSA official, the information from the program's 2018 schedule risk analysis was not particularly useful for establishing key milestone dates, such as the FPU date. Specifically, this official said that while the schedule risk analysis provided useful information by identifying areas to prioritize work and manage risk, the analysis occurred early in the program and was therefore less useful for establishing the program's schedule and key milestones.

Moreover, NNSA and DOD recently reassessed their decision to approve September 2025 as the FPU delivery date but decided to keep the existing date. Specifically, according to a W80-4 program official, during a Nuclear Weapons Council meeting in February 2020, NNSA and DOD discussed the possibility of adopting a later FPU delivery date to better align testing schedules between the W80-4 and LRSO programs. However, according to this official, NNSA and DOD decided to maintain the current W80-4 FPU delivery schedule.

According to our schedule assessment guide, the results of a schedule risk analysis are best viewed as inputs to program management rather than as forecasts of how the program will be completed.[41] That is, the results of a schedule risk analysis indicate when a program is likely to finish without the program team's taking additional risk mitigation steps. However, according to both our schedule assessment and cost estimating guides, programs should minimize and justify date constraints when establishing program schedules and milestones. In particular, according to our cost estimating guide, "finish-not-later-than" schedule constraints

[40]NNSA and USSTRATCOM officials' perspectives indicate a portfolio management approach to LEPs that focuses on the collective programs, rather than on optimizing individual programs. In a March 2020 testimony, we concluded that NNSA's modernization efforts would benefit from a portfolio management approach. See GAO-20-443T. (Washington, D.C.: Mar. 3, 2020).

[41]GAO-16-89G. The schedule guide is a companion to GAO's cost estimating guide.

are usually artificial and reflect policy decisions rather than program realities.[42]

By adopting an FPU delivery date for the W80-4 of no later than September 2025—despite the W80-4 program's schedule risk analysis projections that this date is more than a year earlier than can reasonably be expected—NNSA has introduced several potential risks to the W80-4 program and other nuclear weapon modernization programs. These risks include the following:

- The adopted delivery date for the W80-4 FPU may not allow the program sufficient time to address risks that could materialize over the course of the LEP.[43] For example, NNSA and the Air Force must prepare for upcoming design reviews and flight tests to ensure that the integrated design of the W80-4 and the LRSO meets the Air Force's needs in advance of the LRSO's initial operational capability date.[44] According to W80-4 program and Air Force officials, using a more realistic—that is, later—FPU delivery date would allow better schedule alignment between the W80-4 and LRSO in planning upcoming design reviews and flight tests, which may reduce the risk of discovering problems with the integrated design in later stages of the program. In April 2020, the Air Force made an earlier than anticipated decision to select a single contractor to develop the LRSO. DOD officials said that this decision may help mitigate some of the alignment-related risks identified at the time of the WDCR.
- The adopted delivery date for the W80-4 FPU may result in increased costs for the program in certain areas. For example, W80-4 program and Air Force officials told us that delivering warheads prior to the LRSO's initial operational capability date would require the Air Force to store the warheads in specially designed storage containers, a costly and complex endeavor. According to these officials, aligning the

[42]GAO-09-3SP.

[43]NNSA has faced delays resulting from realized risks in prior LEPs. For example, we previously reported that the B61-12 LEP program was initially expected to deliver its FPU in 2017, but its schedule was revised to reflect a 2020 delivery date. That program has recently experienced additional delays resulting from technical challenges. GAO, *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.: Feb. 4, 2016).

[44]Initial operational capability occurs when a unit or organization has been equipped and trained, and is determined to be capable of conducting operations with a newly fielded system.

program schedules by using a more realistic FPU delivery date would prevent the Air Force from having to store the warheads in these containers, potentially saving millions of dollars.

- The adopted delivery date for the W80-4 FPU introduces the risk of delays for other NNSA weapon modernization programs. In particular, NNSA relies on the reported FPU delivery date of the W80-4 as it develops the planned production schedules for its portfolio of ongoing and future weapon modernization programs. Delays in one program can have cascading effects on other programs because they rely on the same infrastructure and resources. As a result, adopting an unrealistic FPU delivery date for the W80-4 introduces the risk of delays not only within the W80-4 program, but also for NNSA's portfolio of other nuclear weapon modernization programs.

NNSA officials we interviewed told us that they have taken, or plan to take, steps to ensure that they can deliver the FPU by September 2025, as currently planned. For example, program officials and contractor representatives we interviewed said that NNSA leadership has asked them to review their schedule risk analysis and program scope to identify areas where they can reduce time frames. According to DOD officials, the Air Force's selection of a contractor for the LRSO in April 2020 may support NNSA in doing so.

In addition, NNSA officials told us that in order to achieve the September 2025 FPU delivery date, USSTRATCOM may need to accept adjustments to the military characteristics for the warhead.[45] USSTRATCOM officials we interviewed told us that if certain military characteristics were significant drivers of potential cost increases or schedule delays, they were willing to discuss tradeoffs in order to maintain the FPU schedule. However, officials from the W80-4 program office and the Air Force said that in the past USSTRATCOM held firm on military characteristics when presented with options to reduce cost and schedule risk.

NNSA has the opportunity to address the potential risks posed by adopting an unrealistic FPU delivery date when it updates the WDCR for the W80-4 program. As previously noted, during the current phase of the program, NNSA will issue an updated version of the WDCR, known as the baseline cost report, when it establishes the formal schedule baseline for the program prior to its entry into phase 6.4. When NNSA does so, it

[45]The W80-4 warhead's military characteristics are defined in a DOD document that provides a formal list of required capabilities and/or systems to produce a safe, secure, and effective W80-4 warhead to support the LRSO cruise missile system.

has the opportunity to adopt an FPU delivery date and other key milestone dates based on the program's schedule risk analysis. If other factors prompt NNSA to depart from the dates projected by the program's schedule risk analysis, the issuance of the baseline cost report also provides NNSA an opportunity to document its justification for any such departure. By adopting dates based on a schedule risk analysis, NNSA may be better able to ensure that the program schedule for the W80-4 is more realistic and attainable, thereby reducing the potential risks to the program and other related programs. Establishing a schedule in this manner or documenting any justification for declining to do so would also allow NNSA to provide better information for DOD and congressional decision makers.

If NNSA decides to adopt a more realistic delivery date for the W80-4 FPU—and if that date occurs after September 2025—the agency will not meet the requirements of the National Defense Authorization Act for fiscal year 2015. In such an event, the Secretary of Energy would need to initiate the process the act outlines for DOE and DOD to follow. Specifically:

- The Secretary of Energy may delay the FPU delivery date by up to a year if the Commander of USSTRATCOM certifies to the Chairman of the Nuclear Weapons Council and congressional defense committees that the delay is in the interest of national security and does not negatively affect the Commander's ability to meet nuclear deterrence and assurance requirements. Officials from both the W80-4 program office and the Air Force expressed confidence that delaying the warhead's FPU delivery until 2026 would not affect the LRSO's initial operational capability date—which officials we interviewed from NNSA, the Air Force, and USSTRATCOM all agreed was more important than meeting the interim milestone of the FPU delivery date.
- If the Secretary of Energy determines that the FPU will not be delivered by the original or extended deadline, the Secretary must notify, and explain the delay to, the congressional defense committees, the Secretary of Defense, and the Commander. In turn, the Commander must assess the delay for its effects on national security and nuclear deterrence and assurance and any mitigation options available.[46]

[46]Carl Levin and Howard P. "Buck" McKeon National Defense Authorization Act for Fiscal Year 2015, Pub. L. No. 113-291, §3119, 128 Stat. 3292, 3890.

Moreover, the experience of the W80-4 program indicates that improvements to NNSA program management directives may benefit future NNSA weapon programs. As noted above, the W80-4 program used its integrated master schedule information to inform a formal schedule risk analysis, a practice consistent with best practices identified in our cost estimating guide.[47] NNSA requires its LEPs to develop integrated master schedules, but—as also noted above—it does not require LEPs and modernization efforts of similar complexity to conduct or consider the results of a formal schedule risk analysis when establishing key milestone dates, such as the FPU delivery date. By establishing a requirement, in its Program Execution Instruction or associated directives, that LEPs and modernization efforts of similar complexity establish schedules and key program milestones based on schedule risk analyses, or document any decision to depart from schedules and milestones established in this manner, NNSA may be better able to ensure that program schedules are realistic and attainable. Such a requirement could reduce the risk that delays in one weapon modernization program will negatively affect other weapons programs.

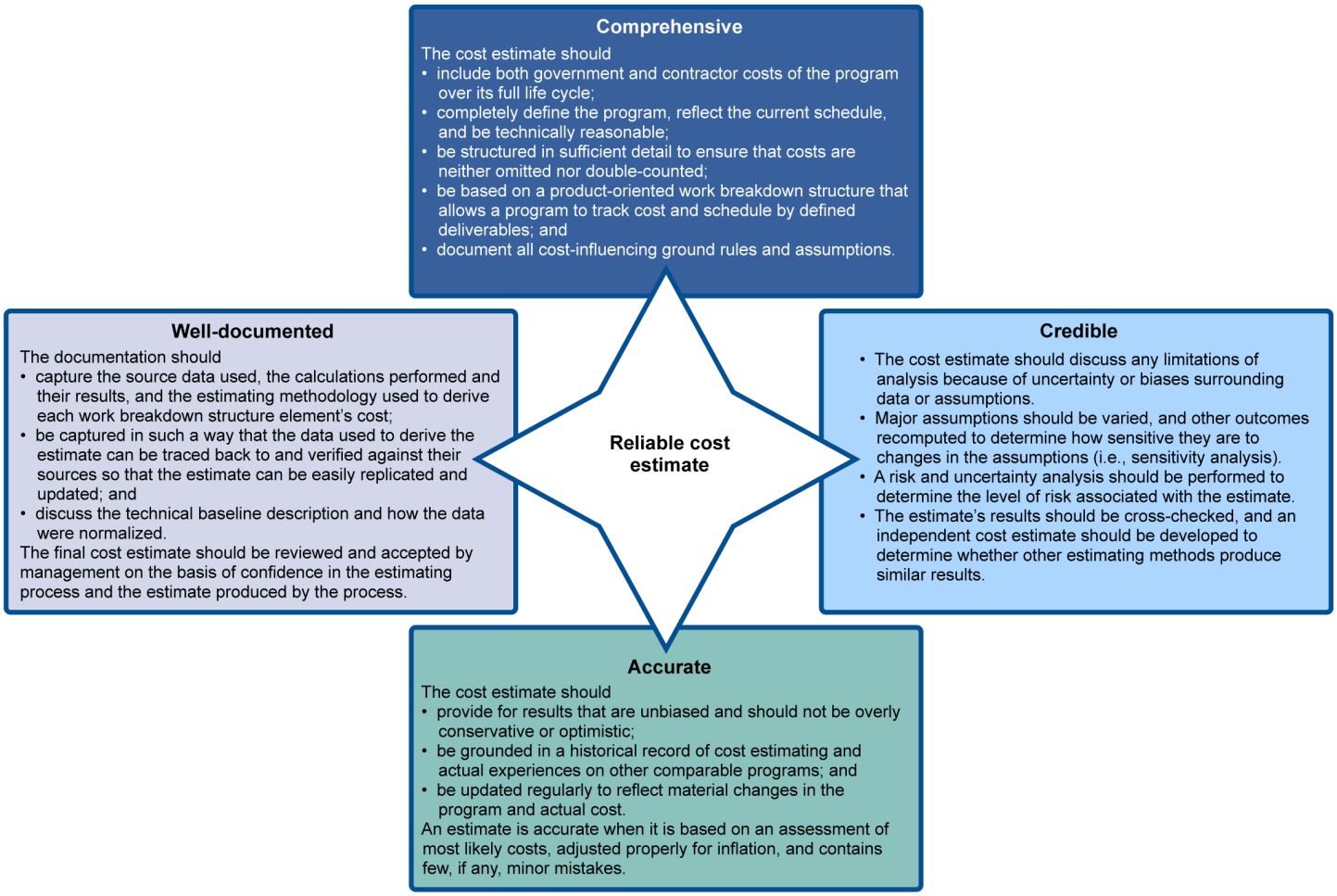
NNSA Substantially Incorporated Best Practices in Developing the Preliminary Cost Estimate for the W80-4 LEP

NNSA's preliminary cost estimate for the W80-4 LEP, documented in the WDCR, substantially incorporated most of the cost estimating best practices identified in GAO's Cost Estimating and Assessment Guide. Our cost estimating guide identifies best practices for developing a high-quality, reliable cost estimate and identifies four characteristics of such an estimate: it is comprehensive, well-documented, accurate, and credible.[48] These four characteristics and some of the best practices that underlie them are illustrated in figure 7.

[47]GAO-09-3SP.

[48]GAO-09-3SP.

Figure 7: Four Characteristics of a High-Quality, Reliable Cost Estimate



Source: GAO's Cost Estimating and Assessment Guide (GAO-09-3SP). | GAO-20-409

We assessed the W80-4 program cost estimate presented in the WDCR by comparing it with the best practices identified in our cost estimating guide and found that it substantially met the criteria for all four

characteristics of a high-quality, reliable cost estimate.[49] A summary of our assessment is presented below, including reasons that support our assessment that the program cost estimate substantially met the criteria under each of the four characteristics, as well as examples of the best practices that the cost estimate could have more fully incorporated. Appendix I provides additional information on our assessment.

- **Comprehensive: Substantially Met.** An estimate is comprehensive if it has enough detail to ensure that cost elements are neither omitted nor double counted. The W80-4 program has instituted processes to support a comprehensive cost estimate. Specifically, the program uses its work breakdown structure—a hierarchical structure that subdivides the work necessary to accomplish the program's objectives into smaller elements—to provide the framework for consistently defining the program across the sites and the federal program office. In addition, the federal program office conducted training on how to create a basis of estimate (BOE) and developed a BOE template to help ensure consistency across sites.[50] The BOEs for the W80-4 program document cost estimates and all assumptions at the component level. However, the estimate given for the program's total cost—$11.2 billion—did not factor in full life-cycle costs. The estimate excludes costs for surveillance of the W80-4 once it has

[49]For each of the four characteristics, we rated the best practices for the estimate on a five-tiered scale, determining that it (1) fully met, (2) substantially met, (3) partially met, (4) minimally met, or (5) did not meet the criteria for each characteristic. According to our scale, fully met means that the agency provided complete evidence that satisfies the entire criteria. Substantially met means that the agency provided evidence that satisfies a large portion of the criteria. Partially met means that the agency provided evidence that satisfies about half of the criteria. Minimally met means that the agency provided evidence that satisfies a small portion of the criteria. Not met means that the agency provided no evidence that satisfies any of the criteria. We determined the overall assessment rating by assigning each individual rating a number: Not Met = 1, Minimally Met = 2, Partially Met = 3, Substantially Met = 4, and Fully Met = 5. We then took the average of the individual assessment ratings to determine the overall rating for each of the four characteristics. The resulting average becomes the Overall Assessment as follows: Not Met = 1.0 to 1.4, Minimally Met = 1.5 to 2.4, Partially Met = 2.5 to 3.4, Substantially Met = 3.5 to 4.4, and Fully Met = 4.5 to 5.0. Appendix I provides more details on the results of our assessment.

[50]BOEs are supporting documentation that outline the details used in establishing an estimate, such as assumptions, constraints, level of detail, ranges, and confidence levels.

entered the stockpile.[51] Surveillance activities were not included in the cost estimate because NNSA manages surveillance activities separately from LEP activities. In addition, the estimate of $11.2 billion for the program does not include costs incurred prior to entry into the development engineering phase of the program.[52] These sunk costs were referred to separately in the WDCR. Without fully accounting for life-cycle costs, management will have difficulty successfully planning program resources and making wise decisions. Nevertheless, the program incorporated practices that substantially met the criteria for a comprehensive cost estimate, which we believe contributed to the program's estimate being reliable.

- **Well-documented: Substantially Met.** Documentation is essential for validating and defending a cost estimate. In our review of sites' contributions to the WDCR, we found that each site provided detailed documentation to substantiate their contributions to the estimate. Specifically, BOEs, data integration templates, and site-specific WDCR submissions were used as the bases for W80-4 program's cost estimate. In addition, the sites' documentation provides information on data normalization, including program assumptions, in their BOEs. Data normalization creates consistency across sites so that comparisons and projections have greater validity.[53] Each site provided substantive documentation, such that an analyst unfamiliar with the program would be able to replicate the sites' cost estimate

[51]According to NNSA's *Fiscal Year 2020 Stockpile Stewardship and Management Plan*, NNSA's surveillance activities provide data to evaluate the safety, security, reliability, and performance of the stockpile. These activities have several goals, such as to identify manufacturing and design defects that affect safety, security, performance, or reliability; to assess the appropriate risks to the safety, security, and performance of the stockpile; and to determine the margins between design requirements and performance at the component and material levels. Surveillance data supports decisions regarding weapon life extensions, alterations, modifications, repairs, and rebuild. See NNSA, *Fiscal Year 2020 Stockpile Stewardship and Management Plan* (Washington, D.C.: July 2019).

[52]A life-cycle cost estimate encompasses all past (or sunk), present, and future costs for every aspect of the program, regardless of funding source. NNSA does not require LEPs to include costs incurred prior to phase 6.3 in their cost estimate, but has instructed LEPs to capture earlier program costs in the WDCR.

[53]The purpose of data normalization is to make a given data set consistent with and comparable to other data used in the estimate. Because data can be gathered from a variety of sources, they are often in many different forms and need to be adjusted before being used in a comparison analysis or serves as a basis for projecting future costs. Cost data are adjusted in a process called normalization, stripping out the effect of certain external influences. The objective of data normalization is to improve data consistency so that comparisons and projections are more valid and other data can be used to increase the number of data points.

submissions. To more fully meet the criteria, the program would need to improve the traceability of documentation from the sites' estimates to the federal program office's integrated cost estimate. Nevertheless, the program incorporated practices that substantially met the criteria for a well-documented cost estimate, which we believe contributed to the program's estimate being reliable.

- **Accurate: Substantially Met.** An accurate cost estimate should be unbiased, be based on an assessment of most likely costs, and include few, if any, mathematical mistakes. The W80-4 program cost estimate considered technical risks and drew upon historical data from other LEPs where possible. Specifically, the W80-4 LEP used historical data from the B61-12 LEP and the W88 Alt 370 program to develop its WDCR. In addition, the W80-4 program established consistent processes across the sites that can help ensure minimal bias in the estimate, such as the BOE template and the Active Risk Manager database structure. However, we found that the site-level submissions we reviewed do not provide estimated cost figures in base-year dollars; instead, they provide estimated costs in then-year dollars using inflation rates specific to each site.[54] According to program officials, the sites use varying inflation rates because NNSA approves site-specific indexes that are more appropriate for the site's locality and type of work. Cost estimates are typically prepared in constant-year dollars to help eliminate distortions caused by factors other than inflation. Since each site applies its own labor and inflation rates to develop site-level estimates, it is a challenge to develop a program-level estimate in constant-year dollars. Further, while the program office has made efforts to better understand each site's inflation rate, there is limited ability to trace the inflation buildup at the site level. As discussed in our cost estimating guide, applying inflation rates consistently is an important step in cost estimating because cost data must be expressed in like terms when developing a cost estimate. Nevertheless, we found that the program incorporated practices that substantially met the criteria for an accurate cost estimate, which we believe contributed to the program's estimate being reliable.
- **Credible: Substantially Met.** Analyses should be performed to ensure that an estimate is credible. An independent cost estimate is considered one of the best and most reliable validation methods because it provides an objective and unbiased assessment of whether the program estimate can be achieved. NNSA's Office of Cost

[54]Then-year dollars—in contrast to base-year dollars—are adjusted to account for the impact of inflation.

Estimating and Program Evaluation performed an independent cost estimate of the W80-4 LEP, using a methodology different from the program's. The program office and the cost estimating office then discussed the results of their respective estimates and, according to officials we interviewed, made mutual adjustments to each prior to the WDCR's issuance. The cost estimating office estimated a program cost of $11.9 billion. To determine an estimate's credibility, key cost elements should be tested for sensitivity, and estimators should develop a cost risk and uncertainty assessment. The sites conducted detailed sensitivity and cost risk and uncertainty assessments. Furthermore, cost estimating techniques should be used to cross-check the estimate and to determine that it is reasonable. Both the sites and the federal program office used comparative programs and methodologies to cross-check their estimates at the total program and site levels. However, to more fully incorporate the criteria for a credible cost estimate, the program should apply alternative methods for lower-level components of the cost estimate to see if they produce similar results. Nevertheless, we believe the program incorporated practices that substantially met the criteria for a credible cost estimate, which we believe contributed to the program's estimate being reliable.

We consider a cost estimate to be reliable if the overall assessment ratings for each of the four characteristics are substantially or fully met—as was the case with the W80-4 program WDCR, which substantially met each characteristic. However, by fully incorporating all of the best practices for the four characteristics, NNSA can better ensure that its future cost estimates are of high quality and reliable. According to NNSA officials, they plan to continue to build upon improvements they have made over the past several years in implementing best practices for cost and schedule estimates.

NNSA Took Several Steps to Evaluate Design Options for the W80-4 Warhead

NNSA took several steps to assess potential options for the W80-4 warhead design, including defining the LEP's mission need and requirements, identifying and assessing the viability of several design options, and considering the costs of these options.

DOD, in coordination with NNSA, is responsible for developing military requirements for nuclear weapons, and DOD and NNSA maintain various documents to ensure that the selected warhead will meet these requirements. These documents define the military characteristics, stockpile-to-target sequence, and missile-to-warhead interface required

for a particular warhead.[55] According to NNSA officials we interviewed, DOD and NNSA communicated on a regular basis between July 2014 and November 2017 to ensure that the design of the W80-4 warhead was feasible and would meet DOD's needs.

Early in the phase 6.X process, NNSA considered a range of design options to determine which designs would meet the agency's mission need. According to NNSA officials we interviewed, NNSA primarily considered LEP designs based on three nuclear weapons: the B61-12, the W80-1, and the W84.[56] NNSA officials said that these three designs were considered because, among other things, they use insensitive high explosives and meet military characteristics. Specifically, in phase 6.1, NNSA considered these three design options during a year-long conceptual design study completed in July 2015. Based on this study, NNSA determined that the B61-12 and W84 design options were unsuitable for the W80-4 LEP. According to NNSA officials, the B61-12 and W84 options were unsuitable because they would not meet military requirements related to weight, warhead dimensions, or available quantities.

Having selected the W80-1 as the basis for subsequent design studies, NNSA program officials we interviewed said that they assessed five design options that ranged in complexity and capability to meet military requirements. As shown in figure 8, the design options ranged from replacing only non-nuclear components to refreshing the primary, rebuilding the secondary, and incorporating additional use control features.[57] Specifically, option 1 would have replaced non-nuclear components but reused many of the existing W80-1 warhead's other components. Option 2A would have entailed replacing non-nuclear components and refreshing the warhead's primary, while option 2B would

[55]The military characteristics, stockpile-to-target sequence, and missile-to-warhead interface documents are all classified. The stockpile-to-target sequence document defines the logistical and employment concepts and related physical environments involved in the delivery of a nuclear weapon from the stockpile to the target. A stockpile-to-target sequence document may also define the logistical flow involved in moving nuclear weapons to and from the stockpile for quality assurance testing, modification and retrofit, and the recycling of limited-life components. NNSA and DOD expect the details of these requirements to evolve well into the warhead design process, according to an NNSA document.

[56]The W84 warhead was formerly fielded on ground-launched cruise missiles, which are no longer part of the U.S. nuclear stockpile.

[57]The term "use control" refers to the collection of measures that facilitate authorized use of nuclear weapons but protect against deliberate unauthorized use.

have also included a secondary rebuild. Options 3A and 3B provided additional use control features compared to their corollaries under option 2.

Figure 8: W80-4 Nuclear Warhead Life Extension Program Design Options Considered by the Nuclear Weapons Council

	Option 1: non-nuclear LEP	Option 2A: non-nuclear and primary refresh	Option 2B: option 2A and secondary	Option 3A: Option 2A+	Selected by Nuclear Weapons Council: Option 3B: option 3A and secondary
Yield meets requirements[a]	No	No	Yes	No	Yes
Insensitive high explosive replacement[b]	No	Yes	Yes	Yes	Yes
Thirty-year design life	High risk	Yes	Yes	Yes	Yes
Detonator safing[c]	No	Yes	Yes	Yes	Yes
Secondary rebuild[d]	No	No	Yes	No	Yes
Additional use control[e]	No	No	No	Yes	Yes

LEP = Life Extension Program

Source: National Nuclear Security Administration. | GAO-20-409

[a]The yield is the weapon's explosive force.

[b]There are two classes of high explosives used in nuclear weapons: insensitive high explosives and conventional high explosives. An insensitive high explosive is less susceptible to accidental detonation than a conventional high explosive and less violent upon accidental ignition, making it safer to handle.

[c]Detonator safing refers to nuclear detonation safety, which deals with preventing nuclear detonation through accidental or inadvertent causes. The goal of nuclear safety design is to prevent inadvertent nuclear yield by isolating the components essential to weapon detonation from significant electrical energy. This involves the enclosure of detonation-critical components in a barrier to prevent unintended energy sources from powering or operating the weapon's functions. When a barrier is used, "gateways" known as stronglinks are required to allow the proper signals to reach the firing set when detonation is intended. Stronglinks operate only upon receipt of a unique signal and are designed to withstand severe accident environments.

[d]The first stage of a nuclear weapon, known as the primary, is a fission device that is the initial source of nuclear energy. The primary includes the nuclear weapon's central core, known as the pit. The second stage, or secondary, is a nuclear stage physically separate from the primary. The primary and the secondary are referred to as the weapon's nuclear explosive package.

[e]The term "use control" refers to the collection of measures that facilitate authorized use of nuclear weapons but protect against deliberate unauthorized use.

According to NNSA program officials, once NNSA selected a W80-based design, the program considered the costs of the various options for pursuing the W80-4 LEP, including options that reused legacy W80 components and materials to varying degrees as well as various security options. In particular, they said that NNSA selected an option that met DOD's needs while capitalizing on cost savings attained through reuse, where possible.

According to NNSA program officials, to fully meet military requirements, the LEP needed to include a replacement of non-nuclear components, a primary refresh, a secondary rebuild, and additional use control. In November 2017, the Nuclear Weapons Council selected option 3B, and the program entered phase 6.2A (design definition and cost study). Option 3B included achieving yield requirements, using insensitive high explosives, extending the warhead's design life, incorporating detonator safety, rebuilding the secondary, and providing additional use control.[58]

Conclusions

LEPs are expensive and complicated endeavors that face inherent design and production challenges. We found that NNSA's preliminary cost estimate for the W80-4 LEP substantially met the criteria for a high-quality, reliable cost estimate. However, NNSA adopted a September 2025 FPU delivery date for the program despite indications from the program's schedule risk analysis that this date may unrealistically constrain the program's schedule and introduce unnecessary risks. Placing artificial constraints on the program's schedule may not reflect

[58]The yield is the weapon's explosive force. There are two classes of high explosives used in nuclear weapons: insensitive high explosives and conventional high explosives. An insensitive high explosive is less susceptible to accidental detonation than a conventional high explosive and less violent upon accidental ignition, making it safer to handle. Nuclear detonation safety deals with preventing nuclear detonation through accidental or inadvertent causes. The goal of nuclear safety design is to prevent inadvertent nuclear yield by isolating the components essential to weapon detonation from significant electrical energy. This involves the enclosure of detonation-critical components in a barrier to prevent unintended energy sources from powering or operating the weapon's functions. When a barrier is used, "gateways" known as stronglinks are required to allow the proper signals to reach the firing set when detonation is intended. Stronglinks operate only upon receipt of a unique signal and are designed to withstand severe accident environments.

program realities. NNSA's push for an expedited W80-4 LEP schedule is influenced by the needs of its portfolio of weapon modernization programs, the requirements of the National Defense Authorization Act for fiscal year 2015, and a desire expressed by officials to push the enterprise. However, ongoing and future programs will rely on the W80-4 program's schedule when establishing their planned production schedules, thereby introducing potential risks.

The National Defense Authorization Act for fiscal year 2015 provides a process for DOE to alert Congress concerning a delay in the delivery of the W80-4 FPU beyond September 2025. In addition, NNSA will revisit its schedule estimate when it issues the baseline cost report for the program prior to entering phase 6.4 of the W80-4 LEP. This report provides NNSA another opportunity to consider schedule risk analysis when adopting key milestone dates for the W80-4 program, including the FPU delivery date. For example, the program's updated schedule can reflect the extent to which risks that NNSA identified prior to the WDCR have been mitigated, such as any risk mitigated as a result of the Air Force's early selection of a contractor for the LRSO. The issuance of the baseline cost report also provides NNSA the opportunity to document justifications for adopting milestone dates different from those suggested by schedule risk analysis, should NNSA decide to do so. Adopting an FPU delivery date that is more consistent with the date projected by the W80-4 program's schedule risk analysis—or documenting any justification for doing otherwise—would allow NNSA to provide better information to DOD and congressional decision makers and improve the alignment between the production schedules for the W80-4 program, other NNSA weapons programs, and the Air Force's LRSO program.

NNSA also has the opportunity to consider the experience of the W80-4 program as it plans other LEPs and modernization efforts—especially given that each of the three major modernization efforts that preceded the W80-4 LEP exceeded initial schedule estimates. The W80-4 program used information from the required integrated master schedule it developed to inform a formal schedule risk analysis. NNSA's Program Execution Instruction already notes that only by maintaining the integrity of the schedule will it be a useful tool to forecast and manage a program. However, the instruction does not require LEPs and efforts of similar complexity to establish program schedules and key milestones, such as the FPU delivery date, based on consideration of formal schedule risk analyses. By establishing such a requirement, and requiring such programs to document any decision to depart from schedules and milestones established in this manner, NNSA may be better able to

ensure that the schedules of future programs are realistic and attainable, and therefore reduce the risk that delays in one program will negatively affect other weapons programs.

Recommendations for Executive Action

We are making the following two recommendations to NNSA:

The NNSA Administrator should require the W80-4 program, when it issues its baseline cost report prior to entry into phase 6.4, to adopt a date for the delivery of a first production unit, and dates for other key program milestones, based on the program's current schedule risk analysis, or document its justification for adopting alternative schedules and milestones based on other factors. If necessary, the Administrator should alert the Secretary of Energy to the need to engage in the extension or notification processes identified in statute for adopting a first production unit delivery date after September 2025. (Recommendation 1)

The NNSA Administrator should revise the Program Execution Instruction or other related directives to require future LEPs and nuclear weapon modernization programs of similar complexity, when they issue a WDCR or baseline cost report, to establish program schedules and key milestone dates (including the FPU delivery date) on the basis of a formal schedule risk analysis that aligns with best practices, or document the justification for any decision to adopt alternative schedules and milestones based on other factors. (Recommendation 2)

Agency Comments and Our Evaluation

We provided a draft of this product to NNSA and DOD for comment. In its comments, reproduced in appendix II, NNSA generally disagreed with our recommendations. NNSA and DOD also provided technical comments, which we incorporated as appropriate. Among other things, we adjusted language in our recommendations to clarify the timing of when the W80-4 program or a future nuclear weapon modernization program should conduct a schedule risk analysis before adopting dates for key program milestones.

Regarding our two recommendations, NNSA disagreed with the premise that the date identified by an initial schedule risk analysis should be the basis for setting the target FPU date for an LEP or nuclear weapon modernization program, stating that the risk analysis must be considered along with other factors in setting the target FPU date. Furthermore, NNSA stated that, while the initial schedule risk analysis provides a clear picture of where to focus risk mitigation activities to ensure the success of the program, NNSA must then evaluate risks and develop mitigation strategies to be factored into final schedule decisions.

In our report, we describe other factors that NNSA and DOD evaluated in determining the FPU delivery date for the W80-4 LEP. In that discussion, we note that a schedule risk analysis can be viewed as one of several inputs to program management, and that the results of a schedule risk analysis indicate when a program is likely to finish without the program team's taking additional risk mitigation steps. Moreover, our recommendations provide NNSA with the flexibility to adopt alternative schedules and milestones for the W80-4 program and future programs based on other factors aside from the schedule risk analysis, provided that NNSA documents its justification for doing so.

However, our report also states that, according to scheduling best practices, programs should minimize and justify date constraints when establishing program schedules and milestones. In particular, we noted that "finish-not-later-than" schedule constraints are usually artificial and reflect policy decisions rather than program realities. We also state that NNSA has an opportunity to update its schedule when it issues its baseline cost report, and that this updated schedule can reflect the extent to which risks identified in the initial schedule have been mitigated. For example, the schedule presented in the baseline cost report can reflect any risk mitigated as a result of the Air Force's early selection of one contractor for the LRSO.

NNSA stated in its comments that it continues to take steps to mitigate and eliminate specific risks for the W80-4 program. It also stated that it would continue to require other LEPs and nuclear modernization programs to conduct similar risk analyses "where beneficial." However, we remain concerned that none of the iterations of the program's schedule risk analysis suggested that the fiscal year 2025 date for delivery of the FPU was achievable at a level of confidence of more than 1 percent—including iterations that made aggressive assumptions regarding the likelihood of risks being successfully mitigated. We also remain concerned that NNSA might choose not to require future LEPs and nuclear modernization programs to conduct schedule risk analyses, even though doing so is a scheduling best practice. In addition, we question the utility of requiring schedule risk analysis if NNSA does not also require that the results inform the key schedule milestones that NNSA adopts, or if NNSA continues to adopt key schedule milestones that the analyses indicate have little likelihood of being achievable.

Consequently, we continue to believe that adopting an FPU date and other key milestone dates based on the W80-4 program's current schedule risk analysis—or documenting any justification for doing

otherwise—will enable NNSA to provide better information to DOD and congressional decision makers and improve the alignment between the production schedules for the W80-4 program, other NNSA weapons programs, and the Air Force's LRSO program. We also continue to believe that by requiring nuclear weapon modernization programs to establish program schedules and key milestone dates (including the FPU delivery date) on the basis of a formal schedule risk analysis that aligns with best practices—or documenting any justification for doing otherwise—NNSA may be better able to ensure that the schedules of future programs are realistic and attainable, and therefore reduce the risk that delays in one program will negatively affect other weapons programs.

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 III.

Allison B. Bawden
Director, Natural Resources and Environment

List of Committees

The Honorable Lamar Alexander
Chairman
The Honorable Dianne Feinstein
Ranking Member
Subcommittee on Energy and Water Development
Committee on Appropriations
United States Senate

The Honorable Marcy Kaptur
Chairwoman
The Honorable Mike Simpson
Ranking Member
Subcommittee on Energy and Water Development, and Related Agencies
Committee on Appropriations
House of Representatives

Appendix I: Results of GAO's Assessment of the W80-4 Life Extension Program Weapon Design and Cost Report Cost Estimate

Characteristic	Overall assessment	Best practice	Individual assessment
Comprehensive	Substantially met	The cost estimate includes all life cycle costs.	Partially met
		The cost estimate completely defines the program, reflects the current schedule, and is technically reasonable.	Substantially met
		The cost estimate work breakdown structure—a hierarchical structure that subdivides the work necessary to accomplish the program's objectives into smaller elements—is product-oriented, traceable to the statement of work/objective, and at an appropriate level of detail to ensure that cost elements are neither omitted nor double-counted.	Substantially met
		The estimate documents all cost-influencing ground rules and assumptions.	Substantially met
Well-documented	Substantially met	The documentation should capture the source data used, the reliability of the data, and how the data were normalized.	Substantially met
		The documentation describes in sufficient detail the calculations performed and the estimating methodology used to derive each element's cost.	Substantially met
		The documentation describes step by step how the estimate was developed so that a cost analyst unfamiliar with the program could understand what was done and replicate it.	Substantially met
		The documentation discusses the technical baseline description, and the data in the baseline is consistent with the estimate.	Substantially met
		The documentation provides evidence that the cost estimate was reviewed and accepted by management.	Fully met
Accurate	Substantially met	The cost estimate results are unbiased, not overly conservative or optimistic, and based on an assessment of most likely costs.	Substantially met
		The estimate has been adjusted properly for inflation.	Partially met
		The estimate contains few, if any, minor mistakes.	Substantially met
		The cost estimate is regularly updated to reflect significant changes in the program so that it always reflects current status.	Fully met
		Variances between planned and actual costs are documented, explained, and reviewed.	Substantially met
		The estimate is based on a historical record of cost estimating and actual experiences from other comparable programs.	Fully met
Credible	Substantially met	The cost estimate includes a sensitivity analysis that identifies a range of possible costs based on varying major assumptions, parameters, and data inputs.	Substantially met

Characteristic	Overall assessment	Best practice	Individual assessment
		A risk and uncertainty analysis was conducted that quantified the imperfectly understood risks and identified the effects of changing key cost driver assumptions and factors.	Substantially met
		Major cost elements were cross checked to see whether results were similar.	Substantially met
		An independent cost estimate was conducted by a group outside the acquiring organization to determine whether other estimating methods produce similar results.	Substantially met

Source: GAO analysis of National Nuclear Security Administration information. | GAO-20-409

Note: GAO's cost estimating guide provides best practices for developing a high-quality, reliable cost estimate and identifies four characteristics of such an estimate: it is comprehensive, well-documented, accurate, and credible. GAO, *GAO Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program Costs*, GAO-09-3SP (Washington, D.C.: March 2009). For each of these four characteristics, listed in the left column of the table, we rated the estimate on a five-tiered scale—shown in the second column from the left—determining that it (1) fully met, (2) substantially met, (3) partially met, (4) minimally met, or (5) did not meet the criteria for each characteristic. According to our scale, fully met means that the agency provided complete evidence that satisfies the entire criteria. Substantially met means that the agency provided evidence that satisfies a large portion of the criteria. Partially met means that the agency provided evidence that satisfies about half of the criteria. Minimally met means that the agency provided evidence that satisfies a small portion of the criteria. Not met means that the agency provided no evidence that satisfies any of the criteria. We determined the overall assessment rating by assigning each individual rating a number: Not Fully Met = 1, Minimally Met = 2, Partially Met = 3, Substantially Met = 4, and Met = 5. We then took the average of the individual assessment ratings to determine the overall rating for each of the four characteristics. The resulting average becomes the Overall Assessment as follows: Not Met = 1.0 to 1.4, Minimally Met = 1.5 to 2.4, Partially Met = 2.5 to 3.4, Substantially Met = 3.5 to 4.4, and Fully Met = 4.5 to 5.0.

Appendix II: Comments from the National Nuclear Security Administration

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

July 13, 2020

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 "Nuclear Weapons: Action Needed to Address the W80-4 Warhead Program's Schedule Constraints" (GAO-20-409). The Department of Energy's National Nuclear Security Administration (NNSA) appreciates GAO's positive recognition of our efforts to apply best practices in developing the W80-4 preliminary cost estimate, and for noting actions we have taken to fully evaluate W80-4 design options and identify and mitigate program risks. However, there appears to be a fundamental difference in philosophy regarding the use of risk analysis.

The report suggests adopting a date for the delivery of a first production unit (FPU) and other key program milestones based on the program's initial schedule risk analysis. We do agree a risk analysis, if available, should be considered in defining final schedule. However, it is just one of a variety of factors to be evaluated in setting the FPU target date. While the initial risk analysis clearly defines certain inherent risk areas to be managed, the probabilities are still highly speculative and not informed by mitigation strategies to be developed as part of on-going program planning. For these reasons, it is not unexpected that the initial risk analysis for the W80-4 showed a low probability of achieving an FPU in fiscal year (FY) 2025, based on information available at the time.

The Nuclear Weapons Council, in February 2019, discussed the risks and other significant factors and reaffirmed the FY 2025 target. Since that time, NNSA has continued to further develop and implement strategies to mitigate and eliminate key risks. We are committed to transparency in our decision processes and stand ready to provide status briefings on our cost, schedule, and risk mitigation activities as requested. Should the Secretary of Energy determine the FPU will be delayed beyond September 30, 2025, the required notifications will be made pursuant to Section 3119 of the *National Defense Authorization Act for Fiscal Year 2015*.

The attached management decision provides the agency's specific response to each of GAO's recommendations. 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 (301) 903-1341.

Sincerely,

Lisa E. Gordon-Hagerty

Enclosure

Enclosure

NATIONAL NUCLEAR SECURITY ADMINISTRATION

Management Decision
"Nuclear Weapons: Action Needed to Address the W80-4 Warhead Program's Schedule Constraints" (GAO-20-409)

The Government Accountability Office recommends the Department of Energy's National Nuclear Security Administration (NNSA):

Recommendation 1: Require the W80-4 program, when it issues its baseline cost report prior to entry into phase 6.4, to adopt a date for the delivery of a first production unit (FPU), and dates for other key program milestones, based on the program's schedule risk analysis, or document its justification for adopting alternative schedules and milestones based on other factors. If necessary, the Administrator should alert the Secretary of Energy to the need to engage in the extension or notification processes identified in the statute for adopting a first production unit delivery date after September 2025.

Management Response: NNSA disagrees with GAO's premise that the date of an initial schedule risk assessment should be the basis for setting the target FPU date for a Life Extension Program (LEP) or nuclear weapon modernization program. While not required, NNSA directed that a schedule risk analysis be conducted for the W80-4 as a best practice to help inform the overall scheduling process. The risk analysis, however, must be considered along with a variety of other factors in setting a target date for the FPU. While the initial risk analysis provides a clear picture of where to focus risk mitigation activities to ensure the success of the program, NNSA must then evaluate the risks and develop mitigation strategies to be factored into final schedule decisions.

In the case of the W80-4, the initial schedule risk assessment in 2018 suggested a low probability of achieving an FPU in fiscal year (FY) 2025, based on information available at the time. At a February 1, 2019, meeting, the Nuclear Weapons Council (NWC) considered the risks and other factors influencing the target FPU date and reaffirmed the FY 2025 FPU. The NWC members further assigned an action to the W80-4 Project Officers Group to return in April 2019 with a framework and path forward for assessing and implementing changes need to achieve that target. NNSA continues to mitigate and eliminate significant risks and, if the Secretary of Energy determines the FPU will be delayed beyond September 30, 2025, the required notifications will be made pursuant to Section 3119 of the *National Defense Authorization Act for Fiscal Year 2015*.

NNSA is committed to transparency and will include status information on cost, schedule, and risk mitigation in its baseline cost report prior to Phase 6.4, Production Engineering. The estimated completion date for this action is early FY 2022.

Enclosure

Recommendation 2: Revise the Program Execution Instruction or other related directives to require other Life Extension Programs (LEP) and nuclear weapon modernization programs of similar complexity, when they issue a weapon design and cost report or baseline cost report, to establish program schedules and key milestone dates (including the FPU delivery date) on the basis of a formal schedule risk analysis that aligns with best practices, and to document the justification for any decision to adopt alternative schedules and milestones based on other factors.

Management Response: NNSA disagrees with GAO's premise that the date of an initial schedule risk assessment should be the basis for setting the target FPU date for a LEP or nuclear weapon modernization program. While not required, NNSA directed that a schedule risk analysis be conducted for the W80-4 as a best practice to help inform the overall scheduling process. The risk analysis, however, must be considered along with a variety of other factors in setting a target date for the FPU. While the initial risk analysis provides a clear picture of where to focus risk mitigation activities to ensure the success of the program, NNSA, in coordination with the Department of Defense, must then evaluate the risks and develop mitigation strategies to be factored into final schedule decisions.

Where determined beneficial, NNSA will continue to require other LEPs and nuclear modernization programs to conduct similar risk analyses, using the results as described above. We will use our experience with the W80-4 to more formally document the drivers for selection of key milestone dates. NNSA considers this recommendation closed based on current practice.

Appendix III: 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), John Hocker (Senior Analyst), Anna Irvine (Senior Operations Research Analyst), and Jennifer Leotta (Assistant Director) made key contributions to this report. Also contributing to this report were Antoinette C. Capaccio, Tara Congdon, John Delicath, Charlotte E. Hinkle, Travis Masters, Steven Putansu, Dan Royer, and Don Springman.

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