United States Government Accountability Office

Report to Congressional Committees

March 2020

# MODERNIZING THE NUCLEAR SECURITY ENTERPRISE

## Uranium Processing Facility Is on Schedule and Budget, and NNSA Identified Additional Uranium Program Costs

Accessible Version

GAO-20-293

March 2020

# GAO Highlights

Highlights of GAO-20-293, a report to congressional committees

# MODERNIZING THE NUCLEAR SECURITY ENTERPRISE

# Uranium Processing Facility Is On Schedule And Budget, And NNSA Identified Additional Uranium Program Costs

## Why GAO Did This Study

A supply of enriched uranium is crucial to support the nation's nuclear weapons stockpile and the U.S. Navy, but the infrastructure of several U.S. uranium-processing facilities is outdated. In 2014, NNSA began plans to meet the nation's uranium needs by redirecting processing capabilities to the UPF and to other existing buildings NNSA plans to upgrade at Y-12 in Oak Ridge, Tennessee.

The National Defense Authorization Act for Fiscal Year 2013, as amended, includes a provision for GAO to periodically review the UPF. Also, a Senate report accompanying the National Defense Authorization Act bill for fiscal year 2012 provides for GAO to review the independent cost estimates for the UPF.

This report, which is GAO's sixth on the UPF, examines (1) the status of the UPF project and plans for starting UPF operations; (2) the extent to which NNSA has followed requirements to obtain independent cost estimates for the UPF, and how NNSA has used information from those estimates; and (3) the extent to which NNSA has made progress in developing uranium program management information since GAO's September 2017 report. GAO reviewed project and program documents on planning, schedule, cost, and implementation, and interviewed program officials.

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## What GAO Found

National Nuclear Security Administration (NNSA) documents and officials reported that the new Uranium Processing Facility (UPF) is on schedule and within budget. As of December 2019, three of the seven UPF subprojects were complete, and four were ongoing. NNSA officials told GAO they estimate that construction of the UPF will be complete in 2022 and that they expect to meet NNSA's goal of completing the UPF project for $6.5 billion by the end of 2025. As required, NNSA and its contractor developed a plan for starting operations at the UPF, which officials stated will likely occur in 2026. According to NNSA's plan, attaining full UPF operational capability will be the final step to enable NNSA to stop certain operations in Building 9212—the oldest building with the highest nuclear safety risk at the Y-12 National Security Complex (Y-12)—and turn it over to the Department of Energy (DOE) for final disposition by 2035.

In managing the UPF project, NNSA obtained independent cost estimates for the four largest UPF subprojects whose total estimated costs exceeded $100 million. Such estimates are required by DOE policy and to satisfy limitations in appropriations laws. Moreover, based on its review of NNSA documents, GAO found NNSA used those estimates to help inform the UPF's approved cost and schedule baseline estimates. NNSA officials stated that they used information from the independent cost estimate and other sources to help negotiate remaining work with the contractor and finalize the overall UPF's baseline estimates before starting construction.

Since GAO last reported on NNSA's broader uranium program in September 2017, NNSA identified and made progress in implementing the uranium program's scope of work that includes capabilities and other activities that are not part of the UPF project but are needed for weapons program. Specifically, NNSA made progress in the following areas:

1. Developing process technologies that are expected to increase the efficiency and effectiveness of certain uranium processing capabilities;
2. Investing in infrastructure to extend the operational lives of older uranium facilities; and
3. Reducing the amount of uranium stored and used in these older uranium facilities.

NNSA has also made progress in implementing GAO's 2017 recommendation to develop key management information for the uranium program. Specifically, NNSA developed an integrated master schedule covering the scope of work for the program through fiscal year 2035 and a life-cycle cost estimate that includes program costs through fiscal year 2026. NNSA estimated that, in addition to completing the UPF project for $6.5 billion, the uranium program will spend over $850 million from fiscal years 2016 through 2026 to support modernizing other needed uranium processing capabilities and transitioning out of Building 9212.

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**Abbreviations**

| | |
|---|---|
| CD | Critical Decision |
| DOE | Department of Energy |
| DOE-PM | DOE Office of Project Management |
| HEUMF | Highly Enriched Uranium Materials Facility |
| NNSA | National Nuclear Security Administration |
| PMI | Project Management Institute, Inc. |
| TRL | Technology Readiness Level |
| UPF | Uranium Processing Facility |

U.S. GOVERNMENT ACCOUNTABILITY OFFICE
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Washington, DC 20548

March 11, 2020

Congressional Committees

A supply of uranium is crucial to support the nation's nuclear weapons stockpile and the U.S. Navy, but the infrastructure of several U.S. uranium-processing facilities is outdated. The National Nuclear Security Administration (NNSA), a separately organized agency within the U.S. Department of Energy (DOE), is responsible for meeting national needs for enriched uranium.[1] NNSA conducts the vast majority of its uranium processing at the Y-12 National Security Complex in Oak Ridge, Tennessee. Several of Y-12's uranium processing facilities are deteriorating to the point that they may pose risks to safety and NNSA's future ability to meet its missions. For example, Building 9212, which houses many key uranium processing operations (e.g., uranium purification and casting[2]), was built in 1945 and does not meet modern nuclear safety requirements to withstand a seismic event (i.e., earthquake and aftershock activity) or high-wind event. According to a 2015 Defense Nuclear Facilities Safety Board report and a 2016 DOE Office of Inspector General report, an earthquake and aftershocks could result in the release of radiological material, exposing Y-12 workers and the public.[3]

To address these and other infrastructure needs, NNSA began planning in 2004 to replace four uranium processing facilities at Y-12 and relocate key processing equipment and capabilities into a single new structure—the Uranium Processing Facility (UPF) project. However, NNSA identified scope, schedule, and cost issues with the UPF, and an October 2013 external review estimated that the cost could be as much as $11 billion.

[1]Enrichment is the process of separating uranium-235—the form that undergoes fission to release enormous amounts of energy in nuclear weapons or reactors—from much of the uranium-238 that naturally occurs with it. NNSA is not currently enriching uranium for defense purposes.

[2]Uranium purification is the process of converting uranium that contains relatively high amounts of impurities, such as carbon, into a more purified form. Uranium casting is the process that heats and casts uranium metal into various shapes.

[3]Department of Energy, Office of Inspector General, *Audit Report: Enriched Uranium Operations at the Y-12 National Security Complex*, DOE-OIG-16-13 (Washington, D.C.: July 14, 2016) and Defense Nuclear Facilities Safety Board, *Staff Issue Report: Structural Evaluations of the 9215 Complex and Building 9204-2E at the Y-12 National Security Complex* (Washington, D.C.: Nov. 14, 2014, issued Feb. 4, 2015).

As we have previously found, NNSA has experienced ongoing issues in contract and project management, including in its modernization of uranium processing capabilities. Because of these issues, we have long designated these activities as at high risk of waste, fraud, abuse, and mismanagement.[4]

To control for these cost and scheduling issues, NNSA reduced the scope of the UPF project in 2014. In doing so, it redirected some processing equipment and capabilities initially planned for the UPF to existing Y-12 buildings, which NNSA intended to upgrade. NNSA shifted the work and costs of needed repairs and upgrades for these existing Y-12 buildings into its broader uranium program rather than including them as part of the UPF project. NNSA's uranium program consists of the following elements: (1) new construction with the re-scoped UPF project; (2) technology development projects that are expected to increase the efficiency and effectiveness of uranium processing capabilities; (3) infrastructure investments to extend the lives of its older facilities—which NNSA calls extended life programs; and (4) reduction of the amount of uranium stored and used in its older facilities—which NNSA calls a reduction in material at risk.

According to NNSA's high-level strategic plan for the uranium program, NNSA's overarching objectives for the uranium program are to complete the re-scoped UPF project for $6.5 billion by the end of 2025 and phase out mission dependency on Building 9212—the oldest building with the highest nuclear safety risk. For capital asset projects with a total cost of

[4]GAO, *High-Risk Series: Substantial Efforts Needed to Achieve Greater Progress on High-Risk Areas*, GAO-19-157SP (Washington, D.C.: Mar. 6, 2019). We designated DOE's contract management, which includes both contract administration and project management, as a high-risk area in 1990 because DOE's record of inadequate management and oversight of contractors had left the department vulnerable to fraud, waste, abuse, and mismanagement. In February 2013, we narrowed the focus of the high-risk designation to the Office of Environmental Management and NNSA's major contracts and projects—those with an estimated cost of $750 million or more. In our 2019 report, we found that NNSA had made progress in a number of areas. Specifically, NNSA enhanced its capability to estimate schedules and costs, and to assess alternatives, for programs and projects, among other things. NNSA also made progress by implementing best practices in several areas, such as those for estimating costs and schedules in nuclear weapons refurbishment activities and capital asset acquisitions.

$100 million or more, which includes the UPF project,[5] a DOE order requires that NNSA have its cost and schedule baseline estimates verified and validated through independent cost estimates before approving the start of construction.[6] Additionally, the order and a DOE memorandum require NNSA to develop and implement a plan for the transition from project construction to facility operations and to attain full operational capability. In September 2017, we reported that NNSA had made progress in managing the UPF project but had not made a commensurate level of progress in managing the rest of its overall uranium program.[7]

A Senate report accompanying the National Defense Authorization Act bill for fiscal year 2012 provides for GAO to review the independent cost estimates for the UPF. Additionally, section 3123(f) of the National Defense Authorization Act for Fiscal Year 2013, as amended by section 3126 of the National Defense Authorization Act for Fiscal Year 2014 and section 3118 of the Carl Levin and Howard P. "Buck" McKeon National Defense Authorization Act for Fiscal Year 2015, includes a provision for us to periodically review the new UPF, including any other issues that we determine appropriate with respect to the requirements, cost, schedule, or technology readiness levels of the project.[8] This is our sixth report in

[5]DOE defines a capital asset project (line item project) as having defined start and end points with an acquisition cost that includes all costs incurred to construct the project for its intended purpose, bringing it to a form and location suitable for its intended use, excluding operating expenses that are part of routine operations and maintenance functions.

[6]Department of Energy, *Program and Project Management for the Acquisition of Capital Assets*, DOE Order 413.3B (Washington, D.C.: Nov. 29, 2010; updated Apr. 12, 2018). Independent cost estimates are to be prepared by an organization independent of the project sponsor to verify and validate the estimate using the same detailed technical and procurement information used to develop the project estimate.

[7]GAO, *Modernizing the Nuclear Security Enterprise: A Complete Scope of Work Is Needed to Develop Timely Cost and Schedule Information for the Uranium Program,* GAO-17-577 (Washington, D.C.: Sept. 8, 2017).

[8]National Defense Authorization Act for Fiscal Year 2013, Pub. L. No. 112-239, § 3123(f), 126 Stat. 1632, 2178-79 (2013), as amended by the National Defense Authorization Act for Fiscal Year 2014, Pub. L. No. 113-66, § 3126, 127 Stat. 672, 1063-64 (2013) and the Carl Levin and Howard P. "Buck" McKeon National Defense Authorization Act for Fiscal Year 2015, Pub. L. No. 113-291, § 3118, 128 Stat. 3292, 3889 (2014). The provision specifies that we review the UPF at such times as the Comptroller General, in consultation with congressional defense committees, determines appropriate, taking into consideration the project's critical decisions.

response to section 3123(f), as amended.[9] This report examines (1) the status of NNSA's UPF project and plans for starting UPF operations; (2) the extent to which NNSA has followed requirements to obtain independent cost estimates for the UPF project, and how NNSA has used information from those estimates; and (3) the extent to which NNSA has made progress in developing uranium program management information since we last reported on the UPF and NNSA's uranium program in 2017.

To examine the status of NNSA's UPF project and plans for starting UPF operations, we reviewed DOE's policies NNSA is to follow when managing capital asset projects such as the UPF project.[10] We also reviewed NNSA documentation of the project's critical decisions, such as those approving cost and schedule baseline estimates and start of construction.[11] We reviewed the most recent DOE project status reports and NNSA budget information at the time of our review for specific cost and schedule information for the UPF project. We also reviewed NNSA's plans to complete construction, start operations, and attain full operational capability for the UPF project. We interviewed NNSA officials from the Office of Defense Programs' uranium program, Office of Acquisition and Project Management, and UPF project office, as well as representatives from the Y-12 contractor, to discuss the UPF project's status and to discuss NNSA's plan for completing the project's construction, starting its operations, and attaining full operational capability for the UPF. We also visited Y-12 to observe the status of the UPF project's construction.

To examine the extent to which NNSA has followed requirements to obtain independent cost estimates for the UPF project and how NNSA has used that information, we reviewed DOE and NNSA's policies and procedures that NNSA is to follow when having independent cost

[9]GAO-17-577; *Nuclear Weapons: Some Actions Have Been Taken to Address Challenges with the Uranium Processing Facility Design,* GAO-15-126 (Washington, D.C.: Oct. 10, 2014); *Nuclear Weapons: Technology Development Efforts for the Uranium Processing Facility,* GAO-14-295 (Washington, D.C.: Apr. 18, 2014); *Nuclear Weapons: Information on Safety Concerns with the Uranium Processing Facility*, GAO-14-79R (Washington, D.C.: Oct. 25, 2013); *Nuclear Weapons: Factors Leading to Cost Increases with the Uranium Processing Facility,* GAO-13-686R (Washington, D.C.: July 12, 2013).

[10]Documents we reviewed included DOE's order that governs the management of capital asset projects—see DOE Order 413.3B.

[11]Under DOE Order 413.3B, DOE capital asset projects with an estimated or baselined total project cost of $50 million or more are to go through five management reviews and approvals called "critical decisions" as the project moves forward from planning and design to construction and operation.

estimates conducted and reconciled with its own cost and schedule estimates as well as our best practices for cost estimating and scheduling.[12] We reviewed the DOE Office of Project Management's (DOE-PM) independent cost estimate reports and the external independent review report for the UPF. We did not assess DOE-PM's compliance with our best practices for this review. We also reviewed NNSA's negotiation strategy to examine how NNSA used information from the independent cost estimates and other independent reviews.[13] We interviewed officials from DOE-PM to discuss their process for conducting independent cost estimates or other independent reviews of the UPF project and for reconciling those estimates with NNSA's project estimates. We also interviewed NNSA UPF project officials and contractor representatives about how they used any information from the independent cost estimates to develop the final overall UPF project cost and schedule baseline estimates.

To examine NNSA's progress in developing uranium program management information since 2017, we reviewed documentation on how NNSA is managing the programmatic activities and projects that will provide essential capabilities to its overall uranium mission. These documents included the program's high-level strategic plan, program's schedule and cost estimate, and various other program and planning documents.[14] During our interviews with NNSA officials from the uranium program and during our visit to Y-12, we discussed and observed the status of key efforts to extend the life of various buildings at Y-12 and to develop and complete uranium processing technology projects. In addition, we met with officials from the Defense Nuclear Facilities Safety Board and reviewed its reports regarding facility safety and other issues

[12]GAO, *GAO Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program Costs*, GAO-09-3SP (Washington, D.C.: Mar. 2009) and GAO, *Schedule Assessment Guide: Best Practices for Project Schedules*, GAO-16-89G (Washington, D.C.: Dec. 2015).

[13]NNSA prepared its negotiation strategy to guide its negotiation of some of the UPF project work with the contractor.

[14]For example, we reviewed the uranium program's implementation plans to extend the operational lives of Buildings 9215, 9204-2E, and 9995, as well as quarterly DOE project status reports.

at Y-12.[15] According to NNSA officials, the UPF was intended to replace enriched uranium processing capabilities and was not intended to replace depleted uranium facilities. We are not including NNSA's management of depleted uranium in this review of the UPF project and the uranium program.[16]

We conducted this performance audit from March 2019 to March 2020 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

# Background

NNSA is responsible for managing national nuclear security missions: ensuring a safe, secure, and reliable nuclear deterrent; supplying nuclear fuel to the Navy; and supporting the nation's nuclear nonproliferation efforts. NNSA largely relies on management and operating contractors to carry out these missions and to manage the day-to-day operations at eight sites collectively known as NNSA's nuclear security enterprise.[17] The Y-12 National Security Complex in Tennessee is the primary site

[15]The Defense Nuclear Facilities Safety Board was established in 1988 to provide independent analysis, advice, and recommendations to the Secretary of Energy to inform him or her in providing adequate protection of public health and safety at defense nuclear facilities.

[16]A Senate report accompanying the National Defense Authorization Act bill for fiscal year 2017 provides for GAO to review NNSA's management of depleted uranium. We are conducting ongoing work in this area.

[17]Management and operating contracts are agreements under which the government contracts for the operation, maintenance, or support, on its behalf, of a government-owned or -controlled research, development, special production, or testing establishment wholly or principally devoted to one or more of the major programs of the contracting agency. 48 C.F.R. § 17.601. The sites that comprise the nuclear security enterprise are the Kansas City National Security Campus in Missouri, Lawrence Livermore National Laboratory in California, Los Alamos National Laboratory in New Mexico, Nevada National Security Site, Pantex Plant in Texas, Sandia National Laboratories primarily in New Mexico, Savannah River Site in South Carolina, and Y-12 National Security Complex in Tennessee.

among these with enriched uranium capabilities.[18] Y-12's primary mission is processing and storing uranium, processing uranium for naval reactors for the Navy, and developing associated technologies, including technologies to produce uranium-related components for nuclear warheads and bombs.

According to NNSA documents, Y-12's enriched uranium operations have key shortcomings, including an inefficient workflow, continually rising operations and maintenance costs stemming from facility age, and hazardous processes that could expose workers to radiological contamination. To address these shortcomings, NNSA developed plans to replace aging infrastructure at Y-12 and relocate key processing equipment without jeopardizing uranium production operations.

## History of UPF Project

In 2004, NNSA initially proposed relocating Y-12's main uranium processing equipment into a new facility referred to as the UPF. NNSA planned to construct this single, consolidated facility that would reduce the overall size of existing uranium processing facilities, reduce operating costs by using modern equipment, and increase worker and environmental health and safety.

NNSA estimated in 2007 that the UPF would cost approximately $1.4 billion to $3.5 billion to design and construct. In June 2012, the Deputy Secretary of Energy approved an updated cost estimate range for the UPF of $4.2 billion to $6.5 billion, with the latter being the project's maximum allowable cost. However, by August 2012, the UPF contractor concluded that the UPF as designed would not provide enough space to house all of the uranium processing and other equipment. In October 2013, an external review estimated that the UPF project could cost as much as $11 billion.

In 2014, because of the high cost and scheduling concerns of a solution focused solely on constructing new buildings, NNSA established its uranium program within its Office of Defense Programs. NNSA also prepared a high-level strategic plan based on its objectives of 1)

[18]In January 2013, NNSA awarded a single management and operating contract to Consolidated Nuclear Security, LLC for two of NNSA's major production sites that contribute to the maintenance of nuclear weapons and production of their components—Y-12 and the Pantex Plant in Texas. Consolidated Nuclear Security began working at Y-12 under this contract in July 2014.

completing the UPF project with a reduced scope within the cost and schedule limits established for the original UPF project and 2) phasing out mission dependency on Building 9212.

Under NNSA's revised approach, the agency plans to transition production operations out of Building 9212 and into the re-scoped UPF or existing buildings at Y-12 after they have been upgraded as described in further detail below.[19]

- **Building 9212.** Constructed in 1945, the building's design predates modern nuclear safety codes. It consists of a number of interconnected buildings that contain capabilities for uranium purification and casting, among other things. One of NNSA's key goals is to shut down the Building 9212 operations that have the highest nuclear safety risks. Because of these risks, NNSA is implementing a four-phase exit strategy to systematically phase out mission dependency on Building 9212. According to NNSA's September 2018 implementation plan for the exit strategy, the first three phases focus on reducing inventory, system isolation and clean out, and relocating capabilities from Building 9212 to other existing Y-12 facilities or to the UPF once startup is complete. Building 9212 will then enter a phase of post-operational clean out, during which operations will be limited to simple processing, recovery, and inventory accountability. By about 2035, management of the building will transition to DOE's Office of Environmental Management for decontamination and decommissioning activities.
- **Building 9215.** Constructed in the 1950s, the building's design predates modern nuclear safety codes. It consists of three main structures, and its current primary function is fabrication, which involves metal machining operations for enriched uranium. As part of the Building 9212 exit strategy, NNSA plans to move capabilities into Building 9215, such as the uranium purification and the processing of uranium metal scraps resulting from machining operations. The uranium program is managing the development and deployment of new technologies to increase the efficiency and effectiveness of these capabilities. NNSA initially intended to house these two capabilities in the UPF before re-scoping the project to meet its cost and schedule goals. According to NNSA documents, NNSA is identifying and

[19]When NNSA refers to a "building," it can include a facility, group of buildings, complex, or structure located at Y-12.

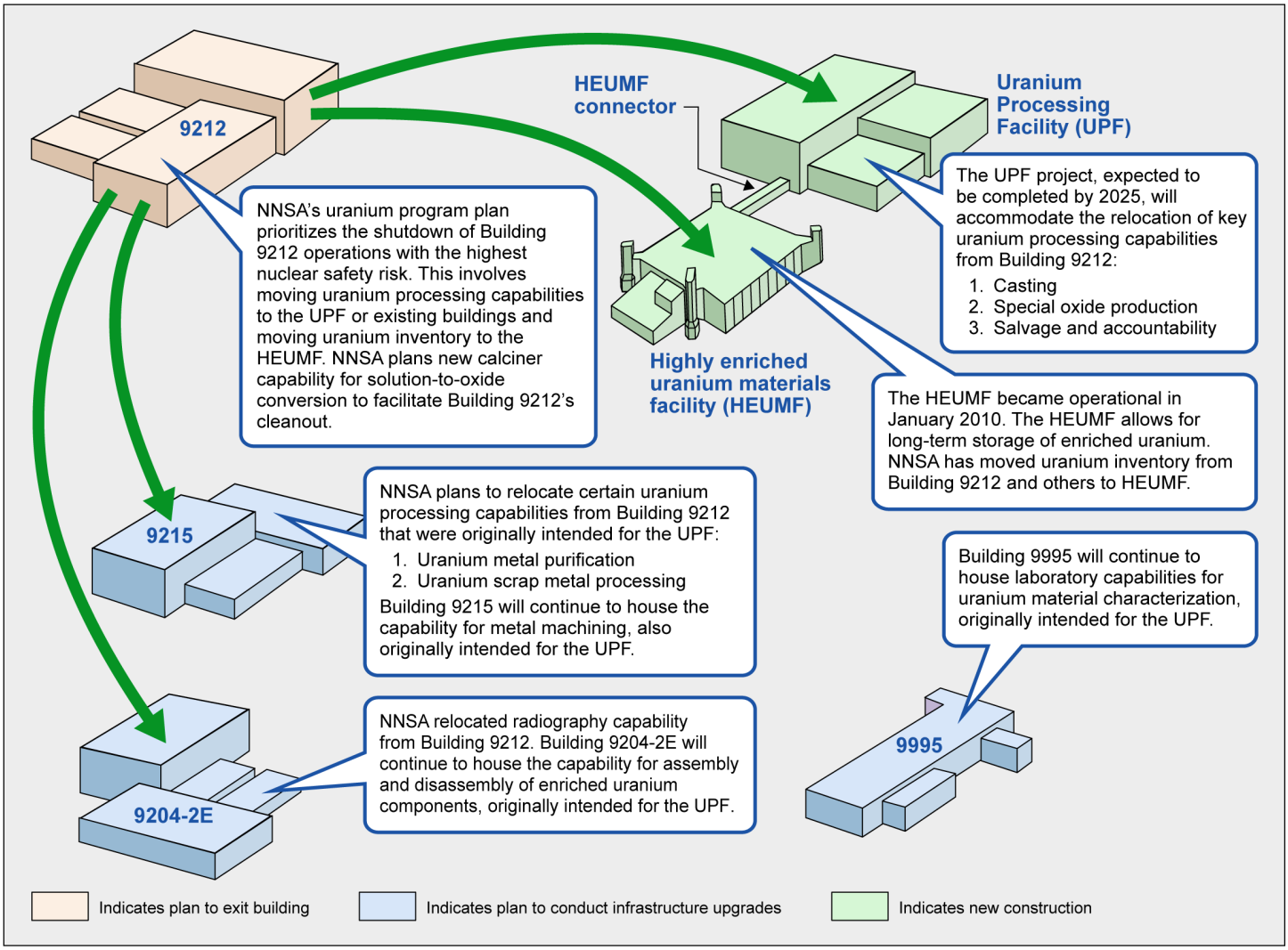
prioritizing infrastructure investments for Building 9215 that are to ensure its reliability through the 2040s.

- **Building 9995.** Constructed in the mid-1950s, this building's design predates modern nuclear safety codes. It consists of a laboratory with capabilities for analytical chemistry operations, which can sample enriched uranium for material assay, chemistry content, and metallography in support of production. NNSA initially intended to house the analytical chemistry capabilities to support enriched uranium processing and material characterization in the UPF before re-scoping the project to meet its cost and schedule goals. According to NNSA documents, NNSA is identifying and prioritizing infrastructure investments for Building 9995 that are to ensure its reliability through the 2040s and its continued analytical chemistry support for the UPF and Y-12 more broadly.
- **Building 9204-2E.** Constructed in the late 1960s, this building's design predates modern nuclear safety codes. It consists of a three-story, reinforced concrete frame structure that includes capabilities for assembly and disassembly of enriched uranium components with other materials. According to NNSA officials, the agency installed its radiography capability in Building 9204-2E in April 2017.[20] According to NNSA documents, NNSA is identifying and prioritizing infrastructure investments for Building 9204-2E that are to ensure its reliability through the 2040s.
- **Highly Enriched Uranium Materials Facility (HEUMF) (also called Building 9720-82).** Beginning operations in January 2010, this building was built to modern nuclear safety codes. It is a reinforced concrete and steel structure that provides long-term storage of enriched uranium materials and accepts the transfer of some legacy enriched uranium from older facilities. HEUMF is the central repository for highly enriched uranium.

Figure 1 shows NNSA's planned relocation of uranium processing capabilities out of Building 9212 and into the re-scoped UPF and existing Y-12 facilities. The figure also indicates which existing facilities will require infrastructure investments to support enriched uranium operations.

[20]Mid-range radiography is used to evaluate the integrity of cast and machined uranium parts. NNSA officials stated that they stopped routine radiography operations in Building 9212 in March 2019.

**Figure 1: National Nuclear Security Administration's (NNSA) Plan for Relocating Uranium Processing Capabilities from Building 9212 to Other Facilities at the Y-12 National Security Complex**




Source: GAO analysis of National Nuclear Security Administration (NNSA) information. | GAO-20-293

Note: This figure shows, as indicated by the arrows, NNSA's plan for relocating certain capabilities out of Building 9212 and into the re-scoped UPF and existing Y-12 facilities. It also shows which existing facilities require infrastructure investments. The size, shape, configuration, and actual locations of the UPF and other facilities are not shown to scale. The UPF includes the three main buildings: the Main Process Building, Salvage and Accountability Building, and Mechanical Electrical Building.

Under the new approach, the re-scoped UPF will be smaller than the UPF project's original design and will house capabilities for casting, oxide production, and salvage and accountability of enriched uranium. NNSA

has stated that the re-scoped UPF is to be built for no more than $6.5 billion by the end of 2025 through seven subprojects, described below.[21]

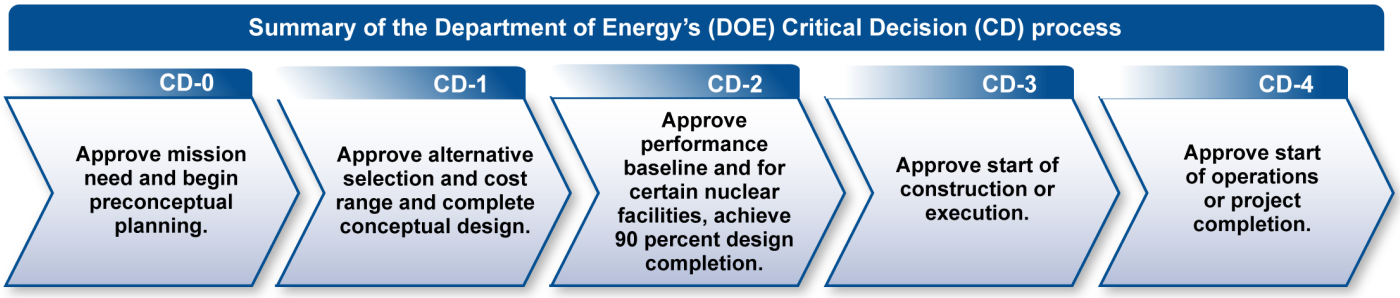
- **Site Readiness.** This subproject included work to relocate an existing road, construct a new bridge, and extend an existing haul road.
- **Site Infrastructure and Services.** This subproject included demolition, excavation, and construction of a parking lot, security portal, concrete batch plant, and support building.
- **Substation.** This subproject included construction of an electrical power substation to provide power to the UPF and Y-12, replacing an existing substation at Y-12.
- **Process Support Facilities.** This subproject includes work to provide chilled water and storage of chemical and gas supplies for the UPF.
- **Salvage and Accountability Building.** This subproject includes construction of a nuclear facility for the decontamination of wastes and recovery of chemicals associated with uranium processing.
- **Main Process Building.** This subproject includes construction of the main nuclear facility to contain casting and special oxide production capabilities and a secure connecting portal to the HEUMF.
- **Mechanical Electrical Building.** This subproject includes construction of a building to house mechanical, electrical, heating, ventilation, air conditioning, and utility equipment for the Salvage and Accountability Building and Main Process Building.

[21]In June 2012, the Deputy Secretary of Energy approved an updated cost estimate range for the UPF of $4.2 billion to $6.5 billion, with the latter being the project's maximum allowable cost. Although the UPF project has since been re-scoped, NNSA maintains $6.5 billion as the estimated total project cost. NNSA's Office of Defense Programs funds the UPF project through the uranium program, and the Office of Acquisition and Project Management manages the UPF project under a separate contract line item to the overall management and operating contract for Y-12. This allows NNSA to incorporate terms and conditions for construction projects not otherwise contained in the overall management and operating contract into that contract. Managing certain construction projects under separate contract line items allows the government to determine strategy and contract type on a case-by-case basis.

## Requirements and Best Practices for Project Management and Technology Readiness Assessments

NNSA is required to manage construction of capital asset projects with a total project cost of greater than $50 million, such as the UPF, in accordance with DOE Order 413.3B. NNSA's Office of Acquisition and Project Management manages the UPF project under DOE Order 413.3B with funding from NNSA's Office of Defense Programs through the uranium program.[22] DOE Order 413.3B requires that the project go through five management reviews and approvals, called "critical decisions" (CD), as the project moves from planning and design to construction and operation. (See fig. 2.) DOE Order 413.3B also requires that, before project completion (CD-4), NNSA issue a transition-to-operations plan, which is to ensure efficient and effective management as a project becomes operational and provide a basis for attaining initial and full operational capability.

**Figure 2: Summary of Department of Energy's (DOE) Critical Decision (CD) Phases and Milestones**




Source: GAO analysis of DOE Order 413.3B. | GAO-20-293

Note: The alternative selection process involves defining, analyzing, and refining project concepts and alternatives. At the end of CD-1, the project team selects and DOE approves the selected approach for the project. The cost range developed at CD-1 is the preliminary cost estimate for the selected approach and is refined through the other steps in the CD process.

For projects likely to have an extended period of transition to the start of operations, an August 2016 memorandum from DOE requires that NNSA

[22]NNSA has seven major program offices: Defense Programs; Defense Nuclear Nonproliferation; Naval Reactors; Emergency Operations; Safety, Infrastructure and Operations; Defense Nuclear Security; and Counterterrorism and Counterproliferation. NNSA has five major functional offices: Acquisition and Project Management; External Affairs: General Counsel; Information Management and Chief Information Officer; and Management and Budget.

develop a more detailed plan to attain full operational capability.[23] The plan must be developed earlier in the project management process—before start of construction (CD-3). In addition, NNSA must provide quarterly updates to DOE's Project Management Risk Committee after completing construction until full operational capability is attained. The memorandum notes that DOE's complex nuclear facilities can have significant risks that continue after project completion. These ongoing risks may impact achievement of full operational capability and thus require more efficient management. In September 2019, we reported that DOE officials stated that the August 2016 memorandum was largely created in response to experience with the Integrated Waste Treatment Unit facility at Idaho National Laboratory.[24] This facility, which is intended to treat two forms of nuclear waste, is not operating as expected approximately 7 years after the completion of its construction.

DOE Order 413.3B also states that projects with a total estimated cost of more than $100 million should have an independent cost estimate and external independent review prior to approval of the project's performance baselines for cost and schedule (CD-2). Further, appropriations acts since fiscal year 2012 have included a limitation that prohibits the use of funds to approve CD-2 (approval of the project's performance baselines for cost and schedule) or CD-3 (approval to start construction) for capital asset projects where total project costs exceed $100 million until a separate independent cost estimate has been developed. According to DOE's standard operating procedure for conducting independent cost estimates, an independent cost estimate is prepared by an organization independent of the project sponsor—DOE-PM, in this case—using the same detailed technical and procurement information that was used to make the initial project estimate.[25] The purpose of the estimate is to validate the project's performance baselines—which include cost and schedule estimates—to determine these estimates' accuracy and reasonableness. DOE-PM may use the independent cost estimate as supporting information in

[23]Department of Energy, Deputy Secretary of Energy, *Memorandum: "Operational Release" Milestone for DOE Projects* (Washington, D.C.: Aug. 11, 2016).

[24]GAO, *Nuclear Waste Cleanup: DOE Faces Project Management and Disposal Challenges with High-Level Waste at Idaho National Laboratory*, GAO-19-494 (Washington, D.C.: Sept. 9, 2019). We reported that construction of DOE's Integrated Waste Treatment Unit was completed in 2012, but design problems have led to DOE reengineering the project and not yet starting operations as of June 2019.

[25]DOE-PM is an office within DOE that reports directly to the DOE Under Secretary for Energy. Department of Energy, *Independent Cost Review (ICR) and Independent Cost Estimate (ICE) Standard Operating Procedure (SOP)* (Washington, D.C.: Aug. 27, 2018).

developing the external independent review. The external independent review is a broader analysis of the project to provide an unbiased assessment of whether NNSA can execute the project within the proposed scope, schedule, and cost commitments while meeting key performance requirements and fulfilling the mission need.

Many of the federal government's more costly and complex capital asset projects, including the UPF, require the development of cutting-edge technologies and integration of those technologies into large and complex systems. For example, DOE and NNSA use a systematic approach for assessing how far a technology has matured to evaluate the technology's readiness to be integrated into a system—Technology Readiness Levels (TRL).[26] This approach is intended to ensure that new technologies are sufficiently mature in time to be used successfully when a project is completed. TRLs progress from the least mature level, in which the basic technology principles are observed (TRL-1), to the highest maturity level, in which the total system is used successfully in project operations (TRL-9). DOE Order 413.3B requires that each critical technology item or system on which a project depends must be demonstrated as a prototype in an operational environment (TRL-7) before the project's performance baselines are approved (CD-2).[27] According to our guide on evaluating technology readiness, assessing technology readiness does not eliminate the risk of relying on new technology but can identify concerns and serve

[26]TRLs were pioneered by the National Aeronautics and Space Administration and have been used by the Department of Defense and other agencies in their research and development efforts. DOE adopted the use of TRLs in response to our recommendation that DOE develop a consistent approach to assessing the extent to which new technologies have been demonstrated to work as intended in a project before starting construction. See DOE Order 413.3B; Department of Energy, *Technology Readiness Assessment Guide,* DOE Guide 413.3-04A (Oct. 22, 2015); and GAO, *Department of Energy: Major Construction Projects Need a Consistent Approach for Assessing Technology Readiness to Help Avoid Cost Increases and Delays*, GAO-07-336 (Washington, D.C.: Mar. 27, 2007).

[27]Prior to DOE's update of DOE Order 413.3B in May 2016, the order required that technology readiness assessments occur prior to approval of performance baselines (CD-2) for major systems projects. Non-mandatory DOE guidance also encourages such assessments during alternative selection and conceptual design, as part of the CD-1 approval process.

as the basis for realistic discussions on how to mitigate potential risks associated with the project's scope, for example.[28]

## Requirements and Best Practices for Program Management

According to the Project Management Institute, Inc. (PMI), effective program management, in addition to effective project management, is important to the success of efforts such as NNSA's uranium program.[29] According to PMI's standard for program management, effective program management helps ensure that a group of related projects and program activities are managed in a coordinated way to obtain benefits not available from managing them individually.[30] Program management involves aligning multiple components to achieve the program's goals.

Other general standards relevant to program management for the uranium program include our cost-estimating guide and schedule assessment guide. In March 2009, we issued our cost-estimating guide to provide a consistent methodology that is based on cost-estimating best practices and that can be used across the federal government for developing, managing, and evaluating program cost estimates.[31] The methodology outlined in the guide is a compilation of best practices that federal cost-estimating organizations and industry use to develop and maintain reliable cost estimates throughout the life of a government acquisition program. According to the guide, developing accurate life-cycle cost estimates has become a high priority for agencies in properly managing their portfolios of capital assets and in decision-making throughout the process. A life-cycle cost estimate provides an exhaustive and structured accounting of all resources and associated cost elements required to develop, produce, deploy, and sustain a particular program. The guide also states that a reliable cost estimate reflects all costs

[28]GAO, *Technology Readiness Assessment Guide: Best Practices for Evaluating the Readiness of Technology for Use in Acquisition Programs and Projects*, GAO-20-48G (Washington, D.C.: Jan. 2020).

[29]PMI is a not-for-profit association that provides global standards for, among other things, project and program management. These standards are utilized worldwide and provide guidance on how to manage various aspects of projects, programs, and portfolios.

[30]See Project Management Institute, Inc., *The Standard for Program Management*®, Fourth Edition (Newtown Square, PA: 2017).

[31]GAO-09-3SP.

associated with a program—meaning that the estimate must be based on a complete scope of work—and the estimate should be updated to reflect changes in requirements (which may affect the scope of work).

In December 2015, we issued our schedule guide, which develops the scheduling concepts introduced in our cost-estimating guide and presents them as best practices associated with developing and maintaining a reliable, high-quality schedule.[32] According to the schedule guide, a well-planned schedule is a fundamental management tool that can help government programs use funds effectively by specifying when work will be performed and by measuring program performance against an approved plan. An integrated master schedule integrates all of the planned work in the program, the resources necessary to accomplish that work, and the associated budget, and it should be the focal point for program management. This schedule can show, for example, the completion dates for all activities leading up to major events or milestones, which can help determine if the program's parameters are realistic and achievable. An integrated master schedule may consist of several or several hundred individual project or other activity schedules that represent the various efforts within a program. It should include the entire known scope of work, including the effort necessary from all government, contractor, and other key parties for a program's successful execution.

In addition, NNSA has various program management policies and guidance that apply to uranium program efforts that are not capital asset projects and that fall outside of DOE Order 413.3B.[33] For example:

- NNSA issued a program management policy in January 2017 that defines general roles and responsibilities for the program managers for all of its strategic materials, such as uranium.[34] This policy broadly

[32]GAO-16-89G.

[33]We reported in November 2016 that DOE does not have a department-wide policy for program management equivalent to DOE Order 413.3B. We recommended that DOE establish (1) a program management policy addressing internal control standards and leading practices and (2) a training program for program managers. DOE did not have any comments on the report. See GAO, *Program Management: DOE Needs to Develop a Comprehensive Policy and Training Plan*, GAO-17-51 (Washington, D.C.: Nov. 21, 2016).

[34]National Nuclear Security Administration, *Program Management Policy for Weapons and Strategic Materials Programs*, Business Operating Procedure BOP-413.5 (Washington, D.C.: Jan. 17, 2017).

outlines the managers' authority and responsibilities for managing the strategic materials; these responsibilities include developing program documentation and managing risk.

- NNSA issued a program management policy in February 2019 that states program managers should establish and document the requirements for scope, schedule, and cost management using a tailored approach to their program.[35] These requirements include the development of schedule and cost estimates that cover the life cycle of a program where appropriate, among other things.
- NNSA's program guidance—applicable to the uranium program and others that fall under the Office of Defense Programs—recommends the development of an integrated master schedule and states that having one supports effective management of a program's scope, risk, and day-to-day activities.[36] Specifically, the guidance states that during the initial phases of a program, an integrated master schedule provides an early understanding of the required scope of work, key events, accomplishment criteria, and the likely program structure by depicting the progression of work through the remaining phases. The guidance allows for tailoring of the agency's management approach based on the particular program being managed.

## NNSA Reports That the UPF Project Is on Schedule and within Budget and Likely to Start Operations in 2026

According to NNSA documents and officials, the UPF project is on schedule and within budget, and NNSA has developed a plan to receive start-up authorization for UPF operations in 2025 and attain full operational capability in 2026.

[35]National Nuclear Security Administration, *Program Management Policy,* NAP-413.2 (Washington, D.C.: Feb. 4, 2019).

[36]National Nuclear Security Administration, *Office of Defense Programs DP Program Execution Instruction* (Washington, D.C.: June 19, 2019). The program guidance states that capital asset projects, like the UPF project, require an integrated master schedule in full compliance with DOE Order 413.3B and recommends that programs have a program-level integrated master schedule that has enough detail to provide a critical path of milestones for any projects and other efforts managed by the program.

## NNSA Reports That the UPF Project Is Currently on Schedule and within Budget

NNSA documents and officials reported that the UPF project is on track to meet its cost and schedule baseline estimates, and thus is expected to be constructed for $6.5 billion by the end of 2025.[37] According to DOE's project report and NNSA officials, three of the seven UPF subprojects are complete and four are ongoing as of December 2019. When we last reported in September 2017, NNSA had completed the Site Readiness subproject.[38] In February 2018, NNSA completed the Site Infrastructure and Services subproject—about 2 months early and about $18 million under budget.[39] In December 2019, NNSA completed the Substation subproject—about 6 months early and $13 million under budget. As shown in table 1, by March 2018 all UPF subprojects' formal scopes of work and cost and schedule baseline estimates were approved (CD-2), and NNSA gained approval to start construction on them (CD-3).[40] Since establishing these cost and schedule baseline estimates, NNSA officials stated that they have not made any significant changes that would require DOE executive-level approval. According to DOE policy, changes that affect the project's ability to satisfy the mission need or that increase costs by the lesser of $100 million or half the project costs must be approved by the DOE Deputy Secretary as DOE's Chief Executive for Project Management.[41]

[37]According to NNSA budget documents and officials, this amount includes approximately $820 million in cost contingency and this schedule includes approximately a year of schedule contingency.

[38]GAO-17-577.

[39]NNSA initially baselined the Site Infrastructure and Services subproject for completion in April 2018 for $78.5 million. However, NNSA officials stated that they completed the subproject in February 2018 for $60.5 billion—approximately 2 months early and $18 million under budget. NNSA officials stated that they re-baselined the subproject's cost to the actual amount of $60.5 million in order to shift available overall project funding to the other ongoing subprojects before establishing those subprojects' baselines estimates.

[40]NNSA combined CD-2 and CD-3 for several of its subprojects, including the four larger subprojects—Mechanical Electrical Building, Process Support Facilities, Salvage and Accountability Building, and Main Process Building.

[41]DOE Order 413.3B.

**Table 1: Selected Critical Decision (CD) Milestones and Cost Estimates for Uranium Processing Facility Subprojects**

Dollars in millions

| Subproject | Approved baselines and start of construction (CD 2/3)[a] | Approved for start of operations or project completion (CD 4) | Approved baseline cost estimate ($) | Actual cost ($) |
|---|---|---|---|---|
| Site Readiness | Approved Jan. 2013 | Approved Feb. 2015 | 43.7 (65.0)[b] | 43.7 |
| Site Infrastructure and Services | Approved Mar. 2015 | Approved Feb. 2018 | 60.5 (78.5)[c] | 60.5 |
| Substation | Approved Sept. 2016 | Approved Dec. 2019 | 60.0 | 47.0 |
| Mechanical Electrical Building | Approved Dec. 2016 | Estimated Jan. 2022 | 284.0 | _ |
| Process Support Facilities | Approved Mar. 2018 | Estimated Dec. 2025 | 140.0 | _ |
| Salvage and Accountability Building | Approved Mar. 2018 | Estimated Dec. 2025 | 1,180.0 | _ |
| Main Process Building | Approved Mar. 2018 | Estimated Dec. 2025 | 4,731.8 | _ |
| **Overall UPF project** | **Mar. 2018** | **Dec. 2025** | **6,500.0** | **n/a** |

Legend: n/a = not applicable.

Source: National Nuclear Security Administration (NNSA) Budget Justification for fiscal year 2020. | GAO-20-293

[a]NNSA combined CD-2 and CD-3 for several of its subprojects.

[b]NNSA initially baselined the Site Readiness subproject's cost at $65.0 million, but completed the subproject for $43.7 million. NNSA officials stated that they re-baselined the subproject's cost to the actual amount of $43.7 million in order to shift available overall project funding to the other ongoing subprojects.

[c]NNSA initially baselined the Site Infrastructure and Services subproject's cost at $78.5 million but completed the subproject for $60.5 billion. NNSA officials stated that they re-baselined the subproject's cost to the actual amount of $60.5 million in order to shift available overall project funding to the other ongoing subprojects.

According to DOE's project report and NNSA officials, the four ongoing subprojects were progressing on schedule and within budget as of December 2019. NNSA officials stated that they expect these subprojects to meet their respective cost and schedule performance baselines and that the overall UPF project will be constructed for $6.5 billion by the end

of 2025.[42] (See fig. 3 for photograph of Main Process Building and Salvage and Accountability Building's construction progress as of September 2019.)

**Figure 3: Ongoing Construction of the Uranium Processing Facility's Main Process Building and Salvage and Accountability Building, September 2019**

Source: National Nuclear Security Administration. | GAO-20-293

Note: The Main Process Building is pictured on the left, and the Salvage and Accountability Building is pictured on the right.

[42]The U.S. District Court for Eastern Tennessee ruled in September 2019 that NNSA's previous records of decision and supplemental analyses related to meeting enriched uranium requirements at Y-12 violated the National Environmental Policy Act (NEPA). *Oak Ridge Envtl. Peace All. v. Perry*, No. 3:18-CV-150, 2019 WL 4655904, at *52 (E.D. Tenn. Sept. 24, 2019). NNSA has to complete additional environmental and seismic risk analysis to bring these analyses into compliance with NEPA. Federal defendants have appealed this ruling, plaintiffs have cross-appealed, and those appeals are pending as of January 2020. *Oak Ridge Envtl. Peace Alliance v. Perry*, *appeals docketed*, No. 19-6332 (6th Cir. Nov. 26, 2019), No. 19-6391 (6th Cir. Dec. 11, 2019). In October 2019, NNSA formalized its decision to continue building the UPF while complying with the federal court order to conduct additional environmental review and seismic risk analysis. NNSA officials stated that they do not anticipate that the court ruling will have any effect on the UPF project's construction and start of operations.

## NNSA Plans to Start UPF Operations in 2025 and Reach Full Operational Capability in 2026

NNSA and its contractor for Y-12 have developed a plan to receive start-up authorization for UPF operations in 2025 and then will likely attain full operational capability for the UPF in 2026, according to NNSA officials and contractor representatives. DOE and NNSA approved this plan, which is required by DOE policy,[43] in February 2018. This plan outlines three major risks associated with the UPF project that NNSA will need to address so that the project can attain full operational capability:

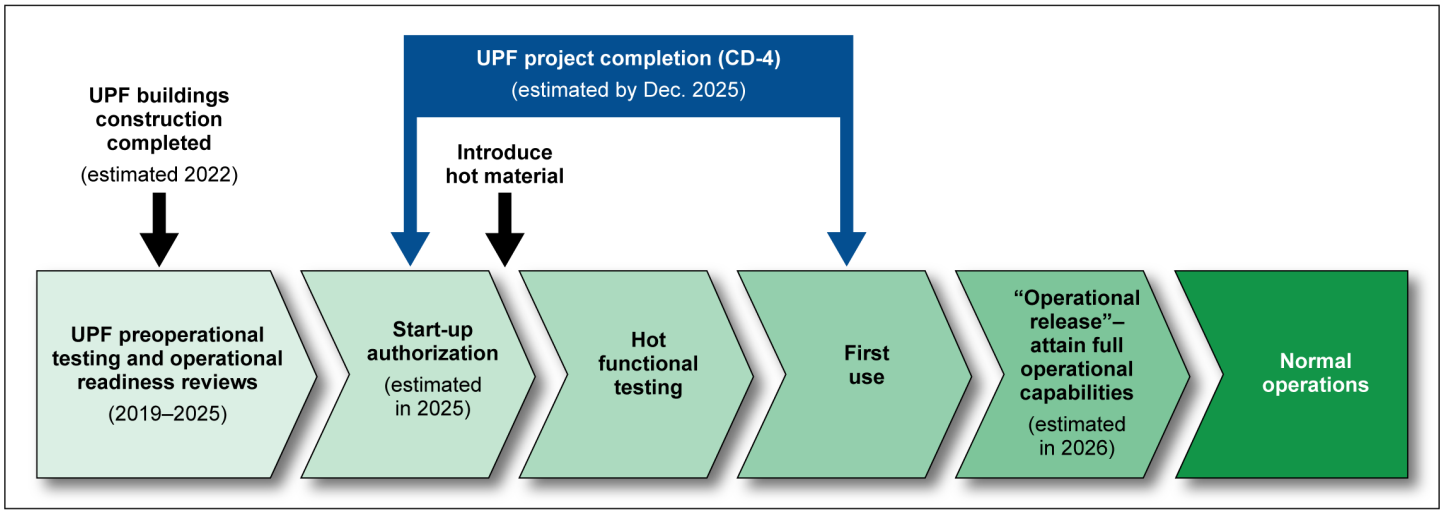
1. **Capabilities and systems integration within the UPF**. Addressing this risk includes actions to ensure that all of the UPF's systems, and the capabilities that those systems provide (e.g., casting, oxide production), can function together as designed through testing.
2. **Process prove-in and design authority qualification.** Addressing this risk includes actions to ensure that the UPF's systems meet certain metrics and are qualified for mission work. Aspects of this include laboratory analysis, statistical validation of repeatability, and engineering evaluations.
3. **Integration of UPF with other facilities**. Addressing this risk includes actions to ensure that the UPF systems can interface with other facilities' systems (e.g., those in Buildings 9215, 9204-2E, and 9995) as designed and that all systems are able to support full-scale operations.

NNSA officials estimated that construction of the UPF will be completed in 2022. According to the plan, the UPF will then go through various preoperational testing and operational readiness reviews to demonstrate the capabilities using nonhazardous surrogate material. Following testing and readiness reviews, the UPF will gain startup authorization, go through additional testing and first use, and then attain full operational capability—also referred to as "operational release." NNSA officials and contractor representatives stated in June 2019 that the UPF should receive startup authorization sometime in 2025, before the project's estimated completion

[43]DOE Order 413.3B and Department of Energy, Deputy Secretary of Energy, *Memorandum: "Operational Release" Milestone*.

(CD-4) date of December 2025.[44] These officials and representatives estimated that the UPF would attain full operational capability about a year from receiving that startup authorization—that is, sometime in 2026. (See fig. 4.)

**Figure 4: National Nuclear Security Administration's (NNSA) Plan to Start Operations and Attain Full Operational Capability for the Uranium Processing Facility (UPF)**




Source: GAO analysis of NNSA Operational Release Plan for the UPF. | GAO-20-293

NNSA officials stated in October 2019 that in fiscal year 2020 they will update the plan to attain full operational capability to include a schedule with more specific time frames for startup authorization, hot functional testing, first use, and operational release, among other things.[45] According to NNSA's plan, attaining full operational capability for the UPF is the final step that will ultimately lead to and enable the cessation of

[44]According to DOE Order 413.3B, CD-4 is the achievement of the project completion criteria and the approval of transition to operations, and it marks the completion of the execution phase of the project. The approval of CD-4 is predicated on the readiness to operate and to maintain the system, facility, or capability, but is not dependent upon "operational release" when the UPF would achieve full operational capability.

[45]At the end of the construction period, pre-operational hot functional testing is to be conducted and may include the introduction of hot material—special nuclear material and other hazardous chemicals. Hot functional testing and operations under first use controls will help support a controlled transition into production operations.

uranium operations in Building 9212, which could then be turned over to DOE Office of Environmental Management for final disposition in 2035.[46]

# NNSA Obtained Independent Cost Estimates as Required and Used Them to Inform Contractor Negotiations and Baseline Estimates

NNSA followed requirements to obtain independent cost estimates for the UPF (i.e., the four largest UPF subprojects) whose total estimated costs exceeded $100 million. NNSA then used those estimates to help negotiate with contractors and inform baseline estimates.

## NNSA Had UPF Cost and Schedule Baseline Estimates Validated through Reconciled Independent Cost Estimates for the Four Largest Subprojects

NNSA obtained independent cost estimates from DOE-PM for the four UPF subprojects for which total costs exceeded $100 million. As noted above, projects with total costs that exceed $100 million are subject to an appropriations limitation unless independent cost estimates are obtained, and DOE policy requires such estimates for such projects. DOE-PM, an office independent from NNSA and its management of the UPF project, conducted the independent cost estimates for the four larger subprojects: the Mechanical Electrical Building, Process Support Facilities, Salvage and Accountability Building, and Main Process Building subprojects. In addition, NNSA officials stated that they obtained independent reviews for the three subprojects for which costs did not exceed $100 million.[47] DOE policy does not require independent cost estimates for projects whose total estimated costs are less than the $100 million threshold. However, a NNSA policy states that NNSA should obtain an independent cost

[46]Since 1989, the Office of Environmental Management has managed DOE's environmental cleanup of radioactive and hazardous waste left over from nuclear weapons production and energy research at DOE sites and facilities across the country.

[47]The U.S. Army Corps of Engineers, working under an interagency agreement with DOE and NNSA to provide cost engineering services at Y-12, conducted cost reviews of the Site Readiness subproject in September 2011, Site Infrastructure and Services subproject in April 2014, and Substation subproject in April 2016.

estimate or independent cost review to validate a project's cost baselines for those projects for which estimated costs are between $20 million and $100 million.[48]

NNSA organized the independent cost estimates for the four larger subprojects so that some of the independent cost estimates included work for more than one subproject. Specifically, DOE-PM completed two estimates—one in March 2016 and one in December 2016—that included site preparation work and long lead procurements for the Salvage and Accountability Building and Main Process Building subprojects.[49] In November 2016, DOE-PM completed the independent cost estimate for the Mechanical Electrical Building, which was the only estimate to include a single UPF subproject. NNSA officials explained that they handled the estimate for this subproject differently because work for the Mechanical Electrical Building could be separated easily from the other subprojects, and it was largely designed as a commercial-grade building. Lastly, in November 2017, DOE-PM completed the independent cost estimate for the majority of the work for the Process Support Facilities, Salvage and Accountability Building, and Main Process Building subprojects. NNSA officials stated they organized the independent cost estimates in this way to meet DOE requirements and appropriations limitations but still be able to begin work on the aspects of the overall UPF project that need to be completed earliest.

DOE-PM conducted the four UPF subprojects' independent cost and schedule estimates using our cost estimating and scheduling best practices, according to DOE-PM's independent cost estimate reports.[50] DOE-PM reviewed the project's key cost drivers—elements whose sensitivity significantly affects the total project cost. The DOE-PM team then established independent estimates for those cost drivers, which may include vendor quotes for major equipment and detailed estimates for other materials, labor, and subcontracts. The team also prepared an independently generated resource-loaded schedule that allowed them to

[48]According to NNSA's procedure, an independent cost review is an independent evaluation of a project's cost estimate that examines its quality and accuracy with emphasis on costs and technical risks. See National Nuclear Security Administration, *Independent Cost Estimates Procedure*, Business Operating Procedure BOP-413.3 (Washington, D.C.: Feb. 27, 2014).

[49]According to PMI, long lead procurements are items such as construction equipment or materials that need to be purchased and whose lead times for that purchase may be prolonged, having the potential to stall construction or project progress if not ready in time.

[50]We did not assess DOE-PM's compliance with our best practices for this review.

check for adequate funding compared with the project's funding profile developed by the project team. DOE-PM's analyses are based on their review of the UPF project's work breakdown structure and associated documents, which include all of the activities that make up the project's scope. DOE-PM also compared the UPF project estimates with our cost estimating and scheduling best practices, according to DOE-PM's independent cost estimate reports. For example, DOE-PM's November 2017 report found that the three larger UPF subproject's cost and schedule estimates partially met the best practices and recommended some changes to the contractor to address those estimates that did not.

DOE-PM reconciled the results of its independent cost estimates with the initial project estimates, as required by DOE's standard operating procedure and NNSA's business operating procedure for conducting independent cost estimates.[51] During the reconciliation, DOE-PM worked with the UPF project team to adjust both the initial project estimates and its own independent cost estimates to correct any errors or misinterpretations of project requirements, according to the independent cost estimate reports. Under DOE's and NNSA's independent cost estimate procedures and according to DOE-PM officials, any remaining differences should be identified and explained, but estimates should not be changed.[52] DOE-PM drew from the independent cost estimates for the Mechanical Electrical Building subproject to complete an external independent review of that subproject in November 2016. Then, DOE-PM drew from the independent cost estimates that included work for the Main Process Building, Salvage and Accountability Building, and Process Support Facilities subprojects to complete its external independent review of the UPF project in March 2018.

## NNSA Used Information from the Independent Cost Estimates and External Independent Reviews to Inform the UPF's Cost and Schedule Baseline Estimates

NNSA officials stated that they used information from DOE-PM's independent cost estimate and external independent review reports to

[51]Department of Energy, *Independent Cost Review and Independent Cost Estimate Standard Operating Procedure* and National Nuclear Security Administration, BOP-413.3.

[52]According to DOE's procedure on conducting independent cost estimates, reconciliation is not intended to resolve differences between the independent cost estimates and the contractor or program's initial project estimates, but to ensure all of the estimates use the same detailed technical and procurement information.

help negotiate remaining work with the contractor and finalize the overall UPF project's baseline estimates before starting construction. In June 2018, NNSA prepared a strategy to guide its negotiation of the remaining UPF project work that had not yet been priced with the contractor. Based on our review of NNSA's negotiation strategy, we found that NNSA used DOE-PM's independent cost estimate and external independent review reports to negotiate at least 14 of the 22 major and minor issues identified for discussion. These 14 issues included, for example, reducing concrete and freight direct costs, reducing the margin added to cover any increase in design scope, reducing subcontractor indirect costs, and increasing accuracy of other cost and schedule estimates.

DOE approved NNSA's cost and schedule baseline estimates (CD-2) and start of construction (CD-3) in March 2018 for three UPF subprojects.[53] (See table 2 for the recommended cost and schedule baselines from the external independent review report and the final cost and schedule baseline estimates for all UPF subprojects.) In five of the seven subprojects, the final cost baseline estimates were close to or below the recommended baselines from DOE-PM's external independent review. Also, in four of the seven subprojects, the final schedule baseline estimates were close to the recommended baselines. According to NNSA officials, the UPF project final baseline cost estimate includes cost contingency, and the December 2025 final schedule baseline estimate includes a year of schedule contingency. NNSA officials stated that, if necessary, they could use available funds to expedite the schedule. NNSA officials also expressed confidence that the UPF project will meet its goal of construction for $6.5 billion by the end of 2025.

**Table 2: External Independent Review (EIR) Recommended and Final Baseline Estimates for Uranium Processing Facility (UPF) Subprojects**

Dollars in millions

| Subproject | EIR recommended schedule baseline estimate | Final schedule baseline estimate | EIR recommended cost baseline estimate ($) | Final baseline cost estimate ($) |
|---|---|---|---|---|
| Site Readiness | Feb. 2015 | Feb. 2015 | 43 | 44 |
| Site Infrastructure and Services | April 2018 | Feb. 2018 | 79 | 61 |
| Substation | June 2020 | June 2020 | 60 | 60 |

[53]Under DOE Order 413.3B, the DOE Deputy Secretary serves as DOE's Chief Executive for Project Management and has approval authority for CD points for major system projects—projects with a total project cost greater than or equal to $750 million.

| | | | | |
|---|---|---|---|---|
| Mechanical Electrical Building | Jan. 2022 | Jan. 2022 | 284 | 284 |
| Process Support Facilities | Aug. 2026 | Dec. 2025 | 116 | 140 |
| Salvage and Accountability Building | Aug. 2026 | Dec. 2025 | 1,179 | 1,180 |
| Main Process Building[a] | Aug. 2026 | Dec. 2025 | 4,513 | 4,732 |
| Overall estimate[b] | Aug. 2026 | Dec. 2025 | 6,274 | 6,500 |

Source: GAO analysis of Department of Energy Office of Project Management external independent review report and National Nuclear Security Administration Budget Justification for fiscal year 2020. | GAO-20-293

[a]The Main Process Building subproject's cost estimates include about $1.8 billion in design costs. These design costs were for the entire UPF project.

[b]Any discrepancies in total cost estimates are due to rounding.

# NNSA Has Made Progress Implementing the Uranium Program's Scope of Work and Recently Developed a Program Schedule and Cost Estimate

Since we last reported in September 2017, NNSA identified and made progress in implementing the uranium program's scope of work and developed an integrated master schedule and life-cycle cost estimate—key management information for the program. The uranium program's integrated master schedule extends through fiscal year 2035, and the life-cycle cost estimate includes the $7.4 billion in program costs from fiscal years 2016 through 2026.

## NNSA Has Identified and Made Progress in Implementing the Uranium Program's Scope of Work

Since we last reported in September 2017, NNSA identified the uranium program's scope of work and made progress in carrying out key activities. Specifically, NNSA identified the uranium program's scope of work as required under NNSA program management policy and which we identified as a leading practice in our cost estimating and schedule guides.[54] According to NNSA documents we reviewed and officials we interviewed, NNSA developed the uranium program's scope of work in a work breakdown structure, which defines in detail the work or activities necessary to accomplish the program's objectives. NNSA officials stated that the uranium program's scope of work includes the UPF project as

[54]National Nuclear Security Administration, NAP-413.2; GAO-09-3SP; and GAO-16-89G.

well as the capabilities and other activities necessary for the overall modernization effort that are not part of the UPF project.[55] NNSA made progress implementing the following three main areas of the uranium program's scope of work:

- **Process Technology Development.** Since we last reported in September 2017,[56] NNSA's uranium program has made progress in three of the four process technology projects that it manages to develop new uranium processing capabilities. According to NNSA officials, these capabilities are not included in the UPF project but are necessary to complete the suite of uranium capabilities required to meet weapons program needs.
  - NNSA approved the **electrorefining project's** cost and schedule performance baselines and start of construction (CD-2/3) in February 2019. This project, along with the direct chip melt projects discussed further below, are designed to provide a capability that was scoped out of the UPF project. Specifically, the electrorefining project is to provide the capability to purify uranium metal.
  - NNSA officials stated that the **calciner project** will have its cost and schedule baselines and start of construction approved (CD-2/3) in May 2020. This project is to provide the capability to convert uranium-bearing solutions to uranium oxide (a dry solid) so that it can be stored pending further processing in the future. The project will be located in Building 9212 and supports the exit of that building by enabling the processing of certain uranium-bearing solutions (such as the solutions resulting from cleaning out the building's pipes and vessels) into a dry solid oxide that can be stored pending further processing.
  - According to NNSA officials, the **direct chip melt projects** include two related efforts—a front-loading furnace and a bottom-loading furnace—that will provide the capability to process uranium scrap metal. Officials stated that the front-loading furnace direct chip melt project received approval to start work in September 2019 and has an estimated project completion of May 2021. This will provide near-term capability to process uranium

[55]As previously discussed, NNSA's Office of Acquisition and Project Management manages the UPF project under DOE Order 413.3B with funding from NNSA's Office of Defense Programs through the uranium program. This portion of the report focuses on the uranium program capabilities and activities outside of the UPF project.

[56]GAO-17-577.

scrap metal until the bottom-loading furnaces are designed and constructed. Officials said NNSA initiated the bottom-loading furnace direct chip melt project in July 2019 and expects to start construction in January 2021. Because the direct chip melt projects fall below the $50 million threshold for management under DOE Order 413.3B, they do not have CD dates. However, NNSA officials stated they will manage and oversee the bottom-loading furnace project under the Office of Defense Programs' authorization-to-proceed memorandum and follow the sound project management principles outlined in the order.[57]

- NNSA officials stated that the agency requires an **oxide-to-metal conversion capability.** In June 2019, NNSA issued a Notice of Intent to enter into a sole-source contract to provide the uranium oxide to metal conversion capability. According to NNSA officials, this potential sole-source contract is a near-term strategy that could cover any gap caused by phasing out operations in Building 9212.[58] According to NNSA, under this contract the contractor could provide conversion services in 2023, effectively covering any gap caused by phasing out conversion operations in Building 9212. NNSA officials stated that the agency intends to continue pursuing the direct electrolytic reduction technology to provide the oxide-to-metal conversion capability after the sole-source contract, but the technology has not progressed since we last reported in 2017.

- **Extended Life Programs.** In December 2017, NNSA developed the implementation plan for the extended life programs for Buildings 9215 and 9204-2E.[59] NNSA also developed an extended life program for Building 9995 in November 2017 and the implementation plan for that program in September 2018. NNSA updated both of these

[57]In May 2019, DOE's Deputy Administrator for Defense Programs issued a memorandum to NNSA's Production Office authorizing that office to proceed with the bottom-loading direct chip melt project.

[58]NNSA issued a Notice of Intent in June 2019 that it intends to award BWX Technologies subsidiary Nuclear Fuel Services a sole-source contract to convert uranium oxide to metal for nuclear weapons programs. Nuclear Fuel Services is in Erwin, Tennessee, and is a commercial facility licensed by the Nuclear Regulatory Commission to work with enriched uranium. According to NNSA officials, Nuclear Fuel Services uses processes similar to those to convert uranium oxide to uranium metal that are being phased out of Y-12's building 9212.

[59]We reported in September 2017 that NNSA and the Y-12 contractor developed an extended life program for Buildings 9215 and 9204-2E in November 2016.

implementation plans in September 2019. Further, in September 2018, NNSA developed an implementation plan for its strategy to stop operations in Building 9212 and begin post-operations clean-out activities. These implementation plans identify a specific scope of work, and the necessary funding, that NNSA must execute in order to extend the operational lives of Buildings 9215, 9204-2E, and 9995 through the 2040s.

- **Reducing Material at Risk in Older Buildings.**[60] Since we last reported in September 2017, NNSA has made progress in its efforts to move uranium materials out of older facilities and into the HEUMF. Specifically, NNSA officials said in November 2019 that they were about 77 percent done with this effort and had moved more than 50 metric tons of uranium out of older facilities and into the HEUMF since fiscal year 2015. In June 2019, NNSA officials said that their current strategy focuses on incorporating near-just-in-time inventory practices and further reducing material at risk by 2023.[61] According to NNSA officials, this strategy is to further minimize the amount of material that is staged in Y-12's older buildings. Also, according to NNSA officials, NNSA achieved a target working inventory of material in Building 9215 in 2016 and in Building 9204-2E in 2019. NNSA officials stated that, as of November 2019, they were on schedule to complete the remaining efforts by their estimated time frames.

NNSA officials stated that the program's scope of work includes elements for which additional analyses may be required and that any additional program work identified by those analyses will be incorporated into the scope of work, as appropriate. For example, NNSA identified the additional environmental and seismic analyses necessary to develop the scope of work for addressing certain structural deficiencies in Buildings 9215 and 9204-2E. NNSA is under a court order to complete additional environmental and seismic risk analyses following a 2014 update in the seismic hazard map for the area, which showed a greater risk than the

[60]Material at risk reduction refers to NNSA's programmatic effort to move much of the uranium stored in older Y-12 facilities to the HEUMF—a modern facility that became operational in 2010—to reduce the risk of a safety event in those older facilities. According to NNSA officials, this includes modifying the safety basis of the HEUMF so that it can accept different levels and forms of enriched uranium.

[61]Just-in-time inventory principles make up a management strategy that aligns inventory supply with production schedules, which allows for a reduction in that inventory. When complete and operational in 2026, a connection between HEUMF and UPF will further allow near-just-in-time inventory practices.

previous version.[62] According to Defense Nuclear Facilities Safety Board officials, in response to its 2015 report, NNSA identified their approach for re-evaluating the facilities' conditions and risks and addressing some of the board's seismic-related concerns.[63] According to board officials, NNSA plans to start the re-evaluation of these structures in early fiscal year 2020. NNSA officials stated that if the additional analyses identify additional necessary work for the uranium program, NNSA will update the scope of work and revise the extended life program implementation plans to include that work.

## NNSA Has Developed an Integrated Master Schedule and a Life-Cycle Cost Estimate to Manage Its Uranium Program

In December 2019, NNSA developed an integrated master schedule through fiscal year 2035 and a life-cycle cost estimate for the program through fiscal year 2026 that includes over $850 million in costs in addition to the UPF project. Successful management of federal acquisition programs, such as NNSA's uranium program, partly depends on developing this key management information, as stated in our cost estimating and schedule guides.[64] In September 2017, we found that

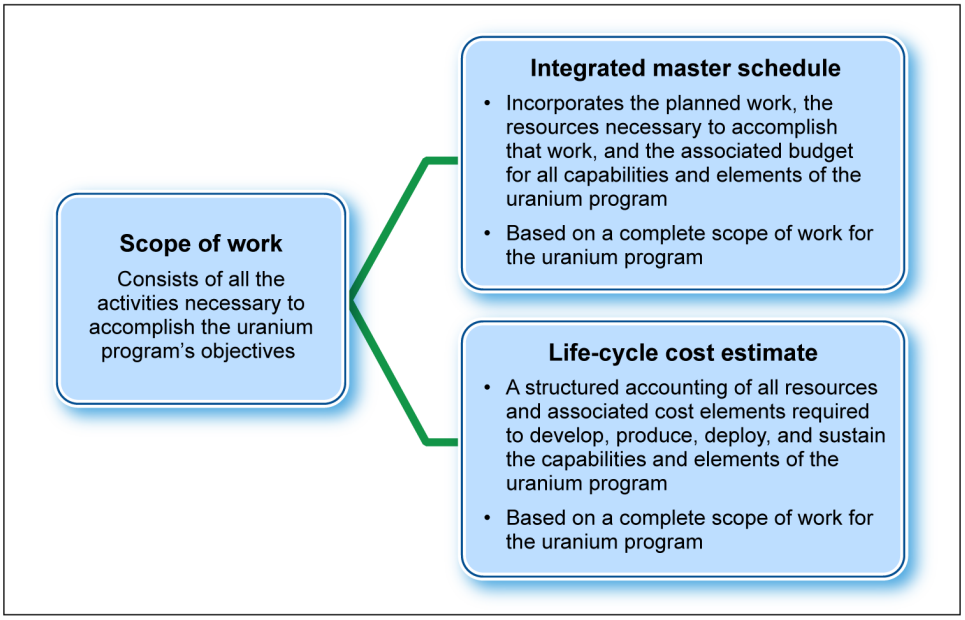
[62]The U.S. Geologic Survey updated its seismic hazard maps for the entire country in 2014, which indicated a higher earthquake hazard for all of East Tennessee (including Y-12) than its previous version in 2008. Specifically, the maps showed increases in estimated ground peak acceleration. In September 2019, a U.S. district court ruling ordered NNSA to complete additional environmental and seismic risk analyses in support of the decision to construct the UPF project and make infrastructure investments in existing buildings to bring the agency into compliance with the National Environmental Policy Act (NEPA). The court found, among other things, that DOE and NNSA did not properly evaluate the environmental impacts resulting from the increased seismic hazard forecast for East Tennessee in its various analyses and decisions that occurred after the 2014 update, and these analyses and decisions are therefore in violation of NEPA. The court stated that NNSA shall conduct further analysis of the earthquake consequences at Y-12 that should include the 2014 seismic hazard map.

[63]Defense Nuclear Facilities Safety Board, *Staff Issue Report: Structural Evaluations of the 9215 Complex and Building 9204-2E at the Y-12 National Security Complex* (Washington, D.C.: Nov. 14, 2014, issued Feb. 15, 2015). The deficiencies that the Defense Nuclear Facilities Safety Board pointed out for Building 9215 included inadequate bracing, outdated connection detailing, overstressed structural members, and poor-performing hollow clay tile exterior walls. With respect to Building 9204-2E, the board noted deficiencies that included seismic detailing of reinforced concrete and seismic concerns with exterior non-structural unreinforced masonry walls.

[64]GAO-09-3SP and GAO-16-89G.

NNSA had not yet developed an integrated master schedule or life-cycle cost estimate for the uranium program and recommended that NNSA set a time frame for doing so.[65] NNSA agreed with this recommendation and has made progress in implementing it. A complete scope of work is required to develop an integrated master schedule and life-cycle cost estimate. (See fig. 5.)

**Figure 5: Relationship between the Scope of Work, Integrated Master Schedule, and Life-Cycle Cost Estimate for the National Nuclear Security Administration's Uranium Program**




Sources: GAO, *Schedule Assessment Guide: Best Practices for Project Schedules*, GAO-16-89G (Washington, D.C.: December 2015) and *GAO Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program Costs*, GAO-09-3SP (Washington, D.C.: March 2009). | GAO-20-293

## NNSA Developed an Integrated Master Schedule to Help Manage Its Uranium Program

In December 2019, NNSA developed an integrated master schedule based on the uranium program's scope of work to help manage its uranium program, as recommended in NNSA's program guidance as well

[65]GAO-17-577.

as our schedule guide and other best practices.[66] According to PMI's Program Management Standard, a program-integrated master schedule is the top-level planning document that includes individual program elements' schedules and defines their dependencies among those required to achieve the program's goals. According to NNSA officials, NNSA included all of the uranium program's capabilities and elements that make up its scope of work, as well as other work that may affect the program, through fiscal year 2035.[67]

NNSA officials stated that the schedule includes the key milestones for each uranium program capability and element, such as project completion (CD-4) and operational release, since these key milestones are important for tracking the uranium program's critical path of activities and for overall program management.[68] NNSA officials stated that they will start reporting the uranium program's progress against this integrated master schedule beginning in 2020. NNSA officials stated that they expect the integrated master schedule to be iterative and that they will update it to capture any changes or additions to the program's scope of work.

## NNSA's Life-Cycle Cost Estimate Identified Additional Costs for Uranium Program

In December 2019, NNSA developed a life-cycle cost estimate through fiscal year 2026 for the uranium program, as called for in our cost

[66]National Nuclear Security Administration, *Office of Defense Programs Execution Instruction*; GAO-16-89G; and Project Management Institute, Inc., *The Standard for Program Management®*.

[67]Because NNSA developed its integrated master schedule late in our review, we did not assess the extent to which it followed our schedule guide and other best practices. As noted previously, Section 3123(f) of the National Defense Authorization Act for Fiscal Year 2013, as amended by section 3126 of the National Defense Authorization Act for Fiscal Year 2014 and section 3118 of the Carl Levin and Howard P. "Buck" McKeon National Defense Authorization Act for Fiscal Year 2015, includes a provision for us to periodically review the new UPF, including any other issues that we determine appropriate with respect to the requirements, cost, schedule, or technology readiness levels of the project. We may review NNSA's integrated master schedule for its uranium program in future UPF-related reviews.

[68]NNSA officials stated that each project, such as the electrorefining project, has its own project schedules that include every activity necessary to complete that project. NNSA officials stated that the key milestones for each of these projects are more important for program management purposes.

estimating guide and other best practices.[69] NNSA estimated that the uranium program will spend a total of approximately $7.4 billion from fiscal years 2016 through 2026 to support its uranium processing modernization efforts. Specifically, NNSA officials stated that the life-cycle cost estimate includes $6.5 billion in UPF project costs and over $850 million in program costs that include developing the uranium processing capabilities that are not part of the UPF project, integrating those capabilities with the UPF, improving the infrastructure of existing buildings, and transitioning out of Building 9212.[70]

NNSA officials stated that they estimated uranium program life-cycle costs from fiscal years 2016 through 2026 because they could not accurately estimate some of the activities in the program's scope of work that are enduring for the nuclear security enterprise rather than specific projects with finite schedules for construction.[71] According to our cost-estimating guide, a reliable cost estimate reflects all costs associated with a program's scope of work, and the estimate should be updated to reflect any changes in requirements—that is, a life-cycle cost estimate can be iterative.[72] NNSA officials stated that they expect to update the life-cycle cost estimate with additional program costs, once known, and will include any additional future scope added to the program.

[69]GAO-09-3SP and Project Management Institute, Inc., *The Standard for Program Management®*.

[70]Because NNSA developed its life-cycle cost estimate for the uranium program late in our review, we did not assess the extent to which it followed our cost estimating guide and other best practices. As noted previously, Section 3123(f) of the National Defense Authorization Act for Fiscal Year 2013, as amended by section 3126 of the National Defense Authorization Act for Fiscal Year 2014 and section 3118 of the Carl Levin and Howard P. "Buck" McKeon National Defense Authorization Act for Fiscal Year 2015, includes a provision for us to periodically review the new UPF, including any other issues that we determine appropriate with respect to the requirements, cost, schedule, or technology readiness levels of the project. We may review NNSA's life-cycle cost estimate for its uranium program in future UPF-related reviews.

[71]According to NNSA officials, the uranium program's life-cycle cost estimate does not include the UPF's full life-cycle costs for its estimated 50-year operating life. The UPF life-cycle cost estimate includes costs outside of the uranium program's responsibility, such as production, operations and maintenance, and final disposition costs.

[72]GAO-09-3SP. We provide a table that discusses the characteristics of reliable cost estimates.

Schedule milestones and cost estimates included in NNSA's integrated master schedule and life-cycle cost estimate for the uranium program are summarized in table 3.

**Table 3: Schedule Milestones and Cost Estimates for National Nuclear Security Administration's (NNSA) Uranium Program Efforts**

Dollars in millions

| Uranium program project or effort | Start of project's construction or start of effort | Project or effort completion | Preliminary or formal baseline cost estimate ($) |
|---|---|---|---|
| Electrorefining project | Approval of baselines and start of construction (CD-2/3) in Feb. 2019 | Feb. 2023 | 101.0 |
| Direct chip melt project[a]: Front-loading furnace | Approval to start construction in Sept. 2019 | Estimated May 2021 | 16.8 |
| Direct chip melt project: Bottom-loading furnace | Estimated to start construction in Jan. 2021 | Estimated March 2024 | 38.7 |
| Calciner project | Estimated approval of baselines and start of construction (CD-2/3) in May 2020 | Estimated June 2023 | 84.4[b] |
| Oxide-to-metal conversion capability | To be determined; capability to be contracted out | To be determined; capability to be contracted out | To be determined; capability to be contracted out[c] |
| Extended life program for Buildings 9215 and 9204-2E | Implementation plan approved in Dec. 2017, updated Sept. 2019 | Estimated through 2040s | 78.3[d] |
| Extended life program for Building 9995 | Implementation plan approved in Sept. 2018, updated Sept. 2019 | | |
| Reduction of material at risk effort | Efforts started in fiscal year 2016 | Estimated in fiscal year 2023 | 247.6 |
| Technology integration | Efforts started in fiscal year 2016 | Estimated in fiscal year 2026 | 63.5 |
| Building 9212 exit and transition strategy | Efforts started in fiscal year 2016 | Estimated in fiscal year 2026 | 184.1 |
| UPF integration | Efforts started in fiscal year 2016 | Estimated in fiscal year 2026 | 39.5 |
| **Overall uranium program** | **n/a** | **n/a** | **853.9** |

Legend:
CD-2: Approve the project's formal scope of work, cost estimate, and schedule baselines.
CD-3: Approve start of construction.
CD-4: Approve start of operations or project completion.
n/a = not applicable.

Source: GAO review of NNSA and Department of Energy documents and NNSA officials' statements. | GAO-20-293

[a]Because the direct chip melt projects fall below the $50 million threshold for management under DOE Order 413.3B, neither project has CD dates.

[b]Formal cost and schedule baselines will be established at CD-2. NNSA officials stated that the calciner project will probably have a total project cost estimate of $105 million when the formal cost baseline estimate is established.

[c]NNSA officials stated that they were unsure of the schedule and costs of this contract because they were not far enough along in the acquisitions process. According to NNSA officials, NNSA has not yet determined whether they will pursue the direct electrolytic reduction technology to provide the oxide-to-metal conversion capability.

[d]According to NNSA officials, the uranium program is to provide $78 million in funding for the extended life programs from fiscal year 2016 through fiscal year 2026. NNSA estimates that both extended life programs will cost approximately $25 million a year for 10 years for a total of

approximately $250 million. NNSA's Office of Safety, Infrastructure, and Operations is to largely fund the extended life program work.

We are encouraged that NNSA may be able to better manage the day-to-day activities of the uranium program and mitigate any risks associated with integrating the UPF project with other aspects of the program through its development of key program management information—a scope of work, an integrated master schedule, and a life-cycle cost estimate. Successful program management through the life of a program depends in part on all of these efforts and may provide decision makers such as Congress with needed information on the program's complete scope of work, key events, and expected long-term program costs.

## Agency Comments

We provided DOE and NNSA with a draft of this report for review and comment. NNSA provided technical comments, which we incorporated as appropriate.

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

If you or your staff have any questions about this report, please contact me at (202) 512-3841 or trimbled@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 key contributions to this report are listed in appendix I.

David C. Trimble
Director, Natural Resources and Environment

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# Appendix I: GAO Contact and Staff Acknowledgments

## GAO Contact

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## Staff Acknowledgments

In addition to the individual mentioned above, Jonathan Gill (Assistant Director), Elizabeth Luke (Analyst in Charge), Danny Baez, John Bauckman, Brian Bothwell, Juaná Collymore, Jennifer Echard, Justin Fisher, Juan Garay, William Gerard, Cynthia Norris, Dan Royer, and Kiki Theodoropoulos made key contributions to this report.

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