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

Nuclear Weapons: Information on the National Nuclear Security Administration's Research Plan for Plutonium and Pit Aging

The radioactive element plutonium is a strategic material in the nation's nuclear weapon stockpile that was first made and isolated in 1940. Plutonium is used in pits, which are the central core of all nuclear weapons in the stockpile; pits are compressed or imploded with high explosives to create a nuclear explosion. Because the U.S. has not produced significant numbers of pits since 1989, most pits in the stockpile are at least 30 years old. The U.S. is reestablishing production facilities to manufacture new plutonium pits. However, as we have previously reported, the full pit production capability currently planned will not be achieved as expected by 2030.[1] Production delays will create an increased reliance on existing plutonium pits in the stockpile for years to come. Moreover, since 1992, the U.S. has observed a unilateral moratorium on nuclear explosive testing. As a result, pit performance must be assessed in other ways.

Scientists and other weapons experts have identified concerns that radioactive decay of plutonium in a pit, called aging, over many years may degrade a weapon's performance. For example, plutonium decay releases helium as a byproduct, which forms bubbles within the plutonium metal that can affect plutonium strength and change the way a pit compresses, among other things. Other byproducts from plutonium's radioactive decay can also affect the way a pit compresses. The concern about such changes in plutonium is that, over time, they could lead to an unacceptable yield reduction in a weapon's first stage, the primary. A plutonium pit in a weapon's primary, when imploded, must produce a sufficient yield to initiate a nuclear weapon's second stage, referred to as the secondary, to achieve the weapon's intended yield performance.[2]

[1]GAO, *Nuclear Weapons: NNSA Does Not Have a Comprehensive Schedule or Cost Estimate for Pit Production Capability,* GAO-23-104661 (Washington, D.C.: Jan. 12, 2023).

[2]Most nuclear weapon systems in the U.S. stockpile are two-stage weapons. The first stage (primary) consists of a hollow pit typically made of plutonium and other materials, surrounded by explosive material. The second stage (secondary) may consist of uranium, lithium, and other materials. The primary and the secondary together, housed within a radiation case, are referred to as the weapon's explosive package. When detonated, these nuclear components produce the weapon's explosive energy, or "yield."

The National Nuclear Security Administration (NNSA)—a separately organized agency within the Department of Energy (DOE)—is responsible for ensuring the stockpile's performance, safety, and reliability. NNSA oversees the nuclear security enterprise, which comprises national security laboratories, production plants, and other sites dedicated to carrying out this mission. To assess the stockpile in the absence of nuclear testing, scientists at the national security laboratories rely on physics models and computer simulations. The physics models used to assess the stockpile were originally built using data from a wide array of experiments and historic underground nuclear explosive tests. However, because plutonium pits currently in the stockpile are older than pits evaluated through underground testing, NNSA must also rely on data from new and ongoing experimental research on plutonium aging to inform and improve these models.

Beginning in the late 1990s, scientists at the national security laboratories conducted a campaign of studies and modeling to assess plutonium aging. In 2006, the laboratories reported that there was no degradation in primary performance for weapon systems due to plutonium aging that would be cause for near-term concern regarding their safety and reliability. The JASON Defense Advisory Group (JASON) independently reviewed the laboratories' assessments and reported in 2007 that the laboratories used a valid framework for evaluating pit lifetimes.[3] Further, the JASON report recommended that NNSA continue to conduct research and develop weapon system-specific lifetimes for pits, among other things. Weapon system-specific lifetime assessments are necessary because each weapon type has different military requirements and operating environments that can affect plutonium aging.

While NNSA and the laboratories have continued to conduct aging research since 2007, NNSA and Congress recognize that uncertainties remain about the effects plutonium aging has on primary performance for each weapon system in the stockpile. Further, NNSA identifies new pit production as a mitigation against these uncertainties. However, while pits continue to age, NNSA's efforts to reestablish pit production, as noted above, have taken longer than planned.

In 2018 and 2019, the Defense Programs Advisory Committee (DPAC) and JASON, respectively, reported that NNSA was not sufficiently prioritizing plutonium and pit aging research.[4] These classified, independent evaluations stated that NNSA and its laboratories had made some progress in aging research—notably in developing samples of artificially aged plutonium.[5] Both reports recommended that NNSA develop a focused program of experiments, theory, and simulations to study the effects of plutonium aging.

[3]JASON Defense Advisory Group, *Pit Lifetime*, JSR-06-335 (McLean, Va.: Jan. 11, 2007). JASON's mission is to contribute to national security and public benefit by working on problems of importance to the U.S. government. The group is organized and supported by the MITRE Corporation—a not-for-profit research and development organization.

[4]Defense Programs Advisory Committee, *Assessment of the State of Understanding of Pu Primary Aging* (Washington, D.C.: Aug. 1, 2018) and JASON Defense Advisory Group, *Pit Aging,* JSR-19-2A (McLean, Va.: Nov. 23, 2019). DPAC provides NNSA leadership with independent advice and recommendations from experts regarding how to deliver the mission more efficiently and effectively while keeping pace with threats and evolving conditions. DPAC was replaced by the Advisory Committee for Nuclear Security in April 2023.

[5]Artificially aged samples are needed because existing, naturally aged plutonium is limited to 65 years old. Plutonium alloys used in pits are artificially aged by spiking samples with more rapidly decaying types of plutonium to approximate aging effects of 150 years or more.

Following these reports, Congress directed NNSA to develop a comprehensive, integrated 10-year research program plan for pit and plutonium aging.[6] NNSA submitted such a plan to Congress in September 2021. The plan includes areas of study, planned experiments, mid- and long-term goals, and estimated costs.[7]

House Report 117-397, accompanying a bill for the National Defense Authorization Act for Fiscal Year 2023, includes a provision for GAO to assess NNSA's plan to study plutonium aging.[8] Our review examined (1) the current age and estimated lifetimes of pits in the stockpile; (2) key goals, milestones, program elements, enabling capabilities, and budgetary requirements of NNSA's research plan; and (3) the impact that lifetime estimates may have on stockpile management and pit production. This report provides an unclassified summary of our November 7, 2023, classified briefing to you on the results our review.

To address our objectives, we reviewed NNSA's *Research Program Plan for Plutonium and Pit Aging* (Research Plan) and other documentation on stockpile planning. We also reviewed NNSA information on the ages of pits currently in the stockpile. In addition, we interviewed NNSA officials and national security laboratory scientists about the Research Plan, the current status of plutonium aging research, pit ages and expected lifetimes, and how results from the research may be used to inform decisions about stockpile management and modernization. We also reviewed the two classified, independent evaluations, with recommendations, on NNSA's plutonium pit aging research priorities: a 2018 DPAC report and a 2019 report from JASON.[9] Further, we attended two classified seminars at NNSA on planned experiments relevant to the plutonium aging research.

We conducted this performance audit from March 2023 to February 2024 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

In our November 2023 briefing, we provided key classified details on the following topics:

- Pit ages for current nuclear weapon systems in the U.S. stockpile and average ages for which NNSA has confidence in pit performance
- Key goals and milestones for NNSA's Research Plan, including for developing high-confidence, age-aware modeling for each stockpile system
- Experimental facilities, other capabilities, and budget estimates to implement the Research Plan

[6]Explanatory Statement accompanying Consolidated Appropriations Act, 2021, Pub. L. No. 116-260, 134 Stat. 1182 (2020), printed in 166 Cong. Rec. H8375-6 (daily ed. Dec. 21, 2020) (statement of Rep. Lowey).

[7]NNSA, *Research Program Plan for Plutonium and Pit Aging* (Washington, D.C.: September 2021).

[8]H.R. Rep. No. 117-397, at 436-7 (2022) (accompanying H.R. 7900, a bill for the National Defense Authorization Act for Fiscal Year 2023).

[9]Defense Programs Advisory Committee, *Assessment of the State of Understanding of Pu Primary Aging,* and JASON Defense Advisory Group, *Pit Aging.*

- Key experimental and modeling and simulation activities included in the Research Plan
- Impacts that pit lifetime estimates may have on stockpile management and pit production

According to NNSA officials, the results from the Research Plan will allow NNSA to more confidently predict pit lifetimes for each weapon system in the stockpile. To do so, NNSA will require the use of experimental facilities across the nuclear security enterprise. For example, NNSA's plan includes the use of the Enhanced Capabilities for Subcritical Experiments (ECSE) instruments at the Nevada National Security Site.[10] NNSA will also need to expand its library of artificially aged plutonium samples so that aging effects can be projected decades into the future.

According to the Research Plan, NNSA's estimated budgetary requirements to carry out the planned experiments, modeling, and simulation activities total about $1 billion over the 10-year period of fiscal years 2021 through 2030. This estimated budget does not include costs related to existing facilities or establishing new equipment and infrastructure such as the ECSE, which are supported in other parts of NNSA's budget. In addition to plutonium aging research, NNSA officials and independent evaluations identified the need to continue to pursue plutonium pit production to mitigate risks associated with plutonium aging.

Agency Comments

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

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

If you or your staff have any questions about this report, please contact me at (202) 512-3841 or bawdena@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made key contributions to this report were Brian M. Friedman (Assistant Director), John W. Hocker (Analyst in Charge), Antoinette Capaccio, Pamela Davidson, and Cynthia Norris.

Allison Bawden
Director, Natural Resources and Environment

[10]We previously reported on the need for NNSA to better manage risks associated with new subcritical experimental equipment and infrastructure. NNSA agreed with our recommendation; as of February 2024, the agency had not yet completed actions necessary to address it. GAO, *Nuclear Weapons: Program Management Improvements Would Benefit U.S. Efforts to Build New Experimental Capabilities,* GAO-23-105714 (Washington, D.C.: Aug. 30, 2023).

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