U.S. GOVERNMENT ACCOUNTABILITY OFFICE
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Washington, DC 20548

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Congressional Committees

Plutonium Disposition: Observations on DOE and Army Corps Assessments of the Mixed Oxide Fuel Fabrication Facility Contract

Plutonium—a man-made, radioactive element produced by irradiating uranium in nuclear reactors—poses a risk of proliferation and risks to human health and the environment if not managed safely. In 1997, the Department of Energy (DOE) established the Plutonium Disposition program to address the disposition of weapons-grade plutonium. As part of the program, the National Nuclear Security Administration (NNSA) began constructing the Mixed Oxide Fuel Fabrication Facility (MOX facility) in 2007 at DOE's Savannah River Site in South Carolina.[1] MOX fuel is a mixture of plutonium and uranium oxides that can be used in modified commercial nuclear reactors. If MOX fuel is used in a reactor, the plutonium in the fuel is transformed into radioactive spent fuel similar to the spent fuel produced in commercial reactors, which prevents it from being reused in a nuclear weapon.

In 2007, DOE formally approved a cost estimate of $4.8 billion for construction of the MOX facility, with a scheduled completion date of September 2016. By 2012, NNSA had spent about $3.4 billion on the facility, and the contractor estimated that it needed approximately $4 billion more to complete construction by 2019. In August 2016, in response to a provision in the National Defense Authorization Act for Fiscal Year 2016,[2] DOE developed a revised cost estimate of approximately $17.2 billion to complete construction of the MOX facility by 2048. We reported in September 2017 that the DOE construction cost estimate did not fully meet all of the best practices in the GAO cost-estimating guide, but it substantially met all four characteristics of a high-quality, reliable cost estimate (comprehensive, well documented, accurate, and credible) and therefore could be considered reliable.[3]

Starting with its fiscal year 2014 budget request—submitted in April 2013—DOE proposed slowing down work on the MOX facility while it assessed alternative approaches for plutonium disposition. In April 2014, DOE completed an analysis of plutonium disposition options that identified an alternative "dilute and dispose" approach that DOE believes could significantly reduce the life-cycle cost of the Plutonium Disposition program.[4] Under this approach, plutonium

[1]NNSA is a separately organized agency within DOE that is responsible for the management and security of the nation's nuclear weapons programs.

[2]Pub. L. No. 114-92, § 3119, 129 Stat. 726, 1197 (2015).

[3]A cost estimate is considered reliable if the overall assessment ratings for each of the four characteristics are substantially or fully met. GAO, *Plutonium Disposition: Proposed Dilute and Dispose Approach Highlights Need for More Work at the Waste Isolation Pilot Plant,* GAO-17-390 (Washington, D.C.: Sept. 5, 2017).

[4]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, and it encompasses all past (or sunk), present, and future costs for every aspect of the program, regardless of funding source.

would be diluted with inert material to inhibit its future use in weapons. It would then be packaged and shipped to a repository for permanent disposal. While NNSA examines the activities needed to implement the dilute and dispose approach, construction of the MOX facility has continued. DOE's fiscal year 2018 budget request proposes to terminate construction of the MOX facility and pursue the dilute and dispose approach for plutonium disposition.

The National Defense Authorization Act for Fiscal Year 2017 required DOE to arrange with the U.S. Army Corps of Engineers (Corps) to prepare a report on the contract for the construction, management, and operations of the MOX facility. This report was to include an assessment of the contractual, technical, and managerial risks for DOE and the contractor; an assessment of the elements of the contract that could be changed to fixed-price provisions; and recommendations on changes to the contract to reduce risk and cost to DOE while preserving a fair and reasonable contract.[5] DOE was to submit to the congressional defense committees a report on the Corps report.

The Corps submitted its report to DOE on February 22, 2017. In its report, the Corps recommended that DOE should determine the scope of the remaining work and that, after reaching agreement on final design, the agency should convert the construction portion of the current contract—which is a cost-reimbursable line item—to a fixed-price incentive firm contract line item.[6] According to the Corps' report, changing the contract to a fixed-price incentive firm contract would reduce the level of risk to the government from the level currently experienced under the existing contract. However, if an agreement to convert the contract cannot be reached, the Corps recommended that DOE consider terminating the current contract.

DOE submitted its report to congressional committees on July 14, 2017, and stated that the department believes terminating construction of the MOX facility is the best approach. DOE's report further stated that if construction of the facility continues, the department recognizes the merits of the Corps' recommendation to convert the current contract to a fixed-price incentive firm contract so as to reduce cost and risk to the government.

The National Defense Authorization Act for Fiscal Year 2017 also included a provision that we review the actions taken by DOE related to the Corps' report. This report discusses (1) the potential effects of converting the MOX facility contract to a fixed-price incentive firm contract, as discussed in the DOE and Corps reports, on the cost for construction of the MOX facility; (2) the potential effects of converting the MOX facility contract to a fixed-price incentive firm contract, as discussed in the DOE and Corps reports, on the life-cycle cost of the Plutonium Disposition program; and (3) other observations on the Corps report and MOX facility. In September 2017, we briefed congressional committees on the results of our review. This report publishes the briefing we provided to congressional committees. (See enclosure.)

To address our objectives, we reviewed the required Corps and DOE reports, as well as responses to questions from NNSA by the contractor constructing the MOX facility—CB&I AREVA MOX Services, LLC (MOX Services)—which were included in the DOE report. In

[5]Pub. L. No. 114-328, § 3116(b)(4), 130 Stat. 2000, 2760 (2016).

[6]The current MOX facility contract includes seven contract line items, one of which pertains to designing and constructing the MOX facility. Under a cost-reimbursement type contract, the government pays allowable incurred costs to the extent specified in the contract and may include an additional fee. Under a fixed-price incentive firm contract, the government agrees to a target cost and a price ceiling, and there are financial incentives to control costs. The contractor can realize profits by completing work below the price ceiling and has the ability to earn higher profit by ensuring costs remain below the target cost.

addition, we interviewed Corps, DOE, and NNSA officials responsible for developing the reports and NNSA officials at the MOX Project Management Office at the Savannah River Site. We also interviewed representatives from MOX Services.

To determine the potential effects of converting the MOX facility contract to a fixed-price incentive firm contract on the cost for construction of the MOX facility, we also reviewed information on DOE's 2016 cost estimate for completing construction of the MOX facility, including our September 2017 finding that the revised cost estimate substantially met best practices and could be considered reliable.[7]

To determine the potential effects of converting the MOX facility contract to a fixed-price incentive firm contract on the life-cycle cost of the Plutonium Disposition program, we also reviewed NNSA's revised 2016 life-cycle cost estimate for the program using the MOX approach, which is the most current NNSA life-cycle cost estimate available. In our September 2017 report, we found that this estimate did not follow best practices; we note this limitation when we discuss the estimate.[8]

To determine other observations on the Corps report and MOX facility, we compared information about how DOE and the contractor calculated the percentage of work completed against GAO's cost-estimating guide, a compilation of cost-estimating best practices drawn from across industry and government.[9] We also reviewed data from MOX Services' Quantity Tracking System on 29 commodities used in constructing the MOX facility. We assessed the reliability of the data by interviewing knowledgeable contractor staff and conducting electronic testing of the data. We found the data to be sufficiently reliable to provide information on the contractor's assessment of the status of commodity installation.

We conducted this performance audit from July 2017 to November 2017 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.

In summary, we found the following:

- **Potential effects of converting the contract on the cost for construction of the MOX facility.** According to NNSA and Corps officials and MOX Services representatives, changing the contract type is not certain to reduce the total costs to the government for constructing the MOX facility. The process of converting the MOX facility contract to a fixed-price incentive firm contract could present uncertainty about the costs of the project. For example, according to representatives of MOX Services, the contractor will account for increased risks and other uncertainties when developing its proposal. In addition, NNSA officials and representatives of the contractor said that the time needed to convert the contract would increase the time needed to complete construction, which could add to the cost of the project. However, according to the Corps report, completing the conversion of the current line item for MOX construction to a

[7]GAO-17-390.

[8]GAO-17-390.

[9]GAO, *GAO Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program Costs*, GAO-09-3SP (Washington, D.C.: Mar. 2, 2009).

fixed-price incentive firm line item would limit the government's risk of potential future cost increases by shifting this risk to the contractor.

- **Potential effects of converting the contract on the life-cycle cost of the Plutonium Disposition program.** NNSA officials we interviewed said they do not expect that converting the MOX facility construction contract to a fixed-priced incentive firm contract would significantly alter the life-cycle cost for the Plutonium Disposition program. NNSA's 2016 life-cycle cost estimate for the Plutonium Disposition program—which we found did not follow best practices—calls for 25 years of annual funding greater than $1 billion, including 10 years during MOX construction and 15 years during operations.[10] Contractor representatives we interviewed told us that the costs to operate the MOX facility would be less than NNSA's estimate. Moreover, NNSA is developing a life-cycle cost estimate for the dilute and dispose approach, which, according to agency officials, could be completed by the end of calendar year 2018 and will be performed in accordance with best practices.

- **Other observations.** We presented other observations on the Corps report and MOX facility in three areas:

    - **Estimates of time to convert to a fixed-price incentive firm line item.** The Corps estimated it would take 31 to 43 months to convert the MOX facility construction line item to a fixed-price incentive firm line item. According to Corps officials we interviewed, this estimate reflects the disagreement between NNSA and the contractor on the amount of work completed and the time needed to agree on a design and schedule for the MOX facility.

    - **Estimates of percentage of work completed.** Construction of the MOX facility is about 30 percent complete, based on the contractor's earned value data and DOE's 2016 construction cost estimate, which we found to be reliable in our September 2017 report.[11] The contractor's estimate of about 74 percent of work completed, which was calculated in accordance with GAO's cost-estimating guide,[12] is based on a 2012 estimate of construction costs that we found in February 2014 did not fully reflect the characteristics of a high-quality estimate and could not be considered reliable, in part because it was a proposal that was not reviewed and accepted by DOE.[13] We found that the key difference between DOE's estimate and the contractor's is the estimated budget at completion that each used, with DOE using its 2016 construction cost estimate minus proposed fees ($16.7 billion) and the contractor using its 2012 estimate minus management reserves, contingency, and fees ($6.6 billion).

[10]Some of the costs for the Plutonium Disposition program would occur regardless of whether the program uses the MOX facility or the dilute and dispose approach.

[11]Earned value data are taken from an earned value management system, which is a project management tool used to, among other things, compare the value of work accomplished in a given period with the value of the work expected in that period.

[12]GAO-09-3SP.

[13]GAO, *Plutonium Disposition Program: DOE Needs to Analyze the Root Causes of Cost Increases and Develop Better Cost Estimates,* GAO-14-231 (Washington, D.C.: Feb. 13, 2014).

- **Indication of work completed using commodity data.** We reviewed data from the contractor's Quantity Tracking System to better understand the amount of 29 commodities installed in the MOX facility. This approach, while not a traditional way to look at the percentage of the work that has been completed, provides some information on construction progress without using a calculation based on total project cost. The contractor has completed and verified the work for at least 70 percent of the total expected quantities for 10 commodities. Conversely, the contractor has not yet started the work for at least 70 percent of the total expected quantities for another 11 commodities.

Agency Comments, Third-Party Views, and Our Evaluation

We provided a draft of this report to DOE, the Corps, and MOX Services for review and comment. DOE and MOX Services provided written technical comments, which we summarize below. The Corps did not provide any comments.

DOE's comments addressed three main points. First, DOE reiterated that the department favors pursuing the dilute and dispose approach because it is a lower cost and risk alternative to the MOX facility. Our report did not examine whether the dilute and dispose approach is a lower cost and risk alternative to the MOX facility, as this was outside the scope of our review. Second, DOE stressed that if directed to continue construction of the MOX facility, the department will seek to convert the current MOX facility contract to a fixed-price incentive firm contract. DOE disagreed with the draft report's characterization that conversion of the contract could result in increased costs. We clarified in our report that costs could increase during the process to negotiate and agree upon a fixed-price incentive firm contract and that once a fixed-price incentive firm contract is in place, the level of risk that the government faces for cost increases would decrease. Third, DOE remarked that the draft report did not fully address the Corps report's findings and conclusions regarding risk allocation under the current contract. We revised our report to clarify this point.

In its comments, MOX Services stated it agreed with much of the draft report but provided four comments expressing concerns with parts of our findings.

First, MOX Services stated that it strongly disagrees with the statement that "construction of the MOX facility is about 30 percent complete," stating that its 2012 proposed rebaseline should be used to calculate percentage completed, since MOX Services considers this the latest budget at completion available. We used the 2016 construction cost estimate in this percentage completed calculation because it is the figure used by DOE and is a more current estimate of the likely budget for the project. As we note in the report, we previously reported that the 2012 estimate could not be considered reliable. Moreover, relying on the 2012 proposed rebaseline estimate also presents problems, particularly because it is outdated and skews the percentage completed estimate. MOX Services also took issue with how DOE calculated its 2016 construction cost estimate and with our determination that this estimate substantially met best practices and could be considered reliable. Our September 2017 report assessed DOE's 2016 cost estimate against best practices and found it could be considered reliable.[14]

Second, MOX Services noted that one of the reasons our February 2014 report found the 2012 estimate unreliable is that DOE had not reviewed and accepted the estimate.[15] We provided

[14]GAO-17-390.

[15]GAO-14-231.

additional context in the briefing enclosure to note this. However, our 2014 report finding that the 2012 estimate was unreliable was also based on our conclusion that the estimate did not meet or only minimally met other best practices. For example, we found that the proposal was partially accurate in that the contractor did not update it with actual costs incurred after submitting it to NNSA in September 2012. As stated in our February 2014 report, NNSA and contractor officials agreed that the estimate was no longer an accurate reflection of the cost to complete construction because the proposal assumed a higher level of funding than the project received.

Third, MOX Services stated it continues to believe the costs to operate the MOX facility will be "substantially less" than those estimated by NNSA. We noted MOX Services' position in our report; however, we did not conduct an assessment of the estimated costs to operate the MOX facility nor attempt to corroborate MOX Services' claim that these would be substantially less than estimated by NNSA.

Fourth, MOX Services also provided comments on the plutonium management and disposition agreement with Russia. This agreement was outside the scope of this audit and is not discussed in this report.

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We are sending copies of this report to the appropriate congressional committees, the Secretary of Energy, the Administrator of NNSA, the Secretary of Defense, 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 members have any questions concerning 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. Key contributors to this report were Hilary Benedict (Assistant Director), Rodney Bacigalupo, Antoinette Capaccio, Pamela Davidson, Scott Fletcher, Eleni Orphanides, Steven Putansu, Kevin Remondini, Karen Richey, Sara Sullivan, Kiki Theodoropoulos, and Tatiana Winger.

David C. Trimble
Director, Natural Resources and Environment

Enclosure

List of Committees

The Honorable John McCain
Chairman
The Honorable Jack Reed
Ranking Member
Committee on Armed Services
United States Senate

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

The Honorable Mac Thornberry
Chairman
The Honorable Adam Smith
Ranking Member
Committee on Armed Services
House of Representatives

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

MOX Fuel Fabrication Facility

Briefings in Response to a Mandate in the National Defense Authorization Act for Fiscal Year 2017

September 6, 12, and 14, 2017

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- Objective 3: Other Observations

Background: MOX Facility

In 1997, DOE established the Plutonium Disposition program—now managed by NNSA—to address the disposition of weapons-grade plutonium.

- As part of its Plutonium Disposition program, NNSA began constructing the Mixed Oxide Fuel Fabrication Facility (MOX facility) in 2007 at DOE's Savannah River Site in South Carolina (see fig. 1).

Background: MOX Facility

Figure 1: Aerial View of the Mixed Oxide Fuel Fabrication Facility Construction Project

Source: National Nuclear Security Administration. | GAO-18-122R

Background: MOX Facility

In 2007, DOE formally approved a cost estimate of $4.8 billion for construction of the MOX facility, with a scheduled completion date of September 2016.

- By 2012, NNSA had spent about $3.4 billion on the facility, and the contractor estimated that it needed approximately $4 billion more to complete construction by 2019.

In August 2016, in response to a provision in the National Defense Authorization Act for Fiscal Year 2016, DOE developed a revised cost estimate of approximately $17.2 billion to complete construction of the MOX facility by 2048.

- We recently found this estimate substantially met best practices and can be considered reliable.[1]

[1]GAO, *Plutonium Disposition: Proposed Dilute and Dispose Approach Highlights Need for More Work at the Waste Isolation Pilot Plant*, GAO-17-390 (Washington, D.C.: Sept. 5, 2017).

Background: MOX Facility

In April 2014, DOE completed an analysis of plutonium disposition options that identified an alternative dilute and dispose approach that DOE believes could significantly reduce the life-cycle cost of the Plutonium Disposition program.

- Starting with its fiscal year 2014 budget request—submitted in April 2013—DOE proposed slowing down work on the MOX facility while it assessed alternative strategies for plutonium disposition.

- DOE's fiscal year 2017 and 2018 budget requests proposed to terminate construction of the MOX facility and pursue the dilute and dispose approach for plutonium disposition. Under this approach, plutonium would be diluted with inert material to inhibit its future use in weapons. It would then be packaged and shipped to a repository for permanent disposal.

Background: DOE and Corps Reports

The National Defense Authorization Act for Fiscal Year 2017 required DOE to arrange with the U.S. Army Corps of Engineers (Corps) to prepare a report on the contract for the construction, management, and operations of the MOX facility, including:

- an assessment of the contractual, technical, and managerial risks for DOE and the contractor;
- an assessment of the elements of the contract that could be changed to fixed-price provisions; and
- recommendations on changes to the contract to reduce risk and cost to DOE while preserving a fair and reasonable contract.

DOE was to submit a report on the Corps report to the congressional defense committees.

The Corps submitted its report to DOE on February 22, 2017, and DOE submitted its report to the congressional defense committees on July 14, 2017.

Background: DOE and Corps Reports

The Corps recommended a two-phased approach to changing the contract.

- In the first phase, the Corps recommended determining the scope of the remaining work, which could include slowing down or stopping work on the construction of the facility, rebaselining the project, and negotiating changes to the contract.
- After agreement has been reached on the final design, the Corps recommended a second phase that would include changing the construction portion of the current contract, which is a cost-reimbursable line item, to a fixed-price incentive firm contract line item.
- The Corps estimated that it would take 31 to 43 months to convert the remaining construction work to a fixed-price incentive firm contract line item.

According to the Corps report, changing the contract type would reduce the level of government risk from that currently experienced under the existing contract.

However, if an agreement to convert the contract cannot be reached, the Corps recommended that DOE consider terminating the current contract.

Background: DOE and Corps Reports

According to DOE's report, the department continues to believe that terminating construction of the MOX facility is the best approach.

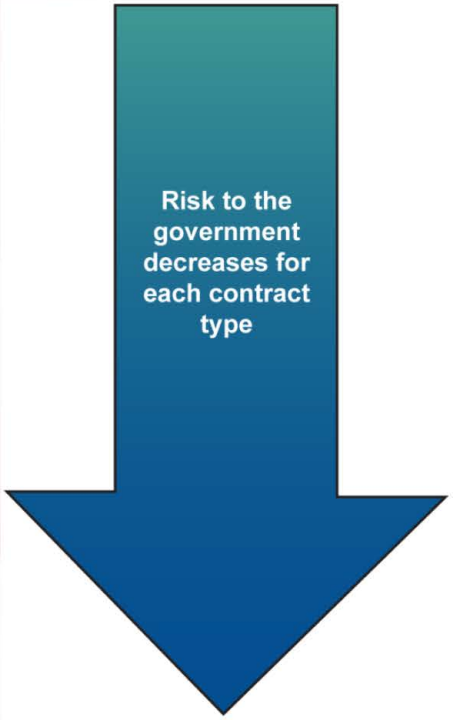
DOE's report further stated that if construction of the facility continues, the department recognizes the merits of the Corps' recommendations to

(1) convert the line item for construction to a fixed-price incentive firm line item so as to reduce cost and risk to the government and

(2) slow down or stop construction during the contract conversion period in order to complete design and determine how much work has been completed.

DOE's report also stated that the department is concerned that there may be significant challenges in reaching an agreement to convert the contract, which could further delay completion of the MOX facility.

Figure 2: Characteristics of Selected Contract Types



Contract type

Cost-Reimbursement Contracts
- The government pays allowable incurred costs to the extent specified in the contract and may include an additional fee (profit).
- The contractor must put forth its best efforts to perform the work within the estimated costs.
- However, the government must reimburse the contractor for its allowable costs regardless of whether the work is completed.

Fixed-Price Incentive
- The contract specifies several contract elements including a profit adjustment formula.
- The government and the contractor share responsibility for cost increases, or decreases, compared to the agreed upon target cost.
- The final negotiated cost is subject to a ceiling price, which is the maximum that may be paid to the contractor, except for any adjustment under other contract clauses.

Firm-Fixed Price
- Government agrees to a set price and the contractor is required to deliver regardless of their actual costs.
- The contractor bears the maximum risk and full responsibility for all costs and resulting profit or loss.

Source: GAO and analysis of the Federal Acquisition Regulation and Defense Acquisition University information. | GAO-18-122R

Objectives

The National Defense Authorization Act for Fiscal Year 2017 included a provision for us to review the actions taken by DOE related to the Corps' report on the MOX facility contract.

This briefing provides information on:

(1) The potential effects of converting the MOX facility contract to a fixed-priced incentive firm contract, as discussed in the DOE and Corps reports, on the cost for construction of the MOX facility.

(2) The potential effects of converting the MOX facility contract to a fixed-price incentive firm contract, as discussed in the DOE and Corps reports, on the life-cycle cost of the Plutonium Disposition program.

(3) Other observations on the Corps report and MOX facility.

Methodology

To answer these objectives, we:

- Reviewed the Corps and DOE reports and interviewed DOE, NNSA, and Corps officials responsible for developing those reports.
- Interviewed NNSA officials at the MOX Project Management Office at the Savannah River Site.
- Interviewed representatives from CB&I AREVA MOX Services, LLC (MOX Services), the contractor constructing the MOX facility, and reviewed the contractor's response to questions from NNSA included in the DOE report.
- Reviewed the contractor's data on 29 commodities used in constructing the MOX facility from its Quantity Tracking System.
  - We assessed the reliability of the data by interviewing knowledgeable contractor staff and conducting electronic testing of the data. We found the data to be sufficiently reliable to provide information on the contractor's assessment of the status of commodity installation.

Methodology

- Reviewed information about DOE's 2016 cost estimate for completing construction of the MOX facility.
  - In our September 2017 report (GAO-17-390), we found that the revised cost estimate substantially met best practices and can be considered reliable.
- Reviewed NNSA's revised 2016 life-cycle cost estimate for the Plutonium Disposition program, which includes the MOX facility.
  - The 2016 estimate is the only current NNSA life-cycle cost estimate available. This estimate is a revision of a draft estimate previously completed in 2013.
  - In our September 2017 report, we found that NNSA's revised 2016 life-cycle cost estimate did not follow best practices. We note this limitation when we discuss the estimate.

We received technical comments on the information in this briefing from DOE, NNSA, the Corps, and the contractor, which we incorporated as appropriate.

Objective 1: Potential Effects of Converting the Contract on the Cost for Construction of the MOX Facility

DOE's current cost estimate for the MOX facility construction is $17.2 billion. In our September 2017 report, we found this estimate substantially met best practices and can be considered reliable.

According to Corps and NNSA officials and MOX Services representatives, it is not certain that changing the contract type will reduce the total costs to the government of constructing the MOX facility.

Converting the current line item for MOX construction to a fixed-price incentive firm line item would limit government risk of potential cost increases for included items by shifting this risk to the contractor.

NNSA officials and MOX Services representatives also stated the continued uncertainty about the future of the facility is likely to lead to further cost increases.

Objective 1: Potential Effects of Converting the Contract on the Cost for Construction of the MOX Facility

The process of converting the MOX facility contract to a fixed-price incentive firm contract could present uncertainty about the costs of the project.

- According to representatives of MOX Services, the contractor will account for increased risks and other uncertainties when developing its proposal.
- NNSA officials and representatives of the contractor said that the time it takes to convert to a fixed-price incentive firm contract would increase the amount of time needed to complete construction. Any schedule delays could lead to increased costs, and during this time, the risk remains with the government.
- As discussed in the Corps report, leaving some items as cost-reimbursable would leave some risk for cost increases for the government.

However, according to the Corps report, once a fixed-price incentive firm contract is in place, the level of risk facing the government for cost increases would decrease from that currently experienced under the existing contract.

Objective 2: Potential Effects of Converting the Contract on the Life-Cycle Cost of the Plutonium Disposition Program

NNSA officials said they do not expect the change to a fixed-price incentive firm line item to significantly alter the life-cycle cost of the Plutonium Disposition program, which includes the MOX facility.

In 2016, NNSA estimated the life-cycle cost for the Plutonium Disposition program to be $56 billion. This includes costs for:

- constructing the MOX facility through 2048;
- operating the MOX facility from 2046 through 2063;
- preparing the feedstock, studying and modifying reactors to accept MOX fuel, and shipping pits—collectively referred to as MOX Irradiation, Feedstock, and Transportation;[2] and
- other program costs, such as program management costs.

[2]Some of these costs would occur regardless of whether the program uses the MOX facility or the dilute and dispose approach.

Objective 2: Potential Effects of Converting the Contract on the Life-Cycle Cost of the Plutonium Disposition Program

We found in September 2017 (GAO-17-390) that NNSA had not applied best practices when revising its 2016 life-cycle cost estimate for the Plutonium Disposition program, which includes the MOX facility.

- In February 2014, we recommended that NNSA revise its life-cycle cost estimate for the Plutonium Disposition program to incorporate best practices.[3]
  - In its response to that report, DOE stated that until a path forward for the Plutonium Disposition program is determined, it would not be cost effective to prepare a revised estimate.
  - We present these estimates because they are the only current estimates available to provide a sense of the potential costs of the Plutonium Disposition program.

[3]GAO, *Plutonium Disposition Program: DOE Needs to Analyze the Root Causes of Cost Increases and Develop Better Cost Estimates*, GAO-14-231 (Washington, D.C.: Feb. 13, 2014).

Objective 2: Potential Effects of Converting the Contract on the Life-Cycle Cost of the Plutonium Disposition Program

NNSA's 2016 life-cycle cost estimate calls for 6 years with annual funding at or above $1.5 billion, and an additional 19 years requiring annual funding greater than $1 billion (see fig. 3). These costs span:

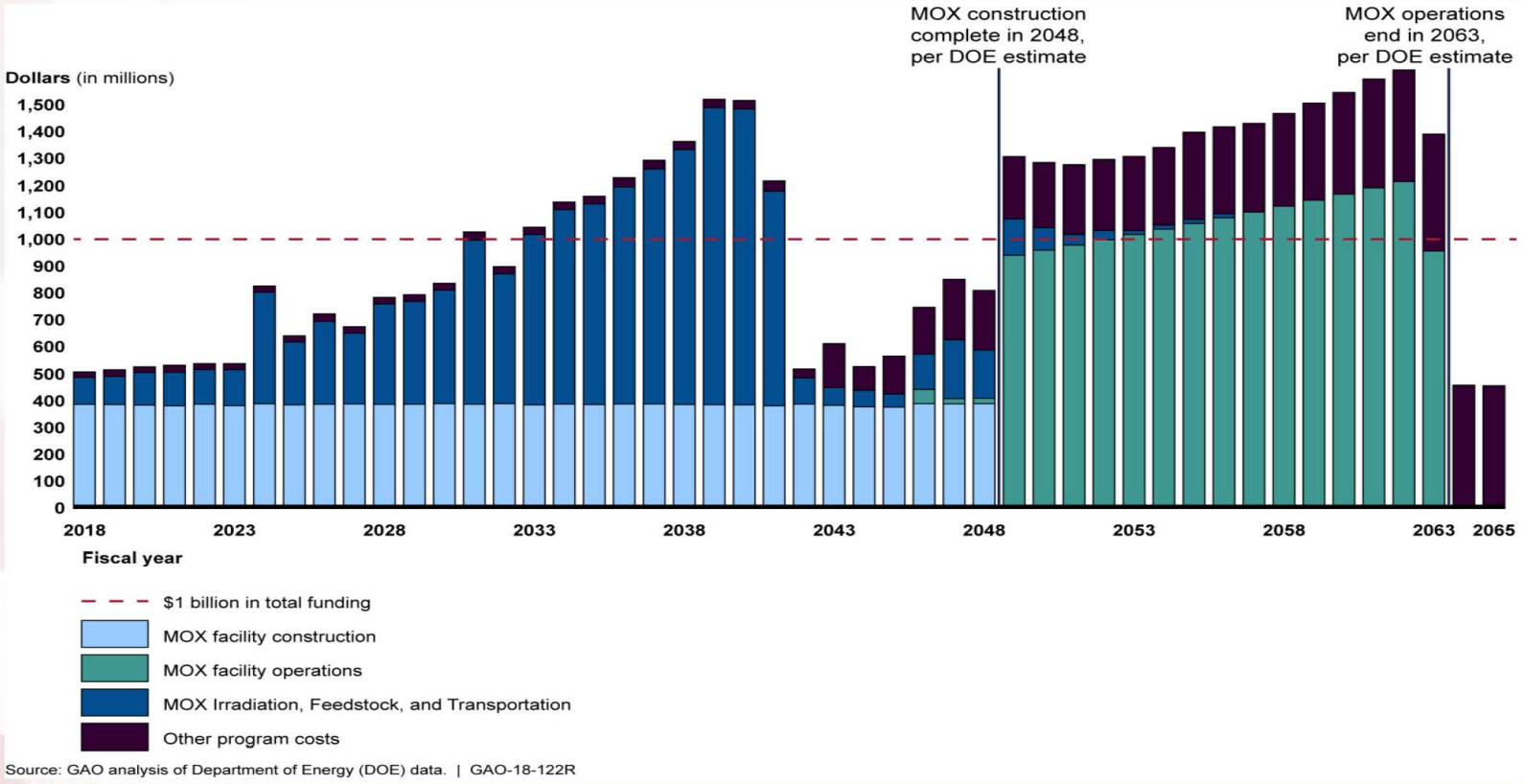
- 10 years during the construction of the MOX facility and
- 15 years while the facility is in operation.

MOX Services representatives said that the costs to operate the MOX facility would be less than NNSA's estimate.

NNSA is developing a life-cycle cost estimate for the dilute and dispose approach. According to NNSA officials, this estimate could be completed by the end of calendar year 2018 and will be performed in accordance with best practices.

Enclosure

Figure 3: DOE's 2016 Life-Cycle Cost Estimate for the Plutonium Disposition Program, including the MOX Facility



Source: GAO analysis of Department of Energy (DOE) data. | GAO-18-122R

Note: We found in September 2017 (GAO-17-390) that NNSA had not applied best practices when revising its 2016 life-cycle cost estimate for the Plutonium Disposition program. We present these estimates as they are the only current estimates available to provide a sense of the potential costs of the program.

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Objective 3: Other Observations

Estimates of Time to Convert to a Fixed-Price Incentive Firm Contract

The Corps estimated that it would take 31 to 43 months from the time a decision is made to convert the remaining work to a fixed-price incentive firm contract line item to the time the contract is modified. This estimated time frame includes:

- 12 to 18 months to determine the work that has been completed and the work remaining,
- 18 to 24 months for the preparation of the contractor's proposal and negotiations, and
- 1 month to modify the contract.

According to Corps officials, their estimate of the time to reach agreement on changes to the contract reflects the disagreement between NNSA and the contractor on the amount of work completed and the time needed to agree on a design and schedule for the MOX facility.

In its report, the Corps recommended slowing the pace of work while determining the work that remains and negotiating the changes to the contract.

Objective 3: Other Observations

Estimates of Percentage of Work Completed

Construction of the MOX facility is about 30 percent complete, based on the contractor's earned value data and DOE's 2016 construction estimate.

According to the GAO cost-estimating guide,[4] the percentage completed for a project is calculated as the budgeted cost for work performed—also known as earned value—divided by the budget at completion. The budget at completion is defined as the contract budget minus amounts for management reserve—money set aside in the project's budget for risks that were unknown at the project's start—and fees.

[4]GAO, *GAO Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program Costs*, GAO-09-3SP (Washington, D.C.: March 2009).

Objective 3: Other Observations

The contractor's estimate that the project is more than 70 percent complete is based on the contractor's 2012 proposed rebaseline estimate. The formula the contractor used to calculate the percentage completed was consistent with GAO's cost-estimating guide.

- In February 2014, we found that the contractor's 2012 proposed rebaseline estimate did not fully reflect the characteristics of a high-quality estimate and could not be considered reliable, in part because it was a proposal that was not reviewed and accepted by DOE.[5]
- In July 2016, the contractor estimated the costs of the project at completion as $9.99 billion based on annual funding of $350 million.

When we compared these estimates of percentage of the project completed, we found that the key difference between DOE's and the contractor's estimates is the estimated budget at completion used in their estimates, as shown in table 1.

[5]GAO-14-231.

Table 1: Comparison of DOE's and Contractor's Estimates of Percentage of Project Completed

Organization	Estimate of percentage completed	Cumulative earned value estimate, based on contractor data	Budget at completion estimate
DOE	about 30 percent	$4.9 billion	$16.7 billion Based on DOE's 2016 construction cost estimate of $17.2 billion, minus proposed fees. In September 2017, we found DOE's 2016 estimate substantially met best practices and can be considered reliable.
MOX Services (contractor)	74 percent[a]	$4.9 billion	$6.6 billion Based on the contractor's 2012 estimate of $7.7 billion minus management reserves, contingency, and fees. In February 2014, we found that the contractor's 2012 proposed rebaseline estimate for the facility did not fully reflect the characteristics of a high-quality estimate and could not be considered reliable.

[a]As noted in the table above, the 74 percent estimate of percentage completed is based on a 2012 estimate that we found to be unreliable in 2014, in part because it was a proposal that was not reviewed and accepted by DOE. Using MOX Services' July 2016 estimate at completion—minus estimated management reserves, contingency, and fees—of approximately $8.7 billion, the estimated percentage completed would be about 56 percent.

Source: GAO analysis of DOE and contractor (MOX Services) information. | GAO-18-122R

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Objective 3: Other Observations

Indication of Work Completed Using Commodity Data

We reviewed data from the contractor's Quantity Tracking System to better understand the amount of the 29 commodities installed in the MOX facility.

- While not a traditional way to look at the percentage of the work that has been completed, this approach provides some information on construction progress without using a calculation based on total project cost.
- The contractor provided us with data for the 29 commodities on the amount (1) expected to be installed in the facility, (2) that has been completed and the work verified by the contractor, (3) that has been started but not completed, and (4) that has not been started.
- The contractor's data do not account for potential issues with work that may need to be redone, referred to as "rework." The Corps report stated that there is a substantial amount of rework that can be anticipated given issues with the current design and schedule, among other issues.

Objective 3: Other Observations

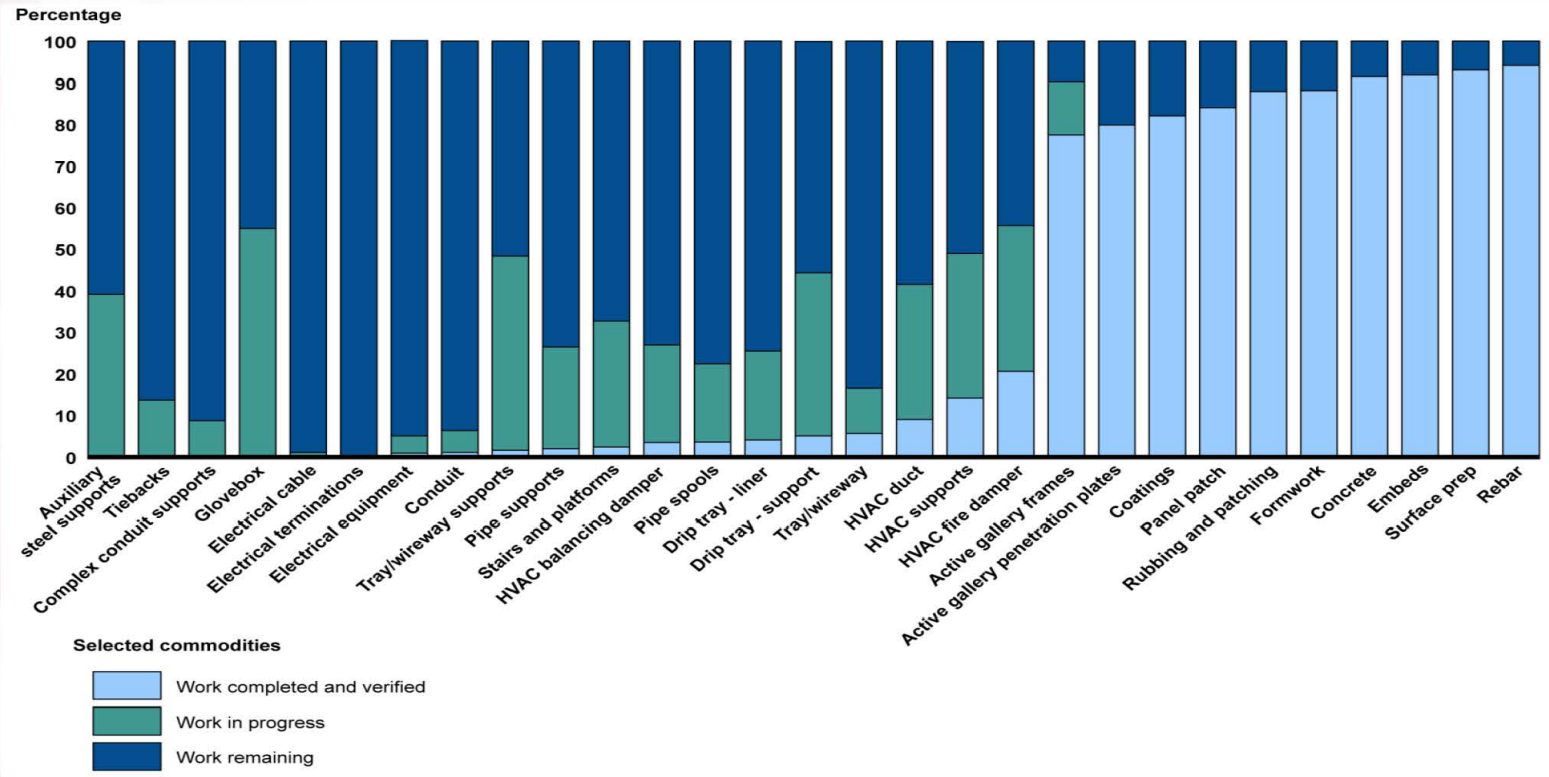
As shown in figure 4 and table 2:

- For 10 commodities, the contractor has completed and verified the work for at least 70 percent of the total expected quantities.
- For another 11 commodities, the contractor has not yet started the work for at least 70 percent of the total expected quantities.

There are limitations to this analysis. For example:

- The work that the contractor has completed generally reflects the typical progression of construction, with much of the concrete work completed first and other commodities, such as electrical wire, installed later.
- Our analysis of the data does not provide recognition of the amount of effort needed to complete the remaining work.

Figure 4: Status of Installation of 29 Commodities in the MOX Facility as a Percentage of the Total Forecast Quantity of the Commodity (as of July 30, 2017)



Source: GAO analysis of MOX facility contractor's Quantity Tracking System data. | GAO-18-122R

Note: The contractor's data do not account for potential issues with work that may need to be redone, referred to as "rework." The Corps report stated that there is a substantial amount of rework that can be anticipated given issues with the current design and schedule, among other issues.

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Table 2: Status of Installation of 29 Commodities in the MOX Facility, as of July 30, 2017

Commodity	Unit of measure	Total forecast quantity	Work completed and verified	Work in progress	Work remaining
Auxiliary steel supports	pounds	594,591	0	232,662	361,929
Tiebacks	each	440	0	60	380
Complex conduit supports	each	841	0	72	769
Glovebox	each	417	0	229	188
Electrical cable	linear feet	6,867,153	0	75,107	6,792,047
Electrical terminations	each	364,965	0	284	364,681
Electrical equipment	each	4,498	39	178	4,281
Conduit	linear feet	728,927	7,992	37,350	683,585
Tray/wireway supports	each	4,438	69	2,069	2,300
Pipe supports	each	32,134	658	7,805	23,671
Stairs and platforms	pounds	1,240,457	30,390	374,166	835,901
HVAC balancing damper	each	1,751	62	408	1,281
Pipe spools	linear feet	444,796	15,959	83,616	345,221
Drip tray – liner	each	1,466	60	313	1,093
Drip tray – support	each	1,937	95	764	1,078

Source: GAO analysis of MOX facility contractor's Quantity Tracking System data. | GAO-18-122R

Table 2: Status of Installation of 29 Commodities in the MOX Facility, as of July 30, 2017 (continued)

Commodity	Unit of measure	Total forecast quantity	Work completed and verified	Work in progress	Work remaining
Tray/wireway	linear feet	83,797	4,608	9,180	70,009
HVAC duct	pounds	1,333,410	118,247	435,035	780,129
HVAC supports	each	9,560	1,351	3,322	4,887
HVAC fire damper	each	1,133	233	396	504
Active gallery frames	each	31	24	4	3
Active gallery penetration plates	each	342	273	0	69
Coatings	square feet	3,185,747	2,613,353	0	572,394
Panel patch	square feet	440,273	369,830	0	70,443
Rubbing and patching	square feet	1,994,537	1,752,950	0	241,587
Formwork	square feet	2,187,928	1,928,492	0	259,436
Concrete	cubic yards	177,549	162,256	0	15,293
Embeds	each	32,531	29,869	0	2,662
Surface prep	square feet	3,441,069	3,199,456	0	241,613
Rebar	ton	37,959	35,730	0	2,229

Source: GAO analysis of MOX facility contractor's Quantity Tracking System data. | GAO-18-122R

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