



January 2018

NUCLEAR WEAPONS

NNSA Should Adopt Additional Best Practices to Better Manage Risk for Life Extension Programs

GAO Highlights

Highlights of [GAO-18-129](#), a report to the Subcommittee on Strategic Forces, Committee on Armed Services, U.S. Senate

Why GAO Did This Study

Weapons in the U.S. nuclear stockpile are aging. NNSA and the Department of Defense undertake LEPs to refurbish or replace nuclear weapons' aging components. Prior LEPs experienced cost overruns, schedule delays, and scope reductions, and prior GAO reports identified the need for NNSA to use EVM and conduct TRAs to address program risks. In 2013, NNSA developed a management approach for LEPs that it regards as an improvement and currently manages three LEPs using its revised approach. NNSA and its contractors conduct the work associated with these LEPs at seven sites across the country.

GAO was asked to review NNSA's management of its LEPs using its revised approach. This report assesses the extent to which NNSA has implemented, consistent with best practices, the use of EVM and TRAs in its management of LEPs. GAO reviewed NNSA directives and compared them to relevant best practices; reviewed LEP documents and reports; and interviewed NNSA program officials.

What GAO Recommends

GAO is making four recommendations, including that NNSA require an independent team to validate contractor EVM systems used for LEPs and establish benchmarks for technology readiness at LEP decision points. NNSA generally agreed with GAO's recommendations.

View [GAO-18-129](#). For more information, contact Allison Bawden at (202) 512-3841 or bawdena@gao.gov.

January 2018

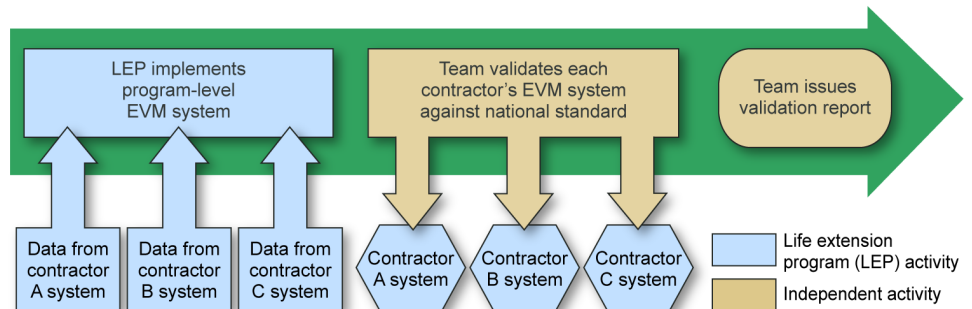
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NNSA Should Adopt Additional Best Practices to Better Manage Risk for Life Extension Programs

What GAO Found

The Department of Energy's National Nuclear Security Administration (NNSA) has implemented the use of earned value management (EVM) in three life extension programs (LEP) as part of its revised management approach. EVM is a management tool that measures the value of work accomplished in a given period and compares it with the planned value of work scheduled and the actual cost of work accomplished. To better measure program performance, NNSA requires its LEPs to implement an EVM system that meets the EVM national standard. Each of its LEPs has implemented, or is in the process of implementing, a program-level EVM system that incorporates cost, schedule, and earned value data from multiple, independent EVM systems maintained by contractors at different sites. However, NNSA has not adopted the best practice of having an independent team validate EVM systems against the national standard (see fig.), which could help the agency better manage risk. Without requiring validation of EVM systems, NNSA may not have assurance that its LEPs are obtaining reliable EVM data for managing their programs and reporting their status.

Best Practice for Validating Earned Value Management (EVM) Systems



Source: GAO analysis of best practices and National Nuclear Security Administration documents. | GAO-18-129

NNSA has begun implementing requirements for independently conducting technology readiness assessments (TRA) of LEP critical technologies, but it has not adopted a key best practice that could help the agency better manage risk for LEPs. A TRA is a systematic, evidence-based process that evaluates the maturity of hardware and software technologies critical to the performance of a larger system. NNSA recently established requirements for its programs to conduct independent TRAs of LEP critical technologies. The agency conducted a TRA in 2014 for one LEP in an early stage and subsequently revised its methodology for how its contractors are to assess the technology readiness of weapon system components. However, NNSA has not established specific benchmarks for technology readiness at LEP decision points, consistent with best practices. Without establishing such benchmarks, NNSA may not have assurance that its LEPs have taken appropriate risk mitigation steps to mature critical technologies to meet program cost and schedule commitments.

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Abbreviations

CEPE	Office of Cost Estimating and Program Evaluation
DOD	Department of Defense
DOE	Department of Energy
DP	Office of Defense Programs
EVM	earned value management
LEP	life extension program
M&O	management and operating
NNSA	National Nuclear Security Administration
TRA	technology readiness assessment
TRL	technology readiness level
W88 Alt 370	W88 Alteration 370

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January 30, 2018

The Honorable Deb Fischer
Chairman
The Honorable Joe Donnelly
Ranking Member
Subcommittee on Strategic Forces
Committee on Armed Services
United States Senate

Many weapons in the U.S. nuclear stockpile have aged far beyond their designed operational lives and, according to the Department of Defense (DOD), require modernization to ensure that the nuclear arsenal is safe, secure, and effective for as long as such weapons exist.¹ To maintain the readiness and extend the operational lives of weapons in the stockpile, the Department of Energy's (DOE) National Nuclear Security Administration (NNSA) and DOD undertake life extension programs (LEP) that refurbish or replace weapon components.² LEPs may also deploy advanced or emerging technologies to enhance safety and security characteristics of weapons, as well as consolidate the stockpile into fewer weapon types to minimize maintenance and testing costs. LEPs can extend the operational lives of weapons by 20 years or more, but they are technically challenging, costing billions of dollars and taking years to complete.

We previously found problems with NNSA's management of its LEPs, which have experienced millions of dollars in cost overruns, years of schedule delays, and reductions in planned numbers of weapon refurbishments. To mitigate these problems, we identified the need for NNSA to use management tools such as earned value management (EVM), which measures the value of work accomplished in a given period and compares it with the planned value of work scheduled for that period and the actual cost of work accomplished; technology readiness

¹See Department of Defense, *Nuclear Posture Review Report* (Washington, D.C.: Apr. 6, 2010). The U.S. nuclear weapons stockpile includes air-delivered bombs, ballistic missile warheads, and cruise missile warheads.

²Established in 1999, NNSA is a separately organized agency within 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 without nuclear testing.

assessments (TRA), which evaluate the maturity of hardware and software technologies critical to the performance of a larger system; and independent cost estimates, which provide an objective and unbiased assessment of whether a program's cost estimate can be achieved. For example, in July 2003, we recommended that NNSA establish its LEPs as projects and manage them according to DOE project management requirements, which then included the use of EVM and independent cost estimates.³ We stated that if NNSA declared its LEPs to be projects subject to these requirements, many useful project management tools would become available to NNSA's LEP managers to reduce the risks of potential cost overruns, schedule delays, and changes in program scope. However, in subsequent reviews, we found no evidence that NNSA had taken any action to establish its LEPs as projects and manage them accordingly, and we continued to find that NNSA had not effectively managed cost, schedule, and technical risks for its LEPs.⁴

In February 2016, we reported that NNSA's Office of Defense Programs (DP), which is responsible for managing NNSA's LEPs, had developed a management approach for one of its LEPs—the B61-12⁵—that the office regards as improved over approaches used for prior LEPs.⁶ For example, the B61-12 LEP is the first LEP to use EVM to measure performance and is the first to integrate the schedules and cost estimates for activities at all participating NNSA sites. DP used this new approach to inform its program management directive,⁷ first issued in November 2013 and now referred to as the *DP Program Execution Instruction*.⁸ We reported at the

³GAO, *Nuclear Weapons: Opportunities Exist to Improve the Budgeting, Cost Accounting, and Management Associated with the Stockpile Life Extension Program*, [GAO-03-583](#) (Washington, D.C.: July 28, 2003).

⁴See GAO, *National Nuclear Security Administration: Additional Actions Needed to Improve Management of the Nation's Nuclear Programs*, [GAO-07-36](#) (Washington, D.C.: Jan. 19, 2007); and *Nuclear Weapons: NNSA and DOD Need to More Effectively Manage the Stockpile Life Extension Program*, [GAO-09-385](#) (Washington, D.C.: Mar. 2, 2009).

⁵The B61 bomb is deployed on Air Force aircraft and bombers and on NATO aircraft.

⁶GAO, *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).

⁷In this report, we use the term "directive" to refer to orders, policy letters, supplemental directives, instructions, and guidance.

⁸National Nuclear Security Administration, *DP Program Execution Instruction: NA-10 Program Management Tools and Processes* (Washington, D.C.: Jan. 14, 2016).

time that it was too soon to determine whether this approach would help the B61-12 LEP address several ongoing management challenges, including an untested EVM system, as well as TRA and cost-estimating requirements and guidance that have not been aligned with best practices.

NNSA has three ongoing LEPs being managed under DP's program management directive.⁹ You asked us to review NNSA's management of LEPs using DP's program management directive. This report assesses the extent to which NNSA has implemented, consistent with best practices, the use of (1) EVM, (2) TRAs, and (3) independent cost estimates in its management of LEPs.

For all objectives, we reviewed DP's program management directive, as well as other DP and NNSA directives related to using EVM and conducting TRAs and independent cost estimates. We analyzed and compared NNSA's directives with best practices for using EVM and conducting TRAs that we have previously reported.¹⁰ We also compared NNSA's directives with federal standards for internal control,¹¹ and with DOE's project management requirements, to the extent that DOE's requirements were consistent with best practices. In addition, we reviewed other NNSA reports and documents related to LEP activities. We interviewed NNSA officials, including officials with DP and the Office of Cost Estimating and Program Evaluation (CEPE)¹² at NNSA

⁹One of these programs, for the W88 Alt 370, is technically an alteration, not a life extension, but we refer to it as both an LEP and an alteration program in this report. NNSA has one additional LEP, for the W76-1, which is nearing completion and has not been subject to DP's recent program management directive, according to DP officials.

¹⁰See GAO, *GAO Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program Costs*, [GAO-09-3SP](#) (Washington, D.C.: March 2009); *GAO Schedule Assessment Guide: Best Practices for Project Schedules*, [GAO-16-89G](#) (Washington, D.C.: December 2015); and *Technology Readiness Assessment Guide: Best Practices for Evaluating the Readiness of Technology for Use in Acquisition Programs and Projects—Exposure Draft*, [GAO-16-410G](#) (Washington, D.C.: August 2016).

¹¹GAO, *Standards for Internal Control in the Federal Government*, [GAO-14-704G](#) (Washington, D.C.: September 2014). Internal control comprises the plans, methods, policies, and procedures used to fulfill the mission, strategic plan, goals, and objectives of the entity.

¹²Congress established CEPE under the National Defense Authorization Act for Fiscal Year 2014. Pub. L. No. 113-66, § 3112, 127 Stat. 672, 1050 (2013) (codified as amended at 50 U.S.C. § 2411 (2017)).

Headquarters in Washington, D.C., as well as LEP program managers and officials at NNSA's Albuquerque Complex. We also interviewed officials from DOE's Office of Project Management Oversight and Assessment, which assists in developing and implementing DOE directives related to project management, to identify DOE requirements on using EVM, conducting TRAs, and estimating costs. We excluded the ongoing W76-1 LEP from our scope because this program is nearing completion and has not been subject to DP's recent program management directive, according to DP officials.

We conducted this performance audit from November 2016 through January 2018 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

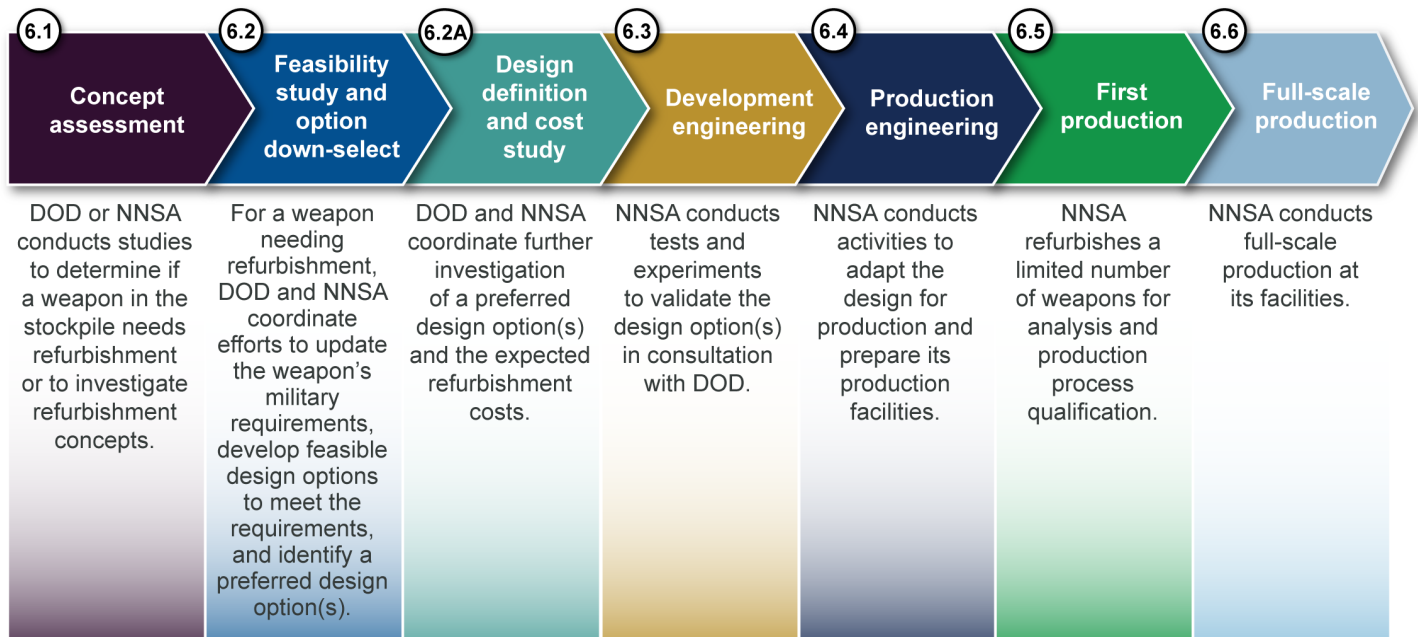
This section describes (1) the framework for managing LEPs, known as the Phase 6.X process; (2) DOE and NNSA directives, and their applicability to LEPs; (3) management and operating (M&O) contracts; (4) EVM; and (5) TRAs.

Phase 6.X Process and Life Extension Programs

DOD and DOE established the Phase 6.X process to provide a framework to conduct and manage refurbishment activities, such as LEPs, for existing nuclear weapons.¹³ The Phase 6.X process includes key phases or milestones that a nuclear weapon refurbishment activity must undertake before proceeding to subsequent steps of the Phase 6.X process (see fig. 1).

¹³According to NNSA Supplemental Directive 452.3-2, *Phase 6.X Process*, approved on January 19, 2017, refurbishment refers to all nuclear weapon modifications to address life extension and other warhead modernization activities due to revised military requirements at the system, subsystem, or component level.

Figure 1: Phase 6.X Process for Managing Refurbishment Activities for Nuclear Weapons



Abbreviations

DOD Department of Defense
 NNSA National Nuclear Security Administration

Source: Nuclear Weapons Council. | GAO-18-129

NNSA and DOD’s implementation of the Phase 6.X process is guided by the *Procedural Guideline for the Phase 6.X Process*.¹⁴ This document describes the roles and functions of DOD, DOE, and NNSA in nuclear weapon refurbishment activities conducted through the Phase 6.X process. It also describes the roles and functions of the Nuclear Weapons Council and its Standing and Safety Committee.¹⁵ Importantly, for more detailed requirements and guidance on program management matters, DOE and DOD each use their own agency-specific directives.

¹⁴Nuclear Weapons Council, *Procedural Guideline for the Phase 6.X Process* (Washington, D.C.: December 2015).

¹⁵The 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 members are the Under Secretary of Defense for Acquisition, Technology and Logistics (generally the Chair), the Under Secretary of Defense for Policy, the Vice Chairman of the Joint Chiefs of Staff, the Commander of U.S. Strategic Command, and the Under Secretary for Nuclear Security of the Department of Energy (who also serves as the Administrator of the National Nuclear Security Administration). 10 U.S.C. § 179 (2017); 42 U.S.C. 7132 (2017).

NNSA currently is managing three LEPs, described in table 1, under DP’s program management directive, which, as discussed later in this report, provides for enhanced management of activities that follow the Phase 6.X process.

Table 1: Selected Ongoing National Nuclear Security Administration (NNSA) Life Extension Programs (LEP)

Program	Current phase	Description
B61-12 LEP	6.4	The B61 bomb is the oldest nuclear weapon in the stockpile. The B61-12 LEP will consolidate and replace the B61-3, -4, -7, and -10 modifications of the bombs. As of March 2017, the B61-12 LEP is estimated to cost about \$8.3 billion and scheduled to complete its first production unit in December 2019, according to program documentation.
W88 Alteration (Alt) 370	6.4	The W88 Alt 370 will replace the arming, fuzing, and firing subsystem for the W88 warhead, which is deployed on the Navy’s Trident II D5 submarine-launched ballistic missile system. In November 2014, the Nuclear Weapons Council decided to replace the conventional high-explosive main charge, which led to an increase in costs for the alteration. As of April 2017, the W88 Alt 370 is estimated to cost about \$2.6 billion and scheduled to complete its first production unit in December 2020, according to NNSA officials.
W80-4 LEP	6.2A	The W80-4 LEP is intended to provide a warhead for a future long-range standoff missile that will replace the Air Force’s current air-launched cruise missile. As of March 2017, the W80-4 has not established a performance baseline for scope, cost, and schedule. In its <i>Fiscal Year 2017 Stockpile Stewardship and Management Plan</i> , NNSA preliminarily estimated that the W80-4 will cost about \$8.4 billion and complete its first production unit in fiscal year 2025.

Source: GAO analysis of NNSA documents and information reported by NNSA officials. | GAO-18-129

Note: This table contains only LEPs being managed under the NNSA Office of Defense Program’s program management directive. NNSA has one additional LEP, for the W76-1, which is nearing completion and is being managed under a previous approach.

In addition, NNSA plans to undertake future LEPs. Specifically, according to NNSA documents, NNSA intends to transition the nuclear stockpile to three interoperable ballistic missile warheads and two air-delivered weapons, a plan NNSA has described as the 3+2 strategy, through life-extension efforts. NNSA plans to move toward this strategy by initiating a series of interoperable warhead programs between about 2020 and 2060. If approved by Congress, NNSA’s plans for the first ballistic missile warhead in the 3+2 strategy—the Interoperable Warhead 1—indicate it would require a total of \$12.4 billion from 2020 to 2041. NNSA has also begun preliminary planning for Interoperable Warhead 2, Interoperable Warhead 3, and B61-12 follow-on programs that, if authorized, would start in the 2020s and 2030s.

DOE and NNSA Directives and Their Applicability to Life Extension Programs

Directives are DOE's primary means to set, communicate, and institutionalize policies, requirements, responsibilities, and procedures for departmental elements (including NNSA) and contractors.¹⁶ DOE classifies its directives into several types, including orders and guides, which DOE describes as follows:

- **Orders** establish management objectives, requirements, and assignment of responsibilities for DOE federal employees.¹⁷
- **Guides** provide information on acceptable, voluntary means for complying with requirements contained in orders.

The NNSA Administrator has authority to establish NNSA-specific policies, unless disapproved by the Secretary of Energy.¹⁸ NNSA does this through the issuance of policy letters, which take the form of policies, supplemental directives, and business operating procedures.¹⁹

DOE and NNSA distinguish between projects and programs and use different management approaches for each, as follows:

- **Projects.** NNSA's management of projects is governed by DOE's project management order.²⁰ The order applies to capital asset projects above a certain cost threshold.²¹ It provides management direction for NNSA and other DOE offices, with the goal of delivering projects within the original performance baseline that are fully capable

¹⁶See Department of Energy, *Departmental Directives Program*, Order 251.1D (Washington, D.C.: Jan. 17, 2017).

¹⁷Orders can also include requirements relevant to DOE contractors, and these requirements would be included as an attachment to an order.

¹⁸50 U.S.C. § 2402(d) (2017).

¹⁹See National Nuclear Security Administration, *Policy Letters: NNSA Policies, Supplemental Directives, and Business Operating Procedures*, Supplemental Directive 251.1 (Washington, D.C.: Oct. 7, 2013).

²⁰Department of Energy, *Program and Project Management for the Acquisition of Capital Assets*, Order 413.3B Chg 4 (Washington, D.C.: Oct. 13, 2017).

²¹DOE's project management order defines a capital asset project in part as "a project with defined start and end points required in the acquisition of capital assets." Capital assets are defined in part in the order as "land, structures, equipment and intellectual property, which are used by the federal government and have an estimated useful life of 2 years or more." The order applies to capital asset projects with a total cost of \$50 million or more.

of meeting mission performance and other requirements, such as environmental, safety, and health standards. The order specifies requirements that must be met, along with the documentation necessary, to move a project past major decision points (referred to as critical decisions). It provides requirements on the use of EVM, TRAs, and, in some cases, independent cost estimates, among other requirements. As we have previously found, DOE's project management order applies to programs only in conjunction with a program's acquisition of capital assets.²²

- **Programs.** Neither DOE nor NNSA has established a program management policy.²³ Specifically, as we found in November 2016, DOE had not established a department-wide policy on program management, and NNSA canceled its program management policy in 2013 without establishing a new one.²⁴ In that report, we recommended that DOE establish a program management policy, but DOE did not provide any comments on our recommendation. In the absence of a DOE-wide or NNSA-wide program management directive, in January 2016 DP issued its own program management directive, the *DP Program Execution Instruction*. This directive applies only to programs managed by DP and not to other NNSA programs, such as those managed by NNSA's Office of Defense Nuclear Nonproliferation. For this reason, in this report we examined both DP and NNSA directives that pertain to program activities.

DP's directive establishes four program management categories and execution requirements for these categories.²⁵ DP's management categories are risk-based and apply different execution requirements commensurate with risk. LEPs fall under DP's "Enhanced Management A" category, which includes activities that require a Selected Acquisition

²²GAO, *Project and Program Management: DOE Needs to Revise Requirements and Guidance for Cost Estimating and Related Reviews*, [GAO-15-29](#) (Washington, D.C.: Nov. 25, 2014).

²³DOE's project management order defines a program in part as an organized set of activities directed toward a common purpose or goal in support of an assigned mission area. Programs typically include labor and operations and maintenance costs. Programs, in turn, frequently rely on the acquisition of capital assets—through capital asset projects—to meet program needs.

²⁴GAO, *Program Management: DOE Needs to Develop a Comprehensive Policy and Training Program*, [GAO-17-51](#) (Washington, D.C.: Nov. 21, 2016).

²⁵DP's four program management categories, listed in order from most rigorous to least rigorous program management requirements, are Capital Acquisition Management; Enhanced Management A; Enhanced Management B; and Standard Management.

Report to Congress and follow the Phase 6.X process.²⁶ DP manages LEPs as programs, not projects, even though LEPs have many project-like characteristics such as a defined scope of work to be completed over a specific schedule. As a result, the requirements in DOE's project management order do not apply to LEPs. For a list of DP's directives that are applicable to LEPs, see appendix I.

M&O Contracts

Since the Manhattan Project produced the first atomic bomb during World War II, DOE and its predecessor agencies have depended on the expertise of private firms, universities, and others with the scientific, manufacturing, and engineering expertise to carry out research and development work and manage the government-owned, contractor-operated facilities where the bulk of the department's mission activities are carried out. DOE relies on contracts in general, and M&O contracts in particular, to do this work. According to the Federal Acquisition Regulation, M&O contracts are agreements under which the government contracts for the operation, maintenance, or support, on its behalf, of a government-owned or government-controlled research, development, special production, or testing establishment, wholly or principally devoted to one or more major programs of the contracting agency. An M&O contract is characterized both by its purpose and by the special relationship it creates between the government and contractor. For example, M&O contracts must use government-owned or government-controlled facilities, and the government must maintain a special, close relationship with the contractor and the contractor's personnel.

NNSA relies on M&O contractors at its weapons laboratories to support understanding of the physics associated with the safety, security, and reliability of nuclear weapons, as well as to maintain core competencies in nuclear weapons science, technology, and engineering. In addition, NNSA relies on M&O contractors at its production sites to maintain, evaluate, repair, and dismantle both the nuclear and nonnuclear components of nuclear weapons; to manufacture weapons components; and to process tritium, a key isotope used to enhance the power of

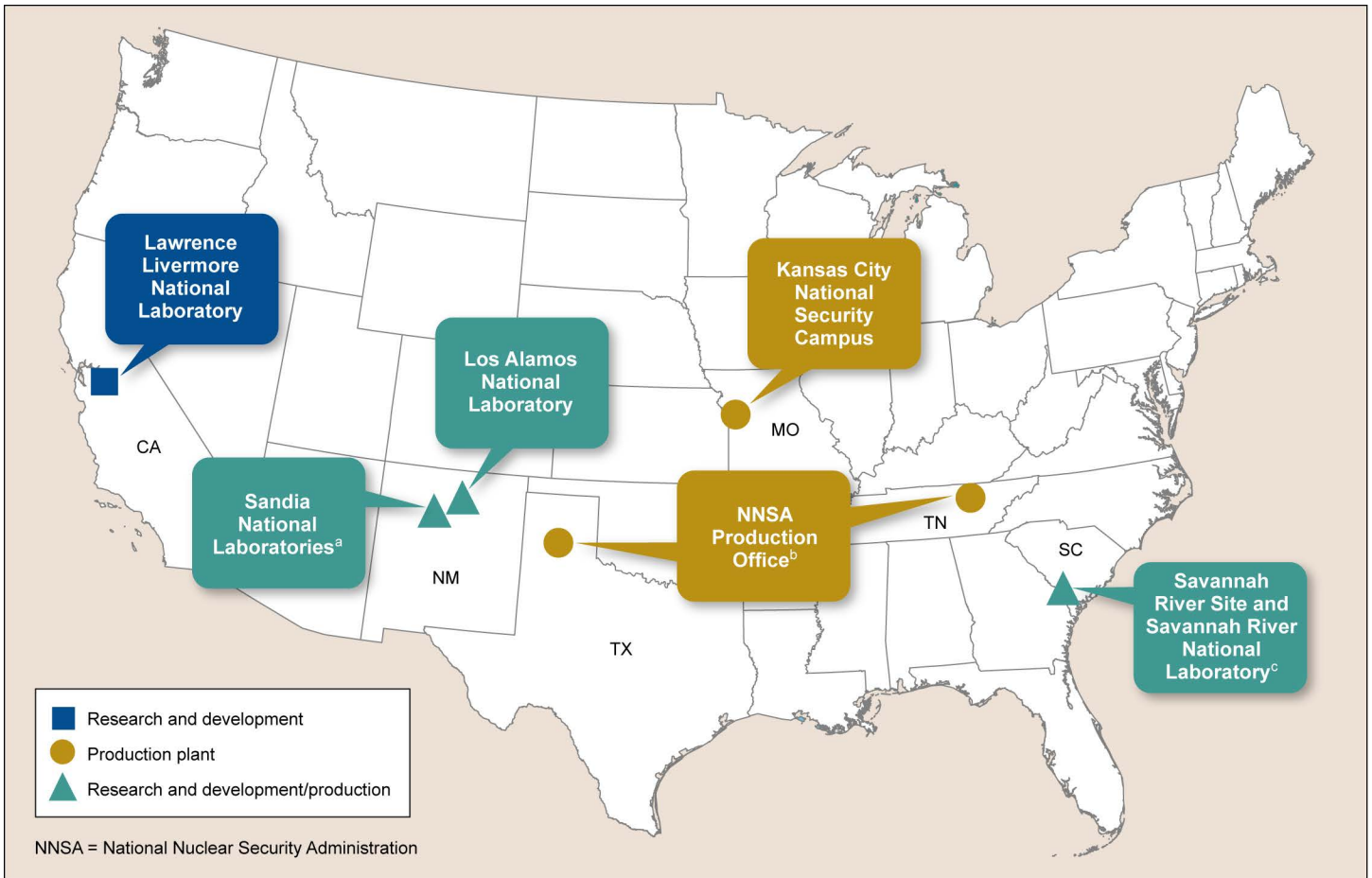
²⁶NNSA is required to issue Selected Acquisition Reports on each nuclear weapon system undergoing life extension. 50 U.S.C. § 2537 (2017). A Selected Acquisition Report is a report required for periodic submission to Congress that includes the status of the total program cost, schedule, and performance, as well as program unit cost and unit cost breach information. It also includes a full life-cycle cost analysis of the program and all its increments.

nuclear weapons. NNSA also relies on M&O contractors at these sites to refurbish or replace aging components of nuclear weapons as part of LEP activities. Figure 2 and appendix II provide additional information on DOE's M&O contract sites and on the contractors who conduct LEP activities.

Figure 2: Department of Energy Management and Operating Contract Sites Associated with Life Extension Programs

Interactive Graphic

Instructions: To view in-depth information about contract sites, hover cursor over a site name below. For a printable version of the interactive information, see appendix II.



Sources: Department of Energy; Map Resources (map). | GAO-18-129

^aSandia National Laboratories has other secondary locations, including at Livermore, California.

^bThe NNSA Production Office includes the Y-12 (Oak Ridge, Tennessee) and Pantex (Amarillo, Texas) sites.

^cThe Savannah River Site and Savannah River National Laboratory are jointly managed by NNSA and the Department of Energy's Office of Environmental Management.

Earned Value Management

EVM is a means of conducting cost and schedule performance analysis. By knowing the planned cost of an effort at any time and comparing that value to both the planned cost of completed work and the actual cost incurred for that work, analysts can measure the program's cost and schedule status. Without knowing the planned cost of completed work and work in progress (that is, earned value), true program status cannot be determined. Earned value provides the missing information necessary for understanding the health of a program; it provides an objective view of program status and can alert program managers to potential problems sooner than expenditures alone can (see text box). Moreover, because EVM provides data in consistent units (usually labor hours or dollars), the progress of vastly different work efforts can be combined. For example, earned value can be used to combine feet of cabling, square feet of sheet metal, or tons of rebar with efforts for systems design and development.

Measuring earned value

Assume, for example, that a contract calls for 4 miles of railroad track to be laid in 4 weeks at a cost of \$4 million. After 3 weeks of work, only \$2 million has been spent. An analysis of planned versus actual expenditures suggests that the project is underrunning its estimated costs. However, an earned value analysis reveals that the project is in trouble because even though only \$2 million has been spent, only 1 mile of track has been laid and, therefore, the contract is only 25 percent complete. Given the value of work done, the project will cost the contractor \$8 million (\$2 million to complete each mile of track), and the 4 miles of track will take a total of 12 weeks to complete (3 weeks for each mile of track), assuming that work continues at the current rate.

Source: GAO. | GAO-18-129

The use of EVM as a management tool is considered a best practice for improving program performance.²⁷ When a program operates within an EVM environment, the EVM system should meet the 32 guidelines of EIA-748, a national standard for EVM systems.²⁸ (See app. III for a list of

²⁷See [GAO-09-SP](#). We found in 1997 that EVM was a sound way to measure progress on major acquisition programs. See GAO, *Major Acquisitions: Significant Changes Underway in DOD's Earned Value Management Process*, [GAO/NSIAD-97-108](#) (Washington, D.C.: May 5, 1997).

²⁸National Defense Industrial Association, *EIA-748 Earned Value Management System (EVMS) Standard* (Sunnyvale, Calif.: March 2013).

these guidelines.) In general, this EVM national standard defines acceptable methods for organizations to define the contract or program scope of work using a work breakdown structure;²⁹ identify the organizations responsible for performing the work; integrate internal management subsystems; schedule and budget authorized work; measure the progress of work based on objective indicators; collect the cost of labor and materials associated with the work performed; analyze variances from planned cost and schedules; forecast costs at contract completion; and control changes.

Assessing Technology Readiness

Many of the government's most costly and complex acquisitions require the development of cutting-edge technologies and their integration into large and complex systems. Acquisitions may also use existing technologies in new applications or environments. At issue is not whether to take risks, but rather where and how to take them so they can be managed more effectively. Using effective management practices and processes to assess how far a technology has matured and how it has been demonstrated are keys to evaluating its readiness to be integrated into a system and managing for associated risks in the federal government's major acquisitions.

According to best practices that can be used across the federal government for evaluating technology maturity,³⁰ a TRA is a systematic, evidence-based process to evaluate the maturity of hardware and software technologies critical to the performance of a larger system or the fulfillment of the key objectives of an acquisition program. TRAs, which measure the technical maturity of a technology or system at a specific point in time, do not eliminate technology risk, but when done well, can illuminate concerns and serve as the basis for realistic discussions on how to mitigate potential risks as programs move from the early stages of technology development, where resource requirements are relatively modest, to system development and beyond, where resource requirements are often substantial. Agencies may decide to conduct a TRA for knowledge-building purposes. Such a TRA may not include any officials independent of the program. However, for TRAs used to inform

²⁹A work breakdown structure is a product-oriented breakdown of the work scope into discrete elements of work to provide a means for integration of cost, schedule, and scope of each element.

³⁰[GAO-16-410G](#).

major acquisition decision points, the program may require that members of the review team be independent of the program to avoid conscious or subconscious bias, or the appearance thereof.

TRAs frequently use a maturity scale of technology readiness levels (TRL) that are ordered according to the characteristics of the demonstration or testing environment under which a given technology was tested at defined points in time. The scale consists of nine levels, each one requiring the technology to be demonstrated in incrementally higher levels of fidelity than the previous level in terms of its form, the level of integration with other parts of the system, and its operating environment, until at the final level the technology is described in terms of actual system performance in an operational environment. See appendix IV for a description of each TRL.

NNSA Has Implemented Earned Value Management in Its Life Extension Programs but Has Not Adopted Two Key Best Practices

NNSA has implemented the use of EVM in the three ongoing LEPs it is managing under DP's program management directive, allowing it to identify significant problems with how two of these programs integrated contractor schedules. However, NNSA has not adopted two best practices related to the use of EVM that could help the agency better manage risk for its LEPs, which are having an independent entity both validate EVM systems against the EVM national standard and conduct surveillance reviews on EVM systems.

NNSA Has Implemented Earned Value Management in Its Life Extension Programs and Identified Problems with Integrating Contractor Schedules

In recent years, NNSA has established and strengthened requirements for using EVM in its LEPs. Specifically, DP's program management directive mandates that LEPs use EVM. Under this directive and a related March 2016 directive,³¹ DP requires its LEPs to implement several tools to manage programmatic scope, schedule, and budget. These management tools and associated requirements are described in table 2.

³¹National Nuclear Security Administration, *DP Program/Project Control System Description: NA-10 Program Management Tools and Processes* (Washington, D.C.: Mar. 14, 2016).

Table 2: National Nuclear Security Administration (NNSA) Earned Value Management (EVM) Tools and Requirements for Life Extension Programs (LEP)

Tool	Requirement	Additional information
EVM system	<ul style="list-style-type: none"> LEPs must implement an EVM system using a tailored approach to meeting EVM requirements and guidance contained in DOE’s project management order, related guidance, and the EVM national standard. The EVM system must include the use of a program work breakdown structure. LEPs must use EVM software (e.g., Deltek wmsight) that will support the export of monthly EV data in a standard format. 	<ul style="list-style-type: none"> According to DP’s directive, a tailored approach means the exercise of judgment in determining the degree to which the performance of a project planning activity is necessary to satisfy a requirement. It does not imply the omission of requirements. Related guidance includes Department of Energy, Earned Value Management System (EVMS), Guide 413.3-10A Chg 1. (Washington, D.C.: Oct. 22, 2015).
Schedule	<ul style="list-style-type: none"> LEPs must establish a program-wide integrated master schedule using a tailored approach to meeting scheduling requirements and guidance contained in DOE’s project management order and the EVM national standard. LEPs must use standard scheduling software (i.e., Primavera P6). 	<ul style="list-style-type: none"> According to cost-estimating best practices, an integrated master schedule includes the entire required scope of effort from government, contractor, and other key parties for a program’s execution from start to finish. According to NNSA officials, an LEP’s integrated master schedule is a compilation of summary elements from site-specific schedules from each site participating in the program.
Performance measurement baseline	<ul style="list-style-type: none"> LEPs must establish a performance measurement baseline. LEPs must conduct an integrated baseline review of the performance measurement baseline. 	<ul style="list-style-type: none"> According to cost-estimating best practices, a performance measurement baseline is the formal baseline plan for accomplishing all work in a certain time and at a specific cost. It takes into account that program activities occur in a sequenced order and are based on finite resources, with budgets representing those resources spread over time. According to cost-estimating best practices, an integrated baseline review evaluates the program’s performance measurement baseline to determine whether all program requirements have been addressed, risks identified, and mitigation plans put in place. It is also used to verify that the baseline’s budget and schedule are adequate for performing the work.
Reporting	<ul style="list-style-type: none"> LEPs must implement cost, schedule, and earned value reporting and analysis monthly. 	<ul style="list-style-type: none"> Contractors must provide monthly project status reports to the LEP manager. LEP managers must provide monthly program status reports to DP.

Source: GAO analysis of National Nuclear Security Administration and GAO documents. | GAO-18-129

The B61-12 LEP and W88 Alteration (Alt) 370 program have each implemented a program-wide EVM system, and according to NNSA officials the W80-4 LEP is in the process of implementing a program-wide EVM system. As described in table 3, the B61-12 LEP and W88 Alt 370

program each use a program-level EVM system that incorporates EVM data from multiple M&O contract sites and systems. For example, the EVM system for the B61-12 LEP incorporates data on earned value, cost, and schedule from six participating M&O contract sites. Two of these sites have both design and production responsibilities and therefore use two EVM systems (one for design and one for production). As a result, the B61-12 LEP EVM system incorporates data from a total of eight site-specific EVM systems maintained by M&O contractors. In addition, the W80-4 LEP is currently in phase 6.2A of the LEP process and is developing and finalizing its EVM system documentation, according to DP officials. The W80-4 LEP officials reported that they plan to issue this documentation to M&O contractors before the start of phase 6.3, currently scheduled for fiscal year 2019. (Table 3 also shows the proposed EVM structure for the W80-4 LEP.)

Table 3: National Nuclear Security Administration (NNSA) Life Extension Programs, Earned Value Management (EVM) Systems, and Participating Management and Operating (M&O) Contract Sites

NNSA program	Participating M&O contract site	Number of M&O contractor EVM systems (and type)
B61-12	Los Alamos National Laboratory	2 (design, production)
	Kansas City National Security Campus	1 (production)
	NNSA Production Office (Pantex) ^a	1 (production)
	NNSA Production Office (Y-12) ^a	1 (production)
	Sandia National Laboratories	2 (design, production)
	Savannah River Site and Savannah River National Laboratory	1 (production)
	Total sites: 6	Total systems: 8
W88 Alt 370	Los Alamos National Laboratory	2 (design, production)
	Kansas City National Security Campus	1 (production)
	NNSA Production Office (Pantex) ^a	1 (production)
	NNSA Production Office (Y-12) ^a	1 (production)
	Sandia National Laboratories	2 (design, production)
	Total sites: 5	Total systems: 7
W80-4 ^b	Lawrence Livermore National Laboratory	1 (design)
	Los Alamos National Laboratory	1 (production)
	Kansas City National Security Campus	1 (production)
	NNSA Production Office (Pantex) ^a	1 (production)
	NNSA Production Office (Y-12) ^a	1 (production)
	Sandia National Laboratories	2 (design, production)
	Savannah River Site and Savannah River National Laboratory	1 (production)
	Total sites: 7	Total systems: 8

Source: GAO analysis of NNSA documents. | GAO-18-129

^aThe NNSA Production Office site includes the Y-12 (Oak Ridge, Tennessee) and Pantex (Amarillo, Texas) sites.

^bAccording to NNSA officials, the W80-4 LEP is in the process of developing its EVM system; as a result, this table shows the proposed EVM structure for the W80-4 LEP.

According to DP officials, several factors contributed to difficulties in implementing EVM for the B61-12 LEP and W88 Alt 370 program. First, the timing of DP’s requirements for implementing EVM made it difficult to implement EVM systems for the B61-12 LEP and W88 Alt 370 program. For example, in a memorandum accompanying its March 2016 directive on EVM, DP stated that its directive applies only to LEPs that have not entered phase 6.3. When the directive was issued, the B61-12 LEP and W88 Alt 370 program were already in phase 6.3. Nonetheless, these two

LEPs developed and issued EVM system documentation (including requirements and procedures) to M&O contractors performing the design and production work. Second, the multisite, multicontractor structure of the EVM systems used for the B61-12 LEP and W88 Alt 370 program complicated the implementation of EVM for these programs, according to DP officials. In contrast, for a capital acquisition project at a single site, an NNSA project manager relies on EVM data from a single contractor EVM system. And third, a DP official stated that the M&O contractors were reluctant to share some cost and schedule data because of concerns that some data were proprietary, which further complicated the implementation of EVM systems for these programs.

NNSA and DOE conducted reviews of some project controls associated with the EVM systems used by the B61 LEP and W88 Alt 370 program in 2016 and 2017, including reviews by NNSA's B61-12 LEP and W88 Alt 370 program offices, CEPE, and DOE's Office of Inspector General. Among other things, these reviews identified problems with both programs' ability to use their integrated master schedules, which are part of their EVM systems, to calculate a valid critical path. The term "critical path" refers to the longest continuous sequence of activities in a schedule and defines a program's earliest completion date or minimum duration. Establishing a valid critical path is necessary for examining the effects of delay in any activity along this path. The program's critical path can be used as a tool to focus the team's energy and management's attention on the activities that will lead to the project's success. Under DP's directives, each LEP should be able to calculate a critical path using its integrated master schedule.³² However, the reviews identified the following problems in the programs:

- **B61-12 LEP.** The program office reported in 2016 that it found deficiencies in site-specific schedules for all participating M&O contract sites, which made calculations of a program critical path "suspect."³³ The DOE Office of Inspector General reported in 2016 that the program's master and site schedules contained multiple scheduling issues that limited the full potential of the program's EVM system to provide program managers with the ability to confidently

³²This requirement is applicable to LEPs that have not entered phase 6.3.

³³National Nuclear Security Administration, Office of Defense Programs, *B61-12 LEP Integrated Baseline Review Final Report* (Washington, D.C.: January 2016).

validate the program's critical path.³⁴ CEPE reported in 2016 that the program's ability to track a valid critical path was not achievable at the time of the office's review.³⁵

- **W88 Alt 370 program.** The program office reported in 2016 that the program could not calculate a valid program critical path because not all of the M&O contractor schedules were integrated.³⁶ Instead, the report stated, the program's integrated master schedule contained summary activities (i.e., a list of key milestones). CEPE reported in 2017 that the program could make significant improvements to its integrated master schedule, starting with the proper integration of site-specific schedules, to allow greater visibility into critical site-to-site hand-offs of activities in the integrated master schedule.³⁷

According to DP officials, the B61-12 LEP and W88 Alt 370 program have worked to address the concerns identified in prior reports regarding their ability to generate a critical path. Specifically, DP officials said that the B61-12 LEP has worked to align the schedules from the six participating M&O contract sites and is now able to generate critical paths at the site level and summarize these site schedules in the program's integrated master schedule. However, DP officials also said that the B61-12 LEP's integrated master schedule does not always provide sufficient information to understand schedule issues and requires more detailed analysis of site-specific schedules. In addition, DP officials said that the W88 Alt 370 program has developed tools to more accurately calculate a critical path that integrates the schedules from the five participating M&O contract sites.

³⁴Department of Energy, Office of Inspector General, *National Nuclear Security Administration's Management of the B61-12 Life Extension Program* (Washington, D.C.: Aug. 18, 2016).

³⁵National Nuclear Security Administration, Office of Cost Estimating and Program Evaluation, *Memorandum: Independent Cost Estimate (ICE) for the B61-12 Life Extension Program (LEP)* (Washington, D.C.: Oct. 20, 2016).

³⁶National Nuclear Security Administration, Office of Defense Programs, *Office of the W88 Alt 370: Integrated Baseline Review Final Report* (Washington, D.C.: Oct. 25, 2016).

³⁷National Nuclear Security Administration, Office of Cost Estimating and Program Evaluation, *Memorandum: Independent Cost Estimate (ICE) for the W88 Alteration 370 (Alt 370) Program* (Washington, D.C.: Apr. 17, 2017).

NNSA Has Not Adopted Two Best Practices for Using Earned Value Management

NNSA has not adopted two best practices for using EVM in its LEPs, which are having an independent entity both validate EVM systems against the EVM national standard and conduct surveillance reviews on EVM systems. According to cost-estimating best practices,³⁸ if EVM is to be used to manage a program, the contractor's EVM system should be validated to ensure that it meets the EVM national standard, provides reliable data for managing the program and reporting its status to the government, and is actively used to manage the program. The validation of the contractor's EVM system (sometimes referred to as a compliance evaluation review) is an independent review conducted by an entity with no stake in the EVM system, project, or contract being reviewed, and which has the knowledge, skills, and abilities to fairly evaluate the fitness of the EVM system's implementation. According to best practices, when no independent entity exists to perform EVM validation, the assessment may be performed by a qualified source that is independent from the program's development, implementation, and direct supervision—for example, an agency's inspector general.

In addition, cost-estimating best practices call for the surveillance of a contractor's EVM system by an independent entity to ensure that the key elements of the EVM process are maintained over time and on subsequent applications. For example, surveillance of a contractor's EVM system would determine whether the system summarizes timely and reliable cost, schedule, and technical performance information directly from its internal management system; meets the EVM national standard; and maintains integrity of the project's baseline. Without an independent surveillance function, a contractor's ability to use EVM as intended may be hampered because problems with the performance measurement baseline or EVM data may go undetected, allowing the data to be distorted and undercutting its usefulness for decision making.

DOE recognizes the importance of having an independent office validate a contractor's EVM system and conduct surveillance of this system over time as shown in its project management order. According to DOE's project management order, for capital asset projects with estimated costs of \$100 million or greater, DOE's Office of Project Management Oversight and Assessment must validate the contractor's EVM system to ensure that it is fully compliant with the EVM national standard prior to approval

³⁸[GAO-09-3SP](#).

of critical decision 3, when the project management executive approves that the project is ready for implementation.³⁹ In addition, the office conducts risk-based surveillance of the contractor's EVM system during the remaining duration of the project. In particular, these requirements regarding EVM validation and surveillance apply to NNSA capital asset projects with estimated costs of \$100 million or greater.

However, DP does not require an independent entity to validate contractor EVM systems used for an LEP to ensure their compliance with the EVM national standard. It also does not require an independent entity to conduct surveillance of these systems during the duration of an LEP. DP officials provided several reasons why DP has not implemented these best practices, as follows:

- DP officials said that because LEPs incorporate cost, schedule, and earned value data from multiple, independent EVM systems maintained by M&O contractors at different sites, it is impractical and overly time-consuming to validate every contractor EVM system against the EVM national standard.
- The M&O contract sites use different practices to track and account for indirect costs.⁴⁰ Because some of the guidelines in the EVM national standard apply to how an EVM system tracks indirect costs at a single site, one DP official said that some of these guidelines are not applicable to the EVM systems used by LEPs.⁴¹ Instead, LEPs are required to take a tailored approach to implementing the EVM national standard in their programs.
- DP officials said that DP does not have sufficient resources to independently validate each contractor's EVM system or to conduct surveillance reviews of these systems over time. DP officials did not provide details on whether and how they planned to obtain resources to address these issues.

³⁹According to DOE's project management order, critical decision 3 is Approve Start of Construction/Execution.

⁴⁰An indirect cost refers to a shared cost that cannot be attributed to only one program or activity. These costs are sometimes referred to as burden or overhead. Examples of indirect costs include fringe benefits and general and administrative costs.

⁴¹For example, guideline 4 states, "Identify the organization or function responsible for controlling overhead (indirect costs)." According to the *DP Program/Project Control System Description* document, an LEP relies on overhead rates established in the existing individual site-wide M&O contracts with NNSA.

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- A DP official said that DP had proposed to the M&O contract sites that contractor EVM systems be validated against the EVM national standard. However, the official said that DP withdrew the proposal when they encountered significant resistance from the contractors.

We agree with DP officials that validating multiple contractor EVM systems used for an LEP will require more resources than validating a single contractor's EVM system used for a capital asset project. We also acknowledge the challenge DP officials face in addressing the variable effect M&O contractors' differing indirect cost structures have on program costs at M&O contract sites. In particular, as we recently reported, the National Defense Authorization Act for Fiscal Year 2014 requires NNSA to develop and submit to Congress a plan for improving and integrating financial management of the nuclear security enterprise, which could help NNSA collect consistent data on indirect costs from M&O contract sites.⁴² However, it is inconsistent for NNSA to require the validation of its capital asset projects against the EVM national standard while not requiring the same result for its LEPs, which often may cost hundreds of millions of dollars more than capital asset projects. Without requiring an independent entity to validate that contractor EVM systems meet the EVM national standard and to conduct surveillance reviews of these EVM systems through program completion, NNSA may not have assurance that its LEPs are obtaining reliable EVM data for managing their programs and reporting their status.

⁴²See GAO, *National Nuclear Security Administration: A Plan Incorporating Leading Practices Is Needed to Guide Cost Reporting Improvement Effort*, [GAO-17-141](#) (Washington, D.C.: Jan. 19, 2017). We found that NNSA's plan to integrate its financial management of the nuclear security enterprise was submitted late and contained few details on its feasibility and expected results.

NNSA Has Implemented Independent Technology Readiness Assessments in One Life Extension Program but Has Not Adopted Benchmarks at Key Decision Points

NNSA has recently established requirements for independently assessing the readiness of critical technologies for LEPs and conducted an independent TRA for the W80-4 LEP in November 2014. NNSA has not implemented the use of independent TRAs for the B61-12 LEP or W88 Alt 370 program due to the maturity of these programs. In addition, NNSA has not adopted a key best practice for using the results of TRAs that could help the agency better manage risk for its LEPs. Specifically, NNSA has not prescribed benchmarks for technology readiness at key program decision points.

NNSA Has Established Requirements for Independently Assessing Technology Readiness and Begun Implementing These Requirements for One Program in an Early Stage of Development

In December 2016, NNSA issued a directive requiring its programs to conduct independent TRAs of LEP critical technologies prior to the authorization of phase 6.2.⁴³ According to the directive, among other things, an NNSA program must (1) designate a federal employee as either the TRA team lead or accountable for the TRA process and results; and (2) identify subject-matter experts for critical technologies under evaluation. The directive also requires the federal TRA team to produce a TRA report containing the results of the assessment, which must fully characterize technology readiness risks of the applicable critical technology elements. In addition, the directive requires CEPE to review and evaluate TRA reports issued by NNSA programs and to document its evaluation in a memorandum to the NNSA Administrator.

DP conducted an independent TRA for the W80-4 LEP in November 2014, according to DP officials, prior to NNSA's 2016 directive on TRAs. According to DP documentation, DP conducted the TRA for a variety of reasons, such as to test a tool for calculating TRLs (referred to as a TRL calculator) and to identify TRLs for the proposed technologies for the W80-4 LEP. For the TRA, the DP team conducted on-site interviews at

⁴³National Nuclear Security Administration, *Technology Readiness Assessments*, Policy Letter 29 (Washington, D.C.: Dec. 8, 2016).

the M&O contract sites involved in the design phase of the LEP (Lawrence Livermore National Laboratory and Sandia National Laboratories) and collected information on the readiness of critical technologies based on a series of technical, manufacturing, and programmatic questions. The DP team used its TRL calculator to translate the collected information into a TRL score for each critical technology. The DP team also asked the M&O contractors to conduct their own assessment of the readiness of critical technologies using existing business practices.⁴⁴ The DP team then compared the TRL scores based on its independent assessment with the TRL scores based on the contractors' assessments.

According to DP officials we interviewed, DP used the results of the W80-4 TRA to change how its programs will assess technology readiness going forward. For example, the DP team found differences in TRLs based on its independent assessment (using its TRA calculator) compared with the M&O contractors' assessments using the existing business practices that predate NNSA's 2016 directive. DP officials said that based on these differences in assessments, they engaged with the M&O contractors through informal working groups to understand how the contractors interpret TRL scores. DP officials said they concluded that the TRL calculator should be incorporated as the tool to measure technology readiness because it provided a more systematic and accurate assessment of the readiness of LEP components than existing business practices. They also said that they plan to introduce the use of the TRL calculator with the W80-4 LEP where the effect will be greater over the program's life cycle, because this program is in an early stage of the Phase 6.X process. In addition, DP used the results of the W80-4 TRA to develop a TRA implementation guide, which DP issued in January 2017, to provide its programs with an understanding of the TRA process, key roles and responsibilities, and the TRL calculator to consistently evaluate TRLs.⁴⁵

DP has not conducted independent TRAs for the B61-12 LEP and W88 Alt 370 program because these programs were already in phase 6.3

⁴⁴According to DP officials, the M&O contractors relied on the requirements and guidance described in the following M&O contractor agreement: NNSA DP, *Conduct Technology Readiness Level (TRL) Assessment*, C018 (Washington, D.C.: Aug. 26, 2013).

⁴⁵National Nuclear Security Administration, Office of Defense Programs, *Technology Readiness Assessment (TRA) Implementation Guide*, Revision 2 (Washington, D.C.: Jan. 30, 2017).

when NNSA issued its directive in December 2016 and therefore were not subject to the requirements, which apply only to programs that have not yet entered phase 6.2. Instead, DP officials said that these programs continue to rely on existing DP business practices to assess the readiness of critical technologies.⁴⁶ Under these existing practices, LEPs rely on M&O contractors to assess the technological readiness of the weapon components, which the contractors are also responsible for developing. According to DP officials, DP program offices review these contractor assessments at decision points, such as at the end of phase 6.2. CEPE does not review these assessments.

NNSA Has Not Adopted a Key Best Practice for Assessing Technology Readiness

According to best practices,⁴⁷ agencies should use TRA results to monitor the development of critical technologies and inform the larger programs that integrate them. As part of this process, decision makers such as governance bodies use TRA reports to certify that critical technologies have reached a prescribed readiness level or benchmark (e.g., a specific TRL) at decision points. Governance bodies are typically made up of one or more senior or executive-level officials, science and technology chiefs, or department heads that review the TRA report and other important information to decide whether critical technologies are sufficiently mature and the program or project that will integrate them is ready to move to the next acquisition phase. Governance bodies certify the TRA results most commonly before a decision is made to formally initiate a program, but they can also use the TRA results at other decision points as warranted depending on the cost, schedule, or technical risk.

Both DOE and NNSA recognize the importance of benchmarking technology readiness at decision points. For example, according to DOE's project management order, for major capital asset projects, an independent review team must conduct a TRA of the project's critical technology items or systems before critical decision 1 approval and again before critical decision 2 approval.⁴⁸ In addition, according to DOE's

⁴⁶The B61-12 LEP and W88 Alt 370 program use C018, an M&O contractor agreement.

⁴⁷[GAO-16-410G](#).

⁴⁸According to DOE's project management order, CD-1 is Approve Alternative Selection and Cost Range, when the project management executive approves a selected alternative as the optimum solution to meeting a mission need; and CD-2 is Approve Performance Baseline, when the project management executive approves the project's scope, cost, and schedule baselines.

order, the project management executive must ensure that each critical technology item or system has reached a TRL of 4, when a component is validated in a laboratory environment, before critical decision 1 and a TRL of 7, when a system prototype is demonstrated in a relevant environment, before critical decision 2. In addition, DP's TRA implementation guide recommends that its program offices complete a TRA as part of (or before) LEP decision points. The guide also recommends that an LEP's critical technologies reach certain TRL benchmarks at decision points—for example, it recommends that an LEP's critical technologies reach a TRL of 4 at the beginning of phase 6.2 and a TRL of 5, when a component is validated in a relevant environment, at the beginning of phase 6.3.

However, while NNSA has required TRAs to be conducted at specific program decision points, NNSA has not established requirements for LEPs to ensure that their critical technologies meet TRL benchmarks at these decision points. According to DP officials, NNSA's directive on conducting TRAs establishes a very basic framework for conducting TRAs and allows each NNSA program office to establish a TRA process best suited to its individual business process. DP officials said that establishing requirements for its program offices to ensure that LEP critical technologies meet specific TRL benchmarks would be too restrictive given the unique mission of the nuclear security enterprise and the unique nature of nuclear weapon refurbishments. Instead, DP's TRA implementation guide provides recommendations, not requirements, and states that programs should determine their expectations for TRLs at each phase weighing their particular technology complexity, as deemed applicable and appropriate. DP officials said that they want LEP program managers to be able to decide what makes the most sense for their programs in terms of assessing technology readiness.

We agree with DP officials that, in some cases, it may not be appropriate to require a critical technology to meet a specific TRL benchmark. In such cases, program executives could document their rationale for not meeting this requirement. However, without establishing a requirement for programs to ensure that critical technologies for LEPs meet specific TRL benchmarks at decision points, NNSA may not have assurance that its programs have taken appropriate risk mitigation steps to mature critical technologies to meet program cost and schedule commitments.

NNSA Has Implemented Independent Cost Estimates for Its Life Extension Programs but Has Not Established a Requirement to Document Key Decisions Based on These Estimates

NNSA has implemented requirements for an independent office to conduct cost estimates of LEPs, but NNSA has not established a requirement to document and justify key decisions based on a reconciliation of program and independent cost estimates. In January 2017, NNSA issued two directives implementing statutory requirements for CEPE to conduct independent cost estimates for NNSA programs, including LEPs.⁴⁹ These directives describe key reviews to be performed by CEPE, including: an independent cost review at the completion of phase 6.2; an independent cost estimate at the completion of phase 6.2A, and a report submitted to the NNSA Administrator prior to phase 6.3 authorization; the independent cost estimate updated at the completion of phase 6.3, and a report submitted to the NNSA Administrator prior to phase 6.4 authorization; and the independent cost estimate updated at the completion of phase 6.4, and the independent cost estimate report submitted to the NNSA Administrator prior to phase 6.5 authorization.

CEPE conducted an independent cost estimate for the B61-12 LEP in 2016 and the W88 Alt 370 program in 2017, and is currently conducting an independent cost review of the W80-4 LEP, according to CEPE officials. CEPE's main findings from its 2016 and 2017 reviews, as documented in memoranda,⁵⁰ are as follows:

- CEPE estimated that the B61-12 LEP would cost about \$10 billion, compared with the B61-12 LEP's estimate of \$7.6 billion—a difference of about \$2.4 billion (31 percent). In addition, CEPE estimated that the LEP's projected date of March 2020 for first production of the B61-12 would be delayed by 2 years.
- CEPE estimated that the W88 Alt 370 program would cost about \$3 billion compared with the W88 Alt 370 program's estimate of about \$2.6 billion—a difference of about \$400 million (17 percent). CEPE also estimated that the program's projected date of December 2019

⁴⁹See National Nuclear Security Administration, *Responsibilities for Independent Cost Estimates*, Policy Letter 28A (Washington, D.C.: Jan. 10, 2017); and *Phase 6.X Process*, Supplemental Directive 452.3-2 (Washington, D.C.: Jan. 19, 2017). These directives implement statutory requirements of the National Defense Authorization Act for Fiscal Year 2014.

⁵⁰See Office of Cost Estimating and Program Evaluation, *Memorandum: Independent Cost Estimate (ICE) for the B61-12 Life Extension Program (LEP)*; and *Memorandum: Independent Cost Estimate (ICE) for the W88 Alteration 370 (Alt 370) Program*.

for first production of the W88 Alt 370 would be delayed by 10 months.

According to DP and CEPE officials we interviewed, NNSA leadership considered both of CEPE's independent cost estimates but decided not to update either program's cost estimate based on CEPE's estimates. Specifically, CEPE and DP officials told us they held discussions to understand CEPE's estimating process and results, as follows:

- Regarding the B61-12 LEP, CEPE officials told us that they met with DP officials and NNSA's Principal Deputy Administrator in August 2016, after phase 6.4 authorization, to discuss CEPE's cost estimate. According to the B61-12 LEP federal program manager, CEPE's cost estimate was useful in providing an independent assessment of cost and schedule risk to NNSA leadership but did not change their position that the B61-12 LEP's cost estimate should remain the definitive estimate for the program.
- Regarding the W88 Alt 370 program, CEPE officials met with DP officials in December 2016, prior to phase 6.4 authorization, and with the NNSA Administrator in March 2017, after phase 6.4 authorization, to discuss CEPE's cost estimate. According to the W88 Alt 370 federal program manager, the program decided not to change its cost estimate because, among other things, DP had already subjected the program's estimate to many levels of reviews and scrutiny and had high confidence in the existing cost estimate.

Regarding the W80-4 LEP, CEPE officials we interviewed said they are currently conducting an independent cost review for the program and expect to issue a report after the start of fiscal year 2018. The W80-4 LEP will be the first NNSA LEP to issue a cost analysis requirements description, according to DP officials.⁵¹ The cost analysis requirements description is to contain the work breakdown structure, program schedule, and staffing requirements, among other things, and is intended to define the program to a sufficient level of detail such that no confusion exists between the parties who will be estimating the program's cost. This description is to be used to inform CEPE's independent cost estimates. According to CEPE officials, the program's current schedule calls for

⁵¹According to NNSA's Policy Letter 28A, issued in January 2017, a cost analysis requirements description must be produced for NNSA independent cost estimates and independent cost reviews consistent with guidance developed by CEPE. The W80-4 LEP independent cost review is the first such review to be scheduled after issuance of this requirement.

CEPE to conduct an independent cost estimate of the W80-4 LEP in the last quarter of fiscal year 2018. CEPE officials we interviewed said they met with the W80-4 LEP federal program office to increase their understanding of the independent cost estimate and review process. CEPE officials told us they plan to use their experience with the B61-12 and W88 Alt 370 programs to improve the independent cost review process for the W80-4 and future LEPs.

However, NNSA has not established a requirement for its management to document and justify key decisions based on a reconciliation of program cost estimates with CEPE's independent cost estimates. According to federal standards for internal control, management should design control activities to achieve objectives and respond to risks.⁵² One attribute associated with this principle is that management designs appropriate types of control activities, such as the documentation of transactions and internal control. Specifically, management clearly documents all transactions and other significant events and internal control in a manner that allows the documentation to be readily available for examination. NNSA has established a general process for reconciliation, which is described in its January 2017 directive, but this directive does not establish a formal requirement for management to document and justify key decisions based on the reconciliation. Because NNSA has not established a requirement for documenting and justifying key decisions based on reconciling program and independent cost estimates, NNSA management did not formally document its decision and rationale for using program cost estimates instead of CEPE's independent cost estimates, according to DP and CEPE officials.

Documenting key decisions regarding cost estimates is particularly important in the context of LEPs, where decisions could potentially increase a program's costs by billions of dollars. Our prior work has shown that, in general, because the independent cost estimate team is outside the acquisition chain, is not associated with the program, and has nothing at stake with regard to program outcome or funding decisions, its estimate is usually considered more accurate than the program's internal estimate.⁵³ However, we have also found that because independent cost estimates are typically higher than program office cost estimates, in some cases management may choose to ignore them because the estimates

⁵²[GAO-14-704G](#).

⁵³See [GAO-09-3SP](#).

are too high.⁵⁴ CEPE and DP officials told us that they agreed that NNSA needs to document management's decisions on the disposition of CEPE's independent cost estimates and management's rationale for its decisions. Without a requirement for its management to document and justify key decisions based on a reconciliation of program cost estimates with CEPE's independent cost estimates, NNSA may not have assurance that CEPE's estimates are being incorporated appropriately into the LEP decision-making process, potentially decreasing the reliability of program cost estimates.

Conclusions

LEPs are a central part of national efforts to ensure that the nuclear arsenal is safe, secure, and effective. Since our 2003 review of NNSA's management of its LEPs, NNSA has made significant strides in improving the rigor of its management requirements and practices for these technically challenging and costly programs. Specifically, NNSA has established and implemented several directives in recent years requiring the use of EVM, independent TRAs, and independent cost estimates of its LEPs. However, NNSA has not adopted several best practices that could help the agency better manage risk for its LEPs. In particular, inconsistent with best practices for using EVM, NNSA does not require an independent entity to validate contractor EVM systems used for LEPs to ensure that they meet the EVM national standard, nor does it require an independent entity to conduct surveillance of these systems to ensure that they maintain compliance with the standard through program completion. Without these requirements, NNSA may not have assurance that its LEPs are obtaining reliable EVM data for managing their programs and reporting their status. Moreover, inconsistent with best practices for using TRA results, NNSA does not require that critical technologies for LEPs meet TRL benchmarks at decision points. Without this requirement, NNSA may not have assurance that its LEPs have taken appropriate risk mitigation steps to mature critical technologies to meet program cost and schedule commitments. In addition, NNSA would more fully comply with internal control standards by establishing a requirement for its management to document and justify key decisions based on a reconciliation of LEP cost estimates with CEPE's independent cost estimates. Without a similar requirement, NNSA may not have assurance that CEPE's estimates are being incorporated appropriately into the LEP

⁵⁴In our prior work, we found that independent cost estimates are historically higher than program office cost estimates because the team conducting the independent cost estimate is more objective and less prone to accept optimistic assumptions.

decision-making process, potentially decreasing the reliability of program cost estimates.

Recommendations for Executive Action

We are making the following four recommendations to the Administrator of NNSA:

The Administrator of NNSA should require an independent entity to validate that contractor EVM systems used for LEPs meet the EVM national standard. (Recommendation 1)

The Administrator of NNSA should require an independent entity to conduct surveillance reviews of contractor EVM systems used for LEPs to ensure that they maintain compliance with the EVM national standard through program completion. (Recommendation 2)

The Administrator of NNSA should require its programs to ensure that LEP critical technologies meet specific TRL benchmarks at decision points, or otherwise document with program executive approval their rationale for not meeting these benchmarks. (Recommendation 3)

The Administrator of NNSA should establish a requirement for NNSA management to document and justify key decisions based on a reconciliation of LEP cost estimates with CEPE's independent cost estimates. (Recommendation 4)

Agency Comments and Our Evaluation

We provided a draft of this report to NNSA for its review and comment. In written comments, reproduced in appendix V, NNSA stated that it agreed with our recommendations. However, NNSA also stated that it has already addressed three of our four recommendations, as discussed below. We disagree and believe that further action is needed to address all of our recommendations. In addition, NNSA provided technical comments, which we incorporated as appropriate.

Regarding our first recommendation, NNSA stated that DOE's Office of Project Management Oversight and Assessment conducts independent assessments of each M&O contractor's EVM system against the national EVM standard. NNSA stated that these independent assessments, along with integrated baseline reviews and other controls over data integration, provide a level of validation for LEP data that exceeds typical program management requirements. In addition, according to NNSA's technical comments, DOE has independently validated the EVM system used by the contractor currently responsible for managing and operating the Los Alamos National Laboratory site (in the context of a capital asset project that the contractor is executing). As a result, NNSA stated that it considers this recommendation closed based on established processes.

In our report, we acknowledge the role that DOE's office plays in independently validating contractor EVM systems against the EVM national standard for capital asset projects with estimated costs of \$100 million or greater. We also agree that for M&O contractors such as the one currently responsible at Los Alamos National Laboratory, where DOE has independently validated the contractor's EVM system used for a capital asset project, NNSA may use that validation as assurance that the contractor's EVM system for an LEP meets the national standard. In addition, we acknowledge in our report that NNSA has conducted independent baseline reviews for the B61-12 LEP and W88 Alt 370 program.

However, we have two main concerns about NNSA's approach to ensuring that its LEPs obtain reliable EVM data for managing their programs and reporting their status. First, according to NNSA's technical comments, DOE has not independently validated EVM systems at six of the seven M&O sites currently involved with LEPs. In some cases, such as with the contractor responsible for managing and operating Lawrence Livermore National Laboratory site, an independent DOE review and validation of the EVM system has not been triggered because the contractor has not managed a capital asset project costing \$100 million or

more in the last decade. Yet the Lawrence Livermore National Laboratory is the lead design laboratory on the W80-4 LEP. Second, validating a site's EVM system against the EVM national standard is not the same as conducting an integrated baseline review of the site's EVM performance measurement baseline. Both activities are important and supplement each other, but one activity is not a replacement for the other. As a result, we continue to believe that NNSA should require an independent entity, such as DOE's Office of Project Management Oversight and Assessment, to validate that contractor EVM systems used for LEPs meet the EVM national standard.

Regarding our second recommendation, NNSA stated that DOE's Office of Project Management Oversight and Assessment conducts periodic surveillance assessments of each M&O contractor's EVM system to evaluate continued compliance with the EVM national standard. NNSA stated that these independent assessments, along with integrated baseline reviews and other controls over data integration, provide a surveillance capability for LEPs that exceeds typical program management requirements. As a result, NNSA stated that it considers this recommendation closed based on established processes.

In our report, we acknowledge the role that DOE's office plays in conducting independent surveillance reviews of contractor EVM systems for capital asset projects with estimated costs of \$100 million or greater. However, we disagree with NNSA's assertion that DOE's surveillance reviews and NNSA's integrated baseline reviews can provide a surveillance capability for LEPs for two reasons. First, according to cost-estimating best practices, surveillance entails reviewing EVM system reports and other documents *related to a specific project or program*. Surveillance reviews of one project do not allow one to infer that an unrelated program has maintained compliance with the EVM national standard. As a result, NNSA cannot use DOE surveillance results for a specific capital asset project at an M&O contract site to assert that the contractor's EVM system used for an LEP has maintained its compliance with the EVM national standard. Second, according to cost-estimating best practices, an integrated baseline review is a one-time event (unless a re-baselining occurs). It evaluates a program's performance measurement baseline to determine whether all program requirements have been addressed, risks identified, and mitigation plans put in place, as well as to verify that the baseline's budget and schedule are adequate for performing the work. In contrast, ongoing surveillance helps determine whether the EVM system is maintaining the integrity of the program's baseline and summarizing timely and reliable cost, schedule, and

technical performance information directly from its internal management system, among other things. Both integrated baseline reviews and surveillance reviews are important, but one activity is not a replacement for the other. As a result, we continue to believe that NNSA should require an independent entity to conduct surveillance reviews of contractor EVM systems for LEPs to ensure they maintain compliance with the EVM national standard through program completion.

Regarding our third recommendation, NNSA stated that it has already taken steps to include specific benchmarks at decision points. Specifically, it stated that DP is incorporating methods to conduct technology readiness assessments on an ongoing basis, and that these methods will be included in a Technology Development Plan, which will go into effect in January 2018. NNSA stated that this plan will have two sets of benchmarks—it will include a recommendation for a TRL of 5 at the beginning of phase 6.3 for an LEP, and it will require an independent TRA at the beginning of phase 6.1. We are encouraged by NNSA's proposed actions, which may provide the agency with more assurance that its LEPs have taken appropriate risk mitigation steps to mature critical technologies to meet program cost and schedule commitments. However, without a requirement for explicit management approval in cases where an LEP's critical technology does not meet a specific TRL, NNSA may not have a sufficiently developed process for assessing and accepting technical risk. As a result, we continue to believe that NNSA should require its programs to ensure that LEP critical technologies meet specific TRL benchmarks at decision points, or otherwise document with program executive approval their rationale for not meeting these benchmarks.

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

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

A handwritten signature in black ink, appearing to read "Allison Bawden". The signature is fluid and cursive, with the first name "Allison" written in a larger, more prominent script than the last name "Bawden".

Allison B. Bawden
Director, Natural Resources and Environment

Appendix I: NNSA Office of Defense Programs Directives for Life Extension Programs

National Nuclear Security Administration's (NNSA) Office of Defense Programs (DP) has established a number of directives that apply to the management of life extension programs (LEP). Selected directives are presented below.

NNSA, DP Program Execution Instruction: *NA-10 Program Management Tools and Processes* (Washington, D.C.: Jan. 14, 2016).

NNSA, *DP Program/Project Control System Description: NA-10 Program Management Tools and Processes* (Washington, D.C.: Mar. 14, 2016).

NNSA, *Defense Programs Integrated Baseline Review (IBR) Guide* (Washington, D.C.: Sep. 30, 2015).

NNSA DP, *Product Realization*, R001 (Washington, D.C.: Aug. 26, 2013).

NNSA DP, *6.X Process*, R006 (Washington, D.C.: Aug. 26, 2013).

NNSA DP, *Portfolio-Program-Project Management*, R008 (Washington, D.C.: Mar. 27, 2013).

NNSA DP, *Risk and Opportunity Management*, R009 (Washington, D.C.: Mar. 20, 2012).

NNSA DP, *Requirement Engineering*, R012 (Washington, D.C.: Mar. 20, 2012).

NNSA DP, T054, *Product Realization Teams*, T054 (Washington, D.C.: Aug. 26, 2013).

NNSA DP, *Risk and Opportunity Management Methodology Guidance*, T057 (Washington, D.C.: Mar. 20, 2012).

NNSA DP, *NNSA Program Plan*, T063 (Washington, D.C.: Aug. 26, 2013).

NNSA DP, *Reviews and Reports*, T068 (Washington, D.C.: Mar. 27, 2016).

NNSA DP, *Cost Estimating Guide*, T071 (Washington, D.C.: May 4, 2016).

NNSA DP, *Comprehensive List of Weapon-Specific Reviews and Exchanges*, T118 (Washington, D.C.: Aug. 26, 2013).

NNSA DP, *Weapon Project Team Guidance*, T121 (Washington, D.C.: Aug. 26, 2013).

NNSA DP, *IPG Implementation Plan*, T140 (Washington, D.C.: Aug. 26, 2013).

NNSA DP, *Gate Review Documentation*, T143 (Washington, D.C.: Nov. 17, 2016).

NNSA DP, *Conduct Manufacturing Readiness Level (MRL) Assessment*, C017 (Washington, D.C.: Aug. 26, 2013).

NNSA DP, *Conduct Technology Readiness Level (TRL) Assessment*, C018 (Washington, D.C.: Aug. 26, 2013).

NNSA DP, *Conduct Technical Design and Production Reviews*, C047 (Washington, D.C.: May 4, 2016).

Appendix II: Additional Information on DOE's Management and Operating Contracts Associated with Life Extension Programs

Table 4 provides additional information on the Department of Energy's management and operating contracts and contractors (as well as contract award and end years) that conduct activities associated with NNSA's life extension programs.

Table 4: Department of Energy Information on Management and Operating Contracts Associated with Life Extension Programs

Contract site	Mission type(s)	Mission	Contractor (composition of contractor)	Award year	Current end year (potential end year with all options /award terms) ^a
Lawrence Livermore National Laboratory ^b	Research and development	Conduct research in national defense, nuclear weapons stockpile stewardship, weapons of mass destruction, and nuclear nonproliferation.	Lawrence Livermore National Security, LLC (Bechtel National, University of California, Babcock & Wilcox, AECOM)	2007	2021 (2026)
Los Alamos National Laboratory ^b	Research and development Production	Conduct research in national defense, nuclear weapons stockpile stewardship, weapons of mass destruction, and nuclear nonproliferation. Produce certain fuel and detonators.	Los Alamos National Security, LLC (University of California, Bechtel National, Babcock & Wilcox Technical Services, AECOM)	2006	2018 (2018)
Kansas City National Security Campus	Production	Produce nonnuclear components for nuclear weapons.	Honeywell Federal Manufacturing & Technologies LLC (Honeywell International Inc.)	2015	2020 (2025)
NNSA Production Office (Pantex Plant and Y-12 National Security Complex)	Production	Produce nuclear and nonnuclear components for weapons and evaluate, repair, and dismantle nuclear weapons.	Consolidated Nuclear Security LLC (Bechtel National Inc., Leidos Innovations Corporation Inc., ATK Launch Systems Inc., SOC LLC)	2014	2019 (2024)
Sandia National Laboratories ^b	Research and development Production	Conduct research in national defense, weapons of mass destruction, transportation, energy, telecommunications and financial networks, and environmental stewardship. Engineer and produce nonnuclear components for weapons.	National Technology and Engineering Solutions of Sandia, LLC (Honeywell International Inc.)	2016	2022 (2027)

**Appendix II: Additional Information on DOE's
Management and Operating Contracts
Associated with Life Extension Programs**

Contract site	Mission type(s)	Mission	Contractor (composition of contractor)	Award year	Current end year (potential end year with all options /award terms)^a
Savannah River Site and Savannah River National Laboratory ^{b, c}	Research and development Production	Conduct research in environmental stewardship, national and homeland security, and clean energy. Conduct tritium processing, research, and development.	Savannah River Nuclear Solutions, LLC (Fluor Corporation, Newport News Nuclear, Honeywell International Inc.)	2008	2018 (2019)

Source: Department of Energy. | GAO-18-129

^aPotential end year is the contract end year assuming all possible extensions occur, through option periods—where the agency can extend the period of performance by exercising an option at its discretion—and award term incentives, where a contractor may earn additional period of performance if the contractor's performance meets criteria outlined in the contract. Current and potential end year is as of August 2017.

^bThis site is a federally funded research and development center, which is intended to meet special, long-term research or development needs that are integral to agency missions.

^cThe Savannah River Site and Savannah River National Laboratory is managed by NNSA and the Department of Energy's Office of Environmental Management.

Appendix III: Guidelines for Earned Value Management Systems

Table 5 lists the 32 guidelines of EIA-748, a national standard for earned value management systems.

Table 5: EIA-748 Guidelines for Earned Value Management Systems

Guideline	Category and statement
Organization	
1	Define the authorized work elements for the program. A work breakdown structure (WBS), tailored for effective internal management control, is commonly used in this process.
2	Identify the program organizational structure, including the major subcontractors responsible for accomplishing the authorized work, and define the organizational elements in which work will be planned and controlled.
3	Provide for the integration of the planning, scheduling, budgeting, work authorization, and cost accumulation processes with each other and, as appropriate, the program WBS and program organizational structure.
4	Identify the organization or function responsible for controlling overhead (indirect costs).
5	Provide for integration of the program WBS and the program organizational structure in a manner that permits cost and schedule performance measurement by elements of either structure or both, as needed.
Planning, scheduling, and budgeting	
6	Schedule the authorized work in a way that describes the sequence of work and identifies significant task interdependencies required to meet the program's requirements.
7	Identify physical products, milestones, technical performance goals, or other indicators that will be used to measure progress.
8	Establish and maintain a time-phased budget baseline, at the control account level, against which program performance can be measured. Initial budgets established for performance measurement will be based on either internal management goals or the external customer-negotiated target cost, including estimates for authorized but undefinitized work. ^a Budget for far-term efforts may be held in higher-level accounts until an appropriate time for allocation at the control account level. If an overtarget baseline is used for performance measurement reporting purposes, prior notification must be provided to the customer.
9	Establish budgets for authorized work with identification of significant cost elements (labor, material) as needed for internal management and control of subcontractors.
10	To the extent it is practical to identify the authorized work in discrete work packages, establish budgets for this work in terms of dollars, hours, or other measurable units. Where the entire control account is not subdivided into work packages, identify the far-term effort in larger planning packages for budget and scheduling purposes.
11	Provide that the sum of all work package budgets and planning package budgets within a control account equals the control account budget.
12	Identify and control level-of-effort activity by time-phased budgets established for this purpose. Only effort not measurable or for which measurement is impractical may be classified as level of effort.
13	Establish overhead budgets for each significant organizational component for expenses that will become indirect costs. Reflect in the program budgets, at the appropriate level, the amounts in overhead pools that are planned to be allocated to the program as indirect costs.
14	Identify management reserves and undistributed budget.
15	Provide that the program target cost goal is reconciled with the sum of all internal program budgets and management reserves.
Accounting considerations	
16	Record direct costs in a manner consistent with the budgets in a formal system controlled by the general books of account.

Appendix III: Guidelines for Earned Value Management Systems

Guideline	Category and statement
17	When a WBS is used, summarize direct costs from control accounts into the WBS without allocating a single control account to two or more WBS elements.
18	Summarize direct costs from the control accounts into the organizational elements without allocating a single control account to two or more organizational elements.
19	Record all indirect costs that will be allocated to the program consistent with the overhead budgets.
20	Identify unit costs, equivalent unit costs, or lot costs when needed.
21	For EVM system, the material accounting system will provide for (1) accurate cost accumulation and assignment of costs to control accounts in a manner consistent with the budgets using recognized, acceptable, costing techniques; (2) cost recorded for accomplishing work performed in the same period that earned value is measured and at the point in time most suitable for the category of material involved but no earlier than the time of actual receipt of material; (3) full accountability of all material purchased for the program, including the residual inventory.
Analysis and management reports	
22	At least monthly, generate the following information at the control account and other levels as necessary for management control, using actual cost data from, or reconcilable with, the accounting system: (1) comparison of the amount of planned budget and the amount of budget earned for work accomplished (this comparison provides the schedule variance); and (2) comparison of the amount of the budget earned and the actual (applied where appropriate) direct costs for the same work (this comparison provides the cost variance).
23	Identify, at least monthly, the significant differences between both planned and actual schedule performance and planned and actual cost performance and provide the reasons for the variances in the detail needed by program management.
24	Identify budgeted and applied (or actual) indirect costs at the level and frequency needed by management for effective control, along with the reasons for any significant variances.
25	Summarize the data elements and associated variances through the program organization or WBS to support management needs and any customer reporting specified in the contract.
26	Implement managerial actions taken as the result of earned value information.
27	Develop revised estimates of cost at completion based on performance to date, commitment values for material, and estimates of future conditions. Compare this information with the performance measurement baseline to identify variances at completion important to management and any applicable customer reporting requirements, including statements of funding requirements.
Revisions and data maintenance	
28	Incorporate authorized changes in a timely manner, recording their effects in budgets and schedules. In the directed effort before negotiating a change, base such revisions on the amount estimated and budgeted to the program organizations.
29	Reconcile current budgets to prior budgets in terms of changes to authorized work and internal replanning in the detail needed by management for effective control.
30	Control retroactive changes to records pertaining to work performed that would change previously reported amounts for actual costs, earned value, or budgets. Adjustments should be made only for correcting errors, making adjustments for routine accounting or the effects of customer or management directed changes, or improving the baseline integrity and accuracy of performance measurement data.
31	Prevent revisions to the program budget except for authorized changes.
32	Document changes to the performance measurement baseline.

Source: Excerpts from National Defense Industrial Association, Integrated Program Management Division, Earned Value Management Systems EIA-748 Intent Guide, 2014. | GAO-18-129

^aAn undefinitized contract is one in which the contracting parties have not fully agreed on the terms and conditions.

Appendix IV: Technology Readiness Levels

Table 6 identifies and describes technology readiness levels published by the Department of Energy in its guidance on conducting technology readiness assessments.¹

Table 6: Technology Readiness Levels and Descriptions

Technology readiness level	Description
Basic principles observed and reported	This is the lowest level of technology readiness. Scientific research begins to be translated into applied research and development (R&D). Examples might include paper studies of a technology's basic properties or experimental work that consists mainly of observations of the physical world. Supporting Information includes published research or other references that identify the principles that underlie the technology.
Technology concept and/or application formulated	Once basic principles are observed, practical applications can be invented. Applications are speculative, and there may be no proof or detailed analysis to support the assumptions. Examples are still limited to analytic studies. Supporting information includes publications or other references that outline the application being considered and that provide analysis to support the concept. The step up from technology readiness level (TRL) 1 to TRL 2 moves the ideas from pure to applied research. Most of the work is analytical or paper studies with the emphasis on understanding the science better. Experimental work is designed to corroborate the basic scientific observations made during TRL 1 work.
Analytical and experimental critical function and/or characteristic proof of concept	Active R&D is initiated. This includes analytical studies and laboratory-scale studies to physically validate the analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative tested with simulants. Supporting information includes results of laboratory tests performed to measure parameters of interest and comparison to analytical predictions for critical subsystems. At TRL 3 the work has moved beyond the paper phase to experimental work that verifies that the concept works as expected on simulants. Components of the technology are validated, but there is no attempt to integrate the components into a complete system. Modeling and simulation may be used to complement physical experiments.
Component and/or system validation in laboratory environment	The basic technological components are integrated to establish that the pieces will work together. This is relatively "low fidelity" compared with the eventual system. Examples include integration of ad hoc hardware in a laboratory and testing with a range of simulants and small scale tests on actual waste. Supporting information includes the results of the integrated experiments and estimates of how the experimental components and experimental test results differ from the expected system performance goals. TRL 4-6 represent the bridge from scientific research to engineering. TRL 4 is the first step in determining whether the individual components will work together as a system. The laboratory system will probably be a mix of on hand equipment and a few special purpose components that may require special handling, calibration, or alignment to get them to function.

¹Department of Energy, *Technology Readiness Assessment Guide*, G 413.3-4A Chg 1 (Washington, D.C.: Oct. 22, 2015).

Appendix IV: Technology Readiness Levels

Technology readiness level	Description
Laboratory scale, similar system validation in relevant environment	The basic technological components are integrated so that the system configuration is similar to (matches) the final application in almost all respects. Examples include testing a high-fidelity, laboratory scale system in a simulated environment with a range of simulants and actual waste. Supporting information includes results from the laboratory scale testing, analysis of the differences between the laboratory and eventual operating system/environment, and analysis of what the experimental results mean for the eventual operating system/environment. The major difference between TRL 4 and 5 is the increase in the fidelity of the system and environment to the actual application. The system tested is almost prototypical.
Engineering/pilot-scale, similar (prototypical) system validation in relevant environment	Engineering-scale models or prototypes are tested in a relevant environment. This represents a major step up in a technology's demonstrated readiness. Examples include testing an engineering scale prototypical system with a range of simulants. Supporting information includes results from the engineering scale testing and analysis of the differences between the engineering scale, prototypical system/environment, and analysis of what the experimental results mean for the eventual operating system/environment. TRL 6 begins true engineering development of the technology as an operational system. The major difference between TRL 5 and 6 is the step up from laboratory scale to engineering scale and the determination of scaling factors that will enable design of the operating system. The prototype should be capable of performing all the functions that will be required of the operational system. The operating environment for the testing should closely represent the actual operating environment.
Full-scale, similar (prototypical) system demonstrated in relevant environment	This represents a major step up from TRL 6, requiring demonstration of an actual system prototype in a relevant environment. Examples include testing full-scale prototype in the field with a range of simulants in cold commissioning. Supporting information includes results from the full-scale testing and analysis of the differences between the test environment, and analysis of what the experimental results mean for the eventual operating system/environment. Final design is virtually complete.
Actual system completed and qualified through test and demonstration	The technology has been proven to work in its final form and under expected conditions. In almost all cases, this TRL represents the end of true system development. Examples include developmental testing and evaluation of the system with actual waste in hot commissioning. Supporting information includes operational procedures that are virtually complete. An operational readiness review has been successfully completed prior to the start of hot testing.
Actual system operated over the full range of expected mission conditions	The technology is in its final form and operated under the full range of operating mission conditions. Examples include using the actual system with the full range of wastes in hot operations.

Source: Department of Energy. | GAO-18-129

Appendix V: Comments from the National Nuclear Security Administration



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



November 29, 2017

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: NNSA Should Adopt Additional Best Practices to Better Manage Risk for Life Extension Programs*" (GAO-18-129). NNSA agrees with GAO's recommendations, recognizing that several have already been addressed by actions taken and planned. Some of GAO's observations, however, are misleading or inaccurate as written and should be modified to provide a clearer and more balanced context regarding management of the Life Extension Programs (LEPs).

NNSA chose to implement an enhanced management strategy for LEPs that exceeds external and Departmental requirements for program management by incorporating key project management principles similar to Department of Energy (DOE) Order 413.3B and implementing Earned Value Management (EVM). This innovative strategy has demonstrated the integration benefits that may be obtained through the thoughtful application of project management and EVM principles to the LEPs, adjusted for inherent differences between capital assets and programs. We have demonstrated our commitment to best practices through the strategy above. Best practices should not, however, be used interchangeably with requirements to imply deficiency in the LEP programs.

GAO's contention that NNSA does not require independent validation of its EVM systems and cannot assess the reliability of EVM data is misleading. The DOE Office of Project Management (PM) conducts independent assessments of each site's EVM system against national standards. The certification pertains not just to capital asset projects, but also to the system itself, whether used for a capital asset project or program. The DOE PM assessments, along with Integrated Baseline Reviews and other controls over data integration, provide a level of validation for LEP data that exceeds program management requirements. Further, it is inaccurate to state that NNSA does not require LEPs to meet national EVM standards. NNSA does require compliance with national standards, but uses a more practical and cost beneficial layered approach to validation as previously described.



**Appendix V: Comments from the National
Nuclear Security Administration**

The enclosure to this letter provides NNSA's detailed response to the report recommendations. Technical comments have also been provided for your consideration under separate cover to address the issues noted above, and enhance the clarity and accuracy of the report.

Sincerely,


Frank G. Klotz

Enclosure

Enclosure

NATIONAL NUCLEAR SECURITY ADMINISTRATION (NNSA)

Response to Report Recommendations

“Nuclear Weapons: NNSA Should Adopt Additional Best Practices to Better Manage Risk for Life Extension Programs” (GAO-18-129)

The Government Accountability Office (GAO) recommends NNSA:

Recommendation 1: Require an independent entity to validate that contractor EVM systems used for LEPs meet the EVM national standard.

Management Response: *Concur.* The Department of Energy Office of Project Management (DOE PM) conducts independent assessments of each site’s EVM system against national standards. The certification pertains not just to capital asset projects, but also to the system itself, whether used for a capital asset project or program. The DOE PM assessments, along with Integrated Baseline Reviews and other controls over data integration, provides a level of validation for LEP data that exceeds typical program management requirements. This more practical and cost beneficial layered approach effectively adapts to the inherent differences between application of EVM to programs and capital projects. NNSA considers this recommendation closed based on established processes. We will, however, fully consider GAO’s observations and make any necessary adjustments to our validation strategy as the LEP EVM programs continue to mature.

Recommendation 2: Require an independent entity to conduct surveillance reviews of contractor EVM systems used for LEPs to ensure that they maintain compliance with the EVM national standard through program completion.

Management Response: *Concur.* DOE PM conducts periodic surveillance assessments of site’s EVM systems to evaluate continued compliance with national standards. The DOE PM assessments, along with Integrated Baseline Reviews and other controls, provides a surveillance capability for LEPs that exceeds typical program management requirements. NNSA considers this recommendation closed based on established processes. We will, however, fully consider GAO’s observations and make any necessary adjustments to our surveillance strategy as the LEP EVM programs continue to mature.

Recommendation 3: Require programs to ensure that LEP critical technologies meet specific TRL benchmarks at decision points, or otherwise document with program executive approval their rationale for not meeting these benchmarks.

Management Response: *Concur.* NNSA has already taken steps to include specific benchmarks at decision points. Defense Programs is incorporating methods to conduct Technology Readiness evaluations on an ongoing basis and this is included in the Technology Development Plan, R006 (version D). This plan will go into effect in Jan 2018, and has two sets of benchmarks:

Enclosure

- 1) Recommends a TRL 5 and MRI 3 at the beginning of Phase 6.3 for an LEP; and,
- 2) Requires a TRA at the beginning of Phase 6.1 conducted independently by Defense Programs's Office of Systems Engineering and Integration.

The estimated completion date for actions to address this recommendation is January 2018, consistent with issuance of the Technology Development Plan. Follow-on actions will be monitored through the established benchmark requirements.

Recommendation 4: Establish a requirement for NNSA management to document and justify key decisions based on a reconciliation of LEP cost estimates with CEPE's independent cost estimates.

Management Response: *Concur.* NNSA will establish a protocol to document management decisions regarding significant variances between LEP and CEPE independent cost estimates. The initial estimated completion date for this action is March 31, 2018.

Appendix VI: GAO Contact and Staff Acknowledgments

GAO Contact

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

Staff Acknowledgments

In addition to the contact named above, Ned Woodward (Assistant Director), Herbert Bowsher, and Jason Holliday made key contributions to this report. Also contributing to this report were Cheryl Andrew, Brian Bothwell, Antoinette Capaccio, Scott Fletcher, and Steven Putansu.

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