United States Government Accountability Office

Report to Congressional Committees

June 2019

NUCLEAR WEAPONS

Additional Actions Could Help Improve Management of Activities Involving Explosive Materials

GAO-19-449

June 2019

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Additional Actions Could Help Improve Management of Activities Involving Explosive Materials

GAO Highlights

Highlights of GAO-19-449, a report to congressional committees

Why GAO Did This Study

NNSA is responsible for the management and security of the U.S. nuclear stockpile. NNSA has ongoing and planned efforts to modernize nearly all of the weapons in the stockpile, which require new explosive components. The production of some key explosives ceased in the early 1990s, and much of the infrastructure supporting this work is aging, making it expensive and difficult to maintain.

The Senate Report accompanying a bill for the National Defense Authorization Act for Fiscal Year 2018 included a provision for GAO to review NNSA's high explosive capabilities specific to nuclear weapons. This report examines (1) explosives activities that NNSA and its sites conduct and how NNSA manages them; (2) challenges NNSA officials and contractor representatives identified in conducting these activities and the extent to which NNSA has taken actions to address them; and (3) the extent to which NNSA's strategic plan for explosives activities describes further actions, if any, to address the challenges identified and follows leading practices for strategic planning. GAO reviewed NNSA documents related to explosives activities, including its strategic plan; compared the plan with leading practices; and interviewed NNSA officials and site representatives.

What GAO Recommends

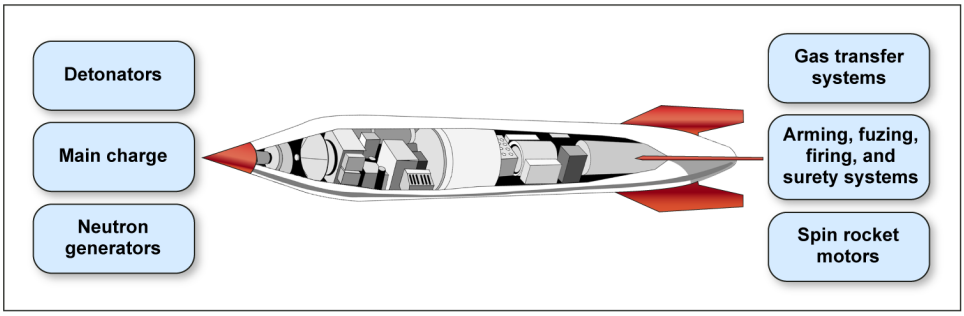
GAO is making three recommendations, including that NNSA, as it revises its strategic plan for explosives activities, include fully developed elements of an effective strategic plan. NNSA agreed with GAO's recommendations.

View GAO-19-449. For more information, contact Allison Bawden at (202) 512-3841 or bawdena@gao.gov.

What GAO Found

Five National Nuclear Security Administration (NNSA) contractor-operated sites conduct activities to design and produce explosive materials. There are about 100 different nuclear weapon components that contain explosive materials (see figure). Each site assumes primary responsibility for certain activities, but most activities require collaboration by multiple sites, according to NNSA officials and contractor representatives. In 2018, NNSA began adopting a centralized approach to managing these activities and coordinating them across its sites.

Key Explosive-Containing Components in a Generic Nuclear Weapon



Source: GAO analysis of National Nuclear Security Administration and Department of Energy documents. | GAO-19-449

Notes: Symbols do not show actual designs. Detonators enable components to function. Main charges compress the nuclear core, or pit, creating a nuclear reaction. Neutron generators facilitate the reaction, which can be enhanced by gas transfer systems that inject gases into the pit. Arming, fuzing, firing, and surety systems ensure that weapons will operate safely, securely, and reliably and only when authorized. Spin rocket motors perform an arming function in nuclear bombs.

NNSA officials and contractor representatives identified several challenges related to explosives activities, such as the agency's dwindling supply of explosive materials, aging and deteriorating infrastructure, and difficulty recruiting and training qualified staff. For example, only a single container of one specialized material remains. NNSA officials and contractor representatives indicated that the agency is taking some actions to address these challenges, such as working to replenish the supply of dwindling, highly specialized materials.

NNSA's strategic plan for explosives activities addresses some of the challenges agency officials and contractor representatives have identified, and NNSA followed several key leading practices in developing its strategic plan. However, some of the plan's elements have not been fully developed consistent with selected leading practices. For instance, the plan does not include a fully developed mission statement, and some performance goals are not quantifiable. NNSA officials stated that they are aware of the strategic plan's limitations and that they released it quickly to ensure that the explosives community could use it as soon as possible. NNSA officials said that they intend to revise the strategic plan in the next year or so. As NNSA revises its strategic plan, by including fully developed elements of an effective strategic plan, NNSA would help make the strategic plan more useful in measuring goal achievement and assessing accountability.

Contents

Abbreviations

CHE	conventional high explosives
DARHT	Dual-Axis Radiographic Hydrodynamic Test Facility
DOD	Department of Defense
DOE	Department of Energy
FIMS	Facilities Information Management System
FTE	full-time equivalent
GPRA	Government Performance and Results Act of 1993, as amended
HMX	high melting explosive (cyclotetramethylene tetranitramine)
IHE	insensitive high explosives
IMX	insensitive munitions explosive
LEP	life extension program
NNSA	National Nuclear Security Administration
OMB	Office of Management and Budget
PETN	pentaerythritol tetranitrate
RDX	research development explosive
TATB	triaminotrinitrobenzene
THKP	titanium sub-hydride potassium perchlorate

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U.S. GOVERNMENT ACCOUNTABILITY OFFICE
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June 17, 2019

Congressional Committees

Approximately 100 different explosive components are essential to the operation of U.S. nuclear weapons.[1] Explosives serve many functions in nuclear weapons because they can deliver energy quickly and precisely. To perform these precise functions, explosives for use in nuclear weapons must be designed and manufactured to exacting specifications. The Department of Energy (DOE) and its contractors ceased producing some key explosives used in nuclear weapon components in the early 1990s. DOE's National Nuclear Security Administration (NNSA) and its contractor-operated sites have recently resumed their production and testing of some explosives in support of ongoing life extension programs (LEP) and modernization efforts for nuclear weapons.[2] Each of these efforts involves replacing or modernizing explosive components. Many of the facilities that support NNSA's LEPs and modernization efforts—and the related activities to develop and produce explosives—were built in the 1940s and 1950s, making them costly and difficult to maintain. The age and condition of some of these facilities also pose safety issues if mitigation actions are not implemented, according to NNSA documents. In this context, in December 2018, NNSA released its *Defense Programs Strategic Plan for Energetic Materials* (strategic plan), which provided a framework for addressing challenges related to managing explosive materials and related activities, such as NNSA's aging infrastructure, as well as strategies to mitigate them.[3]

[1]The term "explosives" refers to a group of materials also sometimes referred to as "energetics." These terms include the same categories of materials (high explosives, pyrotechnics, and propellants). In this report, we use the term explosives unless the National Nuclear Security Administration's documentation specifically refers to energetics.

[2]NNSA is a separately organized agency established within DOE in 1999. NNSA is responsible for the nation's nuclear weapons, nonproliferation, and naval reactor programs. NNSA and the Department of Defense undertake LEPs to refurbish or replace nuclear weapons' components to extend the lives of the weapons and enhance their safety and security characteristics. Other modernization activities include alterations, which represent a material change to a weapon regarding assembly, maintenance, or storage, but do not alter the weapon's operational capability.

[3]National Nuclear Security Administration, NA-122.1 Office of Stockpile Services, *Defense Programs Strategic Plan for Energetic Materials*, Version 1.0 (Washington, D.C.: Dec. 26, 2018).

A Senate committee report accompanying a bill for the National Defense Authorization Act for Fiscal Year 2018 included a provision for us to review NNSA's high explosive capabilities specific to nuclear weapons.[4] This report examines (1) explosives activities that NNSA and its sites conduct and how NNSA manages these activities; (2) challenges NNSA officials and contractor representatives have identified in conducting explosives activities and the extent to which NNSA has taken actions to address these challenges; and (3) the extent to which NNSA's strategic plan for explosives activities describes further actions, if any, to address the challenges NNSA officials and contractor representatives have identified and follows leading practices for strategic planning.

To address all three objectives, we analyzed NNSA planning documents pertaining to NNSA's management of explosives, such as the December 2018 strategic plan. In addition to reviewing documents, we conducted site visits at four of NNSA's five contractor managed and operated sites engaged in explosives activities—Lawrence Livermore National Laboratory in Livermore, California (Livermore); Los Alamos National Laboratory in Los Alamos, New Mexico (Los Alamos); the Pantex Plant in Amarillo, Texas (Pantex); and Sandia National Laboratories in Albuquerque, New Mexico (Sandia). We selected these sites because they conduct nearly all of NNSA's explosives activities. We interviewed NNSA officials and contractor representatives on these site visits and in follow-up meetings about the agency's current explosives activities and future plans related to the design and production, infrastructure, workforce, and the overall management of NNSA's explosives activities. Findings from these site visits are not generalizable to all sites, but they provide illustrative examples of explosives activities at some NNSA sites. We also gathered information on the workforce at NNSA sites that is engaged in explosives activities. We interviewed relevant contractor representatives to ascertain the source of the workforce information they provided and to understand any limitations or caveats associated with it. We also interviewed contractor representatives from the Nevada National Security Site (Nevada), which manages several large testing sites, and the Department of Defense's (DOD) Holston Army Ammunition Plant (Holston), which is NNSA's major supplier of explosive materials, to learn about their involvement supporting NNSA's explosives activities.

[4]S. Rep. No. 115-125, at 356 (2017).

To describe challenges in conducting and managing explosives activities that NNSA officials and contractor representatives identified, as well as actions taken to address these challenges, we reviewed agency documents and interviewed NNSA officials and contractor representatives. In addition, we analyzed data from the Facilities Information Management System (FIMS), DOE's official real property database, according to DOE's order on real property management, on NNSA's explosives-related real property assets.[5] "Assets" include buildings, trailers, and other facilities and infrastructure, such as power lines. In FIMS, officials enter data to describe the character of assets—such as their size, condition, and replacement value—as well as to associate assets with the capability or programmatic activities (like explosives) they support. To understand the data in FIMS and to assess its reliability for our reporting purposes, we interviewed officials who operate the database and reviewed reports that incorporated and used the information. We also reviewed the 2019 FIMS user's guide and DOE's guidance for how sites should characterize their assets in FIMS, including how to associate an asset's primary or secondary programmatic activity.[6] We also observed several assets during our site visits by randomly selecting 22 assets out of the 625 listed as primary or secondary explosives-related assets in FIMS data that NNSA officials provided in April 2018 in order to validate selected information in FIMS about these assets. We observed 5 assets out of 150 at Livermore, 6 out of 205 at Los Alamos, 6 out of 183 at Pantex, and 5 out of 87 at Sandia. We determined that the FIMS data were reliable for purposes of describing the manner in which NNSA uses the system to characterize its explosives-related assets.

To examine the extent to which NNSA's strategic plan for explosives activities describes further actions needed to address identified

[5]DOE, *Real Property Asset Management*, DOE O 430.1C (Washington, D.C.: Aug. 19, 2016). Real property is defined as facilities and land. The explosives-related data we requested from NNSA included 10 FIMS data fields: property sequence number, site, asset name, property type, replacement value, gross square footage, age, rank order, capability name, and capability code. The data also contained one field of information on the mission dependency index. The mission dependency index is a quantitative score on the potential impact the loss of the asset would have on NNSA's mission and is maintained in another NNSA system, G2, which is the program management system used by NNSA's Office of Safety, Infrastructure and Operations. G2 pulls information from FIMS and, among other things, combines FIMS data with other program management information on infrastructure assets.

[6]DOE, *Facilities Information Management System FIMS User's Guide* (Jan. 9, 2019).

challenges and follows leading practices for strategic planning, we reviewed the practices NNSA used to develop, as well as elements NNSA included in, its strategic plan and compared them with selected leading practices and elements in federal strategic planning we had previously identified.[7] In addition, we reviewed the strategic plan (both the draft and final versions) and interviewed NNSA and contractor officials about the strategic planning process used and key elements included in the strategic plan, as well as the extent to which the strategic plan included information about further actions to address identified challenges.

We conducted this performance audit from February 2018 to May 2019 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.

[7]GAO, *Managing for Results: Opportunities for Congress to Address Government Performance Issues*, GAO-12-215R (Washington, D.C.: Dec. 9, 2011); *Executive Guide: Effectively Implementing the Government Performance and Results Act*, GAO/GGD-96-118 (Washington, D.C.: June 1996); *Agencies' Strategic Plans Under GPRA: Key Questions to Facilitate Congressional Review*, GAO/GGD-10.1.16 (Washington, D.C.: May 1997); and *Managing for Results: Critical Issues for Improving Federal Agencies' Strategic Plans*, GAO/GGD-97-180 (Washington, D.C.: Sept. 16, 1997). We selected these practices from our prior work because we judged these practices to be the most relevant for evaluating NNSA's strategic planning actions for its explosives activities. We did not consider all practices from among these sources because our focus was specifically on NNSA's initial efforts to manage explosives enterprise-wide and to develop and issue its first strategic plan for explosives activities—*Defense Programs Strategic Plan for Energetic Materials*.

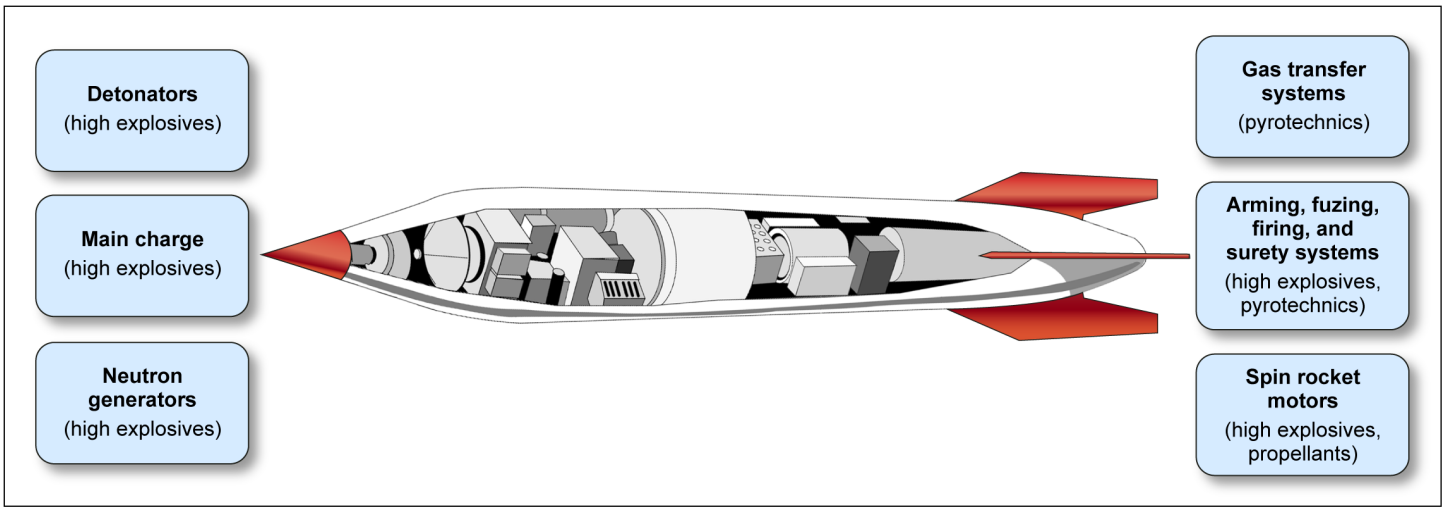
Background

Explosives and Their Production

Explosives include high explosives, propellants, and pyrotechnics.[8] Propellants and pyrotechnics are sometimes referred to as low explosives. All three types of explosives serve essential functions in nuclear weapons. Figure 1 illustrates key explosive-containing components found in a generic nuclear weapon as well as the types of explosives these components contain.

[8]Explosives are molecules that contain chemical energy, which can be rapidly released by an external stimulus, such as heat, friction, impact, electrical discharge, or shock. High explosives release energy through detonation, expanding with shock waves moving faster than the speed of sound. High explosives are used in weapons and in coal extraction, among other purposes. Propellants release amounts of energy similar to high explosives but over a longer period and rapidly generate gases that provide thrust. Propellants have several uses, including in rocket propulsion, gunpowder, and commercial airbags. Pyrotechnics only release energy as light, heat, or sound and are used in fireworks and road flares, among other purposes.

Figure 1: Key Explosive-Containing Components in a Generic Nuclear Weapon



Source: GAO analysis of National Nuclear Security Administration and Department of Energy documents. | GAO-19-449

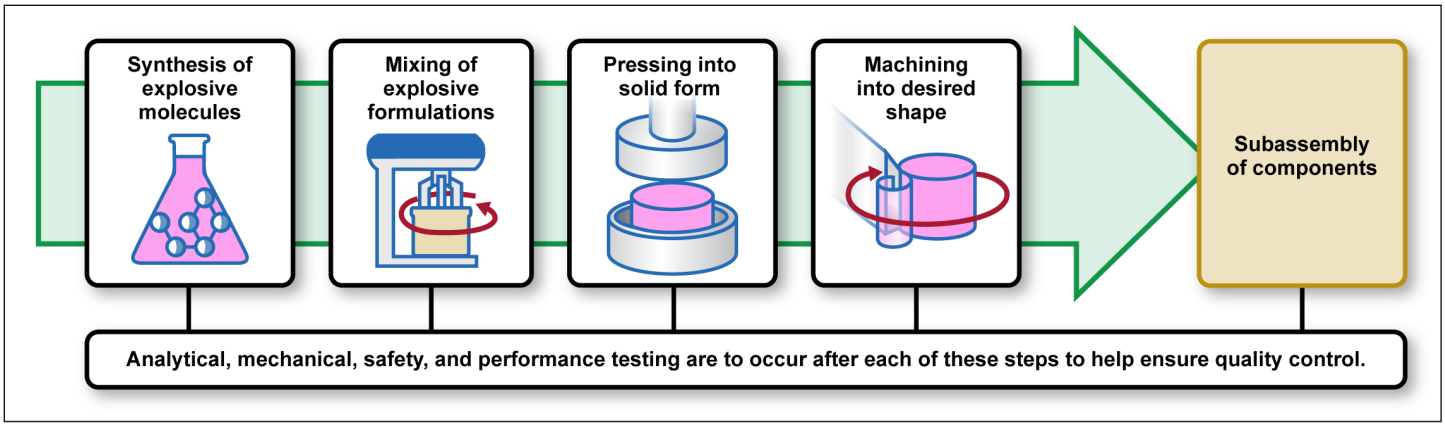
Notes: This diagram is a symbolic representation of some of the components found in a nuclear weapon. None of the symbols represent actual designs. Detonators enable various components to function. Main charge explosives compress the nuclear core, or pit, creating a nuclear reaction. Neutron generators facilitate the nuclear reaction, which can be enhanced by gas transfer systems that inject gases into the pit. Arming, fuzing, firing, and surety systems ensure that a weapon will operate safely, securely, reliably, and only when authorized. Spin rocket motors perform an arming function in nuclear bombs. High explosives release energy through detonation, expanding with shock waves moving faster than the speed of sound. Propellants release amounts of energy similar to high explosives but over a longer period and rapidly generate gases that provide thrust. Pyrotechnics only release energy as light, heat, or sound.

High explosives are the most common explosive by volume in nuclear weapons. There are two classes of high explosives used in nuclear weapons: insensitive high explosives (IHE) and conventional high explosives (CHE). An IHE is less susceptible to accidental detonation than a CHE and less violent upon accidental ignition, therefore it is safer to handle. NNSA places a premium on safety throughout all phases of explosives activities, including research and development, testing, production, and storage, because handling any explosive material is inherently dangerous, according to NNSA officials and contractor representatives.

Producing a high explosive material generally follows four steps, as shown in figure 2: (1) synthesis—producing raw explosive molecules; (2) formulation—mixing raw explosive molecules with binding ingredients to form an explosive mixture; (3) pressing—compacting formulated explosives into shapes of the required density; and (4) machining—

cutting away excess material to achieve the final shape. Analytical, mechanical, safety, and performance testing are to occur after each step.

Figure 2: High Explosive Production Process



Source: GAO analysis of National Nuclear Security Administration documents. | GAO-19-449

During synthesis, technicians use chemicals to produce fine, powder-like raw explosives. During formulation, technicians combine the explosive powder with plastic binder ingredients to produce a mixture that exhibits the physical and performance properties desired. Formulated explosives used by NNSA often appear like small, irregularly shaped pebbles, known as prills, as shown in figure 3.[9]

[9]Formulated high explosives can also take the form of molding powder, which is finer than prills.

Figure 3: Formulated High Explosive Prills (Irregularly Shaped Pebbles)

This photo shows prills of a formulated high explosive.

Source: National Nuclear Security Administration. | GAO-19-449

During pressing, the third step, technicians compact formulated explosives into a solid form. During machining, the fourth step, technicians use computer-controlled equipment to cut and shape the explosive into its final shape. After the explosive has been machined, technicians join explosive and non-explosive parts into functional components during subassembly. Small-scale synthesis and formulation and production-scale pressing, machining, and subassembly activities are carried out at multiple NNSA sites.

After each step of the production process, NNSA's sites conduct tests to ensure that explosives meet NNSA's safety and performance requirements. During safety testing, scientists conduct a variety of tests to

ensure that explosives meet DOE's safety requirements.[10] Regarding performance testing, scientists conduct other tests that require specialized equipment. For example, scientists use scanning equipment, like heat flow sensors, for thermal testing on formulated explosive material. Scientists also conduct tests using X-ray imaging equipment to evaluate weapon characteristics by detonating a "mockup." The mockup uses a high explosive main charge—the explosive material that surrounds the nuclear core, known as the pit—and a nonfissile surrogate material that has similar physical properties to plutonium. The mock implosion is called a hydrodynamic test because the surrogate material and other components become hot enough to flow like fluid.[11]

Explosive Molecules and Formulations Used in Nuclear Weapons

High explosive molecules used in U.S. nuclear weapons include but are not limited to high melting explosive (HMX), pentaerythritol tetranitrate (PETN) and triaminotrinitrobenzene (TATB).[12] First fielded in conventional weapons in World War II, HMX and PETN were later introduced into several components in the U.S. nuclear weapons stockpile and are still used in them today. DOE first introduced TATB into the nuclear stockpile in 1979, and it is still the only molecule that DOE considers to be an IHE (see sidebar). In all U.S. nuclear weapons, the main charge is made of formulations of HMX or TATB. DOD also uses HMX and TATB in certain conventional weapons.

NNSA uses various explosive formulations in nuclear weapon components. For example, the main charges used in weapons for two ongoing LEPs are made from a mixture of TATB and a commercially-

[10]DOE established explosive safety guidelines applicable to developing, testing, handling, and processing of explosives or assemblies containing explosives to ensure that explosives are protected from abnormal stimuli or environments, including: (1) friction forces; (2) excessive pressures and temperatures; (3) impact, shock, and pinching; (4) deformation; (5) electrical sparks, abrasive or welding sparks, and open flame; (6) contamination; and (7) contact with incompatible materials. DOE, *DOE Standard: Explosives Safety*, DOE-STD-1212-2012 (current version) (Washington, D.C.: June 2012).

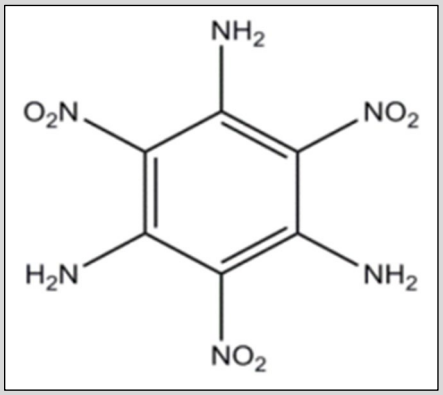
[11]Another term used in the nuclear weapons complex is mock high explosive. Mock high explosive is inert (non-explosive) and is used during design to check for form, fit, and manufacturability of processes. Mock high explosive is currently produced at Pantex.

[12]The CHE molecule cyclotetramethylene tetranitramine—referred to as HMX, for high melting explosive—was developed in the 1940s. Another CHE molecule, pentaerythritol tetranitrate (or PETN), is one of the most sensitive explosives used in nuclear weapons, often in detonators. The IHE molecule triaminotrinitrobenzene is referred to as TATB.

available binding ingredient to create a plastic bonded explosive. Each explosive formulation is designed for a specific application. The performance requirements for explosive formulations in nuclear weapons are more stringent than those for conventional weapons for DOD formulations to ensure both performance and safety. Explosives scientists commonly use the term “recipe” to describe the ingredients and many variables in the process—such as the temperature, mixing speed, or container size—used to make explosive molecules and formulations that meet specific performance requirements.

TATB: NNSA’s Key Insensitive High Explosive

Triaminotrinitrobenzene (TATB) is a key insensitive high explosive that is currently used in National Nuclear Security Administration (NNSA) and Department of Defense (DOD) military applications, including nuclear and conventional weapons. Scientists first synthesized TATB in 1888 but did not initially recognize it as an explosive. In 1966, Los Alamos National Laboratory developed the industrial method for synthesizing TATB. From the late 1970s to the late 1980s, two domestic manufacturers supplied TATB to DOD and NNSA. However, when the Cold War ended and a U.S. nuclear test moratorium began, the demand for TATB declined, and both manufacturers ceased production by 1993. DOD then acquired TATB from a U.K.-based firm until its plant closed in 2005. Beginning in 2007, DOD and NNSA collaborated to re-establish a manufacturing capability for TATB in the United States. Specifically, DOD’s Holston Army Ammunition Plant (Holston), which is located in Kingsport, Tennessee, began producing TATB in 2014. DOD has qualified the Holston-produced TATB for use in conventional weapons but NNSA has not yet qualified it for use in nuclear weapons because the material properties of the formulated material are not yet up to NNSA standards, according to NNSA documentation.



Chemical structure of TATB.

Sources: GAO analysis of NNSA and DOD documents; NNSA (image). | GAO-19-449

Ongoing and Planned LEPs and NNSA's Other Modernization Plans

In December 2018, NNSA completed the last production unit for the W76-1 LEP, marking the completion of warhead production for the first LEP in which NNSA undertook full-scale design activities for weapon systems since 1982.[13] Five other LEPs and stockpile modernization efforts were ongoing as of January 2019, as shown in table 1. As we concluded in an April 2017 report, this is a particularly challenging time for NNSA, as the agency plans to simultaneously execute LEPs and modernization efforts along with major construction projects, such as efforts to modernize NNSA's uranium and plutonium manufacturing capabilities.[14]

Table 1: Ongoing National Nuclear Security Administration (NNSA) and Department of Defense (DOD) Life Extension Programs (LEP) and Modernization Efforts

Program	Description
B61-12 LEP	The B61 bomb is the oldest nuclear weapon in the stockpile. It was first fielded in 1968, with current modifications fielded from 1979 to 1991.[a] The B61-12 LEP is to consolidate and replace the B61-3, B61-4, B61-7, and B61-10 modifications of the bomb.[b] NNSA estimated in October 2016 that it would incur a total cost of about $7.6 billion for the program and that it would complete the first production unit in March 2020.[c] NNSA reported in October 2018 that the first production unit was ahead of this schedule and would be completed by September 2019. However, in May 2019, NNSA officials said that the first production unit date would be delayed due to potential problems with an electrical part, revealed during testing in April 2019.
W88 Alteration 370 program	The W88 Alteration 370[d] program is to replace the arming, fuzing, and firing subsystem and high explosive main charge for the W88 warhead, which is deployed on the Navy's Trident II D5 submarine-launched ballistic missile system. As of 2017, NNSA estimated the program would cost about $2.6 billion and would complete the first production unit in December 2020.[c] NNSA reported in October 2018 that the first production unit was ahead of this schedule and would be completed by December 2019. However, in May 2019, NNSA officials said that the first production unit date would be delayed due to potential problems with an electrical part, revealed during testing in April 2019.
W80-4 LEP	The W80-4 LEP is intended to provide a warhead for a future long-range standoff missile to replace the Air Force's current air-launched cruise missile. As of January 2019, NNSA estimated that the program will cost about $12 billion and that it will complete the first production unit by fiscal year 2025.[c,e]
W76-2 program	The W76-2 program is to leverage the recently completed W76-1 LEP to produce a low-yield submarine-launched ballistic missile warhead, as a requirement derived from the 2018 Nuclear Posture Review.[f] An amendment to the President's budget request for fiscal year 2019 included $65 million for the acquisition of the W76-2. The first W76-2 was produced at the Pantex Plant in February 2019.

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

[14]GAO, *National Nuclear Security Administration: Action Needed to Address Affordability of Nuclear Modernization Programs*, GAO-17-341 (Washington, D.C.: Apr. 26, 2017).

Program	Description
W87-1 program	In fiscal year 2014, the Nuclear Weapons Council directed NNSA to suspend a program that was evaluating a capability that could replace the W78 warhead, used on Air Force intercontinental ballistic missiles, with an interoperable warhead that could be used by both the Air Force and the Navy.[g] The 2018 Nuclear Posture Review directed NNSA to restart a program to replace the W78 for the Air Force in fiscal year 2019, and that program is now known as the W87-1 program. The Nuclear Posture Review further directed NNSA and the Navy to evaluate the feasibility of the Navy using the warhead. NNSA preliminarily estimated in October 2018 that the combined program would cost about $10 billion to $15 billion.

Source: GAO analysis of NNSA documents and information reported by NNSA officials. | GAO-19-449

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

[b]Throughout the history of nuclear weapons development, the United States has developed families of warheads based on a single warhead design. Thus, some weapons in the U.S. stockpile were developed as modifications to an already complete design. For example, the B61 bomb has had 12 variations over time, each designated as a different modification.

[c]The first production unit milestone occurs when DOD accepts the weapon's design and NNSA verifies that the first produced weapon or weapon(s) meets the design.

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

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

[f]The Nuclear Posture Review assesses the global threat environment and establishes policy on U.S. nuclear forces. It is conducted periodically, most recently in 2018 and before that in 2010. In January 2019, NNSA completed the W76-1 LEP.

[g]The Nuclear Weapons Council is the joint DOD and DOE activity responsible for matters related to executive-level management of the nuclear weapons stockpile.

NNSA's Sites, Infrastructure, and Workforce Levels for Explosives Activities

NNSA's nuclear security enterprise consists of eight government-owned sites managed and operated by seven contractors.[15] Five of these sites conduct explosives activities: Livermore, Los Alamos, Sandia, Pantex, and Nevada. In addition to these sites, NNSA relies on several third-party suppliers of explosive materials and related equipment. The largest of these is Holston, which is a government-owned, contractor-operated facility that primarily produces explosives for DOD. Holston is NNSA's sole supplier of explosives used in main charges.

The infrastructure that supports NNSA's explosives activities consists of thousands of real property assets, which are to be tracked in FIMS.[16] The database is managed for NNSA missions by its Office of Safety, Infrastructure and Operations. According to NNSA officials and DOE documents, FIMS helps managers understand the current state of NNSA infrastructure and inform infrastructure modernization funding decisions. We have previously reported on concerns about the accuracy of the FIMS database with respect to certain data fields that were not assessed as

[15]The nuclear security enterprise consists of three national nuclear weapon design laboratories (Lawrence Livermore National Laboratory in California managed by Lawrence Livermore National Security LLC, Los Alamos National Laboratory in New Mexico managed by Triad National Security LLC, and Sandia National Laboratories in New Mexico and California managed by National Technology and Engineering Solutions of Sandia); four nuclear weapon production plants (the Pantex Plant in Texas and the Y-12 National Security Complex in Tennessee both managed by Consolidated Nuclear Security LLC, the Kansas City National Security Campus in Missouri managed by Honeywell Federal Manufacturing and Technologies LLC, and the Savannah River Site in South Carolina managed by Savannah River Nuclear Solutions LLC); and the Nevada National Security Site managed by Mission Support and Test Services, formerly known as the Nevada Test Site.

[16]FIMS data include information on a facility's size, age, gross square footage, location, and operating status. In total, FIMS has more than 150 data fields. FIMS administrators at each of NNSA's sites are responsible for updating the data fields in the database.

part of this review.[17] DOE has taken sufficient steps to address recommendations we have previously made about FIMS.

Workforce levels for explosives activities have generally increased in recent years, which contractor representatives attribute to the increase in workload because of LEP and modernization efforts. Table 2 shows NNSA contractor representatives' estimates for actual full-time equivalents (FTE) and percentages of FTEs engaged in explosives activities at each of the five sites over the last 5 fiscal years.[18]

Table 2: Estimates of Full-Time Equivalents (FTE) and Percentages of FTEs Engaged in Explosives Activities at Five NNSA Sites, Fiscal Years 2014–2018

	FTEs/percentages of FTEs engaged in explosives activities				
Fiscal year	Lawrence Livermore National Laboratory	Los Alamos National Laboratory	Nevada National Security Site	Pantex Plant	Sandia National Laboratories
2014	24/0.5	359/4.9	6/0.3	160/5.1	235/2.4
2015	24/0.5	395/5.4	5/0.2	150/4.9	255/2.6
2016	53/1.0	440/5.9	6/0.3	170/5.2	261/2.5
2017	80/1.4	489/6.1	6/0.3	173/5.4	272/2.6
2018	68/1.1	544/6.6	7/0.3	172/5.3	302/2.8

Source: GAO analysis of National Nuclear Security Administration (NNSA) data. | GAO-19-449

[17]GAO, *DOE Real Property: Better Data and a More Proactive Approach Needed to Facilitate Property Disposal*, GAO-15-305 (Washington, D.C.: Feb. 25, 2015); *Nuclear Weapons: NNSA Needs More Comprehensive Infrastructure and Workforce Data to Improve Enterprise Decision-making*, GAO-11-188 (Washington, D.C.: Feb. 14, 2011); and *Modernizing the Nuclear Security Enterprise: NNSA Increased Its Budget Estimates, but Estimates for Key Stockpile and Infrastructure Programs Need Improvement*, GAO-15-499 (Washington, D.C.: Aug. 6, 2015). These reports have multiple recommendations related to data concerns on consistency and timely reporting of specific data fields in FIMS, such as replacement values and condition assessments. All of the recommendations related to the FIMS data fields in these reports have been closed as implemented. We have not previously reviewed the FIMS data on explosives-related assets that are analyzed in this report.

[18]While NNSA does not track workforce levels for explosives activities across the enterprise, contractor representatives were able to provide us with estimates of the number of their employees engaged in explosives activities.

Selected Leading Practices in Federal Strategic Planning

The Government Performance and Results Act of 1993 as amended (GPRA) requires, among other things, that federal agencies develop strategic plans.[19] The Office of Management and Budget (OMB) provides guidance to federal executive branch agencies on how to prepare their agency-wide strategic plans in accordance with GPRA requirements, as updated and expanded by the GPRA Modernization Act of 2010. We have reported that these requirements also can serve as leading practices for strategic planning at lower levels within federal agencies, such as planning for individual divisions, programs, or initiatives. In addition, we have reported in the past on federal agencies' strategic planning efforts and have identified additional useful practices to enhance agencies' strategic plans.[20] The leading practices in federal strategic planning that we selected are: (1) involving stakeholders, such as federal agencies, state governments, or others, in defining the mission and desired outcomes, which helps ensure that their expectations and interests are met and that resources and efforts are targeted at the program's highest priorities; (2) assessing external and internal forces, which helps managers anticipate future challenges and make adjustments before potential problems become crises; and (3) covering at least a 4-year period while making adjustments as needed to reflect the operating environment.[21]

[19]Pub. L. No. 103-62, § 3, 107 Stat. 285 (1993), *as amended by* GPRA Modernization Act of 2010, Pub. L. No. 111-352, § 2, 124 Stat. 3866 (2011) (*codified as amended at* 5 U.S.C. § 306). The GPRA Modernization Act of 2010 modernizes the federal government's performance management framework. The law requires agency strategic plans to cover not less than 4 years.

[20]GAO, *Environmental Justice: EPA Needs to Take Additional Actions to Help Ensure Effective Implementation*, GAO-12-77 (Washington, D.C.: Oct. 6, 2011); *Aquatic Invasive Species: Additional Steps Could Help Measure Federal Progress in Achieving Strategic Goals*, GAO-16-49 (Washington, D.C.: Nov. 30, 2015); and *Nuclear Nonproliferation: Better Information Needed on Results of National Nuclear Security Administration's Research and Technology Development Projects*, GAO-17-210 (Washington, D.C.: Feb. 3, 2017).

[21]We judgmentally selected these three practices from among GPRA, OMB guidance, and our prior work because we found these practices to be the most relevant for evaluating NNSA's initial strategic planning actions for its explosives activities. We did not select leading practices that were relevant to agency-wide strategic plan efforts rather than strategic plans for individual programs or sets of activities, such as the leading practice of coordinating with other federal agencies.

Further, our past work has shown that effective strategic plans should include several specific elements.[22] These elements include: (1) a comprehensive mission statement that explains why a program exists and what it does; (2) long-term goals and objectives that specify how an agency will carry out its mission and explain what results are expected from the program; (3) strategies to achieve the goals and objectives that are specific enough to allow an agency to assess whether the strategies will help achieve those goals; (4) a description of how performance measures will be used to assess progress toward long-term goals; and (5) the identification of external factors that could significantly affect achievement of the strategic goals.

NNSA's Sites Conduct a Range of Interdependent Explosives Design and Production Activities, and NNSA Has Adopted a Centralized Approach to Managing Them

NNSA's five sites involved in explosives conduct interdependent activities to design and produce explosives and about 100 different nuclear weapon components that contain explosive materials. Each of the sites assumes primary responsibility for certain explosives activities—such as Livermore conducts design, research, and development of new IHE main charge formulations; Pantex produces all main charges; Los Alamos conducts design and production of main charge detonators as well as explosives research and development; Sandia conducts design and production of nonnuclear explosive components; and Nevada conducts large experimental explosive shots to support design activities.[23] However, most of these activities require the participation of multiple sites. The following examples illustrate some of the collaborative, interdependent activities that NNSA's sites and their suppliers undertake to design and produce explosive components found in nuclear weapons.

- **Main charge for the W80-4 LEP.** Livermore manages design activities for the W80-4 LEP, including for its main charge.[24] The main charge used in the W80-4 warhead will consist of newly synthesized

[22]See GAO-12-77, GAO-12-215R, GAO/GGD-97-180, and GAO/GGD-96-118.

[23]Unless otherwise specified, we use "detonator" to refer to a component technically referred to as a detonator cable assembly. We use "nonnuclear explosive components" to refer to components not involved in main charge detonation and pit implosion. We use "shot" to refer to a test involving a high explosive detonation because NNSA and its sites consistently use this term.

[24]Los Alamos manages design activities related to the main charge explosives used in the other ongoing LEPs (the B61-12 LEP and the W88 Alteration 370). Production of main charge explosives for ongoing LEPs takes place or will take place at Pantex, according to contractor representatives.

TATB, formulated with a new binding ingredient, according to contractor representatives. As NNSA officials and contractor representatives explained during our site visits to Livermore and Pantex, Livermore scientists redeveloped the specific process for TATB synthesis and formulation that is being used in the W80-4 LEP, first in small test batches and then in larger amounts. Next, Livermore sent its specifications for synthesis and formulation to Holston, which has produced successively larger batches. As the design and cost study phase of the W80-4 LEP continues, Livermore and Pantex continue to receive and test these batches of formulated explosive and work with Holston to ensure that production lots meet NNSA specifications. In coordination with Livermore, Pantex will press and machine the finished main charges for the W80-4 when the LEP reaches the production phase. Pantex will receive formulated TATB from Holston and conduct its own tests to ensure the quality of the initial production lots and pressing, machining, and subassembly processes.

- **Detonators.** The design and production of main charge detonators involves several NNSA sites and their suppliers.[25] According to contractor representatives, Livermore and Los Alamos share the responsibility for designing the main charge detonators, and Los Alamos will produce all the detonators. As part of production, Los Alamos reprocesses the PETN used in detonators from a stockpile of DOD-grade material purchased 30 years ago. Other detonator parts come from third-party suppliers and from NNSA's Kansas City National Security Campus, another NNSA site that does not have a role in designing or producing explosives, according to contractor representatives. Los Alamos produces and tests completed detonators and then sends them to Pantex for weapon assembly, according to contractor representatives.
- **Spin rocket motors.** Sandia plays the primary role in designing spin rocket motors.[26] Spin rocket motors use pyrotechnics and propellants and are a key component in the B61 and B83 bombs. Contractor representatives at Sandia said that they supply the explosives to third-party suppliers, who produce the motors. The completed spin rocket motors are sent to Sandia for inspection and testing, and after Sandia

[25]Detonators of various types are critical to initiating many components in a nuclear weapon. The detonators for main charges for the B61-12 and W80-4 LEPs contain a sensitive CHE.

[26]Spin rocket motors are designed to rotate a bomb at a precise rate after it is released from a delivery aircraft; pyrotechnics and propellants are used to make the bomb spin.

approves the components, they are shipped to Pantex for weapon assembly, according to contractor representatives.

- **Component manufacturing research.** In addition to designing and producing components for LEPs and modernization efforts, NNSA sites also collaborate on other explosives research and development programs, such as on component manufacturing processes. For example, Los Alamos, Livermore, Sandia, and Pantex are collaborating on additive manufacturing processes for explosives.[27] Additive manufacturing differs from traditional manufacturing in that it builds components by depositing material rather than by cutting material away during machining. This research effort seeks to introduce additive manufacturing into the explosives production process, producing explosive parts with highly complex geometries while meeting NNSA's safety and performance requirements, according to a contractor representative.

In May 2018, according to NNSA documentation, NNSA began implementing a new enterprise-wide approach to improve the management and coordination of explosives activities across its sites. In the past, each program that used explosives—such as an LEP or a research and development program—developed or procured them independently of other programs, without formal coordination to ensure each program's awareness of other programs' requirements or time frames. Under the new enterprise-wide approach, NNSA has taken several steps to centralize management at an enterprise level and to coordinate explosives activities across its sites. Specifically:

- In May 2018, NNSA established the Energetic Materials Enterprise Manager (enterprise manager) position to help coordinate NNSA's explosives activities. The agency issued a May 2018 memorandum formally establishing the position, signed by the Acting Deputy Administrator for Defense Programs. The memorandum specified that

[27]Additive manufacturing (also called three-dimensional, or 3D, printing) refers to a layer-by-layer approach for producing 3D objects from a digital model using materials such as metal powders, plastic, and foundry sand. See GAO, *Highlights of a Forum: 3D Printing: Opportunities, Challenges, and Policy Implications of Additive Manufacturing*, GAO-15-505SP (Washington, D.C.: June 24, 2015), and *Defense Additive Manufacturing: DOD Needs to Systematically Track Department-wide 3D Printing Efforts*, GAO-16-56 (Washington, D.C.: Oct. 14, 2015).

the enterprise manager should encourage collaboration among the sites and programs that conduct explosives activities.[28]

- In September 2018, the enterprise manager established NNSA's Energetics Coordinating Committee (coordinating committee) to identify coordination challenges across the enterprise and emerging needs for critical explosive materials, among other purposes. The coordinating committee is composed of NNSA officials and contractor representatives from NNSA's sites, is chaired by the enterprise manager, and is expected to meet at least once a year. According to NNSA documents, the coordinating committee met twice in 2018 and identified a number of future actions requiring input from the sites, such as defining future needs associated with the production of main charge explosive materials.
- In December 2018, NNSA issued the strategic plan for energetic materials.[29] This strategic plan states that it will help NNSA organize its efforts to meet weapon delivery schedules for the overall energetics community. Prior to the strategic plan's final issuance, the enterprise manager provided a draft to coordinating committee members to solicit their comments.

However, more recent action taken by NNSA indicates that the enterprise approach to managing high explosives is continuing to evolve. First, according to NNSA officials, in 2019 NNSA is planning to reorganize the Office of Defense Programs—which is responsible for all stockpile activities. This reorganization could affect the approach to managing high explosives activities. Specifically, officials said part of this reorganization is the creation of a new organization for production activities, which is expected to divide production activities into several groups oriented around different weapons components. It is currently unclear under which production group explosives activities will fall because there are production activities associated with explosives for both nuclear and nonnuclear components, according to NNSA officials.

Second, in December 2018, NNSA officials indicated that they are considering elevating high explosives to a "strategic material" and managing it more similarly to NNSA's existing approach for managing

[28]Department of Energy, National Nuclear Security Administration, *Enterprise Management for Energetic Materials* (May 2018).

[29]National Nuclear Security Administration, NA-122.1 Office of Stockpile Services, *Defense Programs Strategic Plan for Energetic Materials*.

other strategic materials, such as plutonium.[30] NNSA's strategic materials managers are overseen by a senior NNSA official and appointed to manage each material as a program, with a budget and dedicated staff, according to NNSA documentation. NNSA does not consider the high explosives enterprise manager to be managing a program; therefore, the enterprise manager does not have an explosives budget or dedicated staff, according to NNSA officials. NNSA officials said they anticipate issuing an analysis of alternatives study in spring 2019 that will contain a recommendation to the NNSA Administrator on how explosives activities should be managed going forward, which could reflect a shift toward managing high explosives as a strategic material.

NNSA Officials and Contractor Representatives Identified Management Challenges for Explosives-Related Activities and Have Taken Some Actions in Response, but Have Not Addressed Issues Affecting the Accuracy of Infrastructure Data

NNSA officials and contractor representatives have identified a number of challenges related to NNSA's supply of explosive materials, infrastructure, and staff recruitment and training. First, NNSA's supply of certain highly specialized explosive materials is dwindling, and NNSA officials and contractor representatives stated that it is challenging to reproduce or procure these materials. Second, officials and contractor representatives identified infrastructure that is aging and deteriorating, inaccurate information on that infrastructure, and storage areas filled to near capacity as challenges. Finally, according to NNSA contractor representatives, there are difficulties in recruiting and training qualified staff. NNSA has taken some actions to address these challenges, such as starting to recreate "recipes" for specialized materials and modernize aging infrastructure, according to NNSA officials and contractor representatives. However, taking additional steps to improve the quality of information about its explosives infrastructure would give the agency more reasonable assurance that officials, contractor representatives, and the enterprise manager have the quality information necessary to support management decisions.

[30]NNSA named strategic material program managers in 2014 and 2015 to integrate, oversee, plan, and execute material strategies for uranium (including domestic uranium enrichment), plutonium, and tritium. See GAO, *Nuclear Weapons: NNSA Needs to Determine Critical Skills and Competencies for Its Strategic Materials Programs*, GAO-18-99 (Washington, D.C.: Nov. 14, 2017).

NNSA Officials and Contractor Representatives Identified Challenges in Ensuring an Adequate Supply of Specialized Explosive Materials and Have Taken Some Actions to Address Them

NNSA's Challenges Producing Fogbank

The National Nuclear Security Administration (NNSA) has had challenges in the past producing materials other than explosives that are essential to the successful operation of nuclear weapons. In 2000, NNSA began a life extension program (LEP) to replace or modernize components for W76 warheads, which are delivered by submarine-launched ballistic missile systems. NNSA had to delay production of the refurbished warheads when it encountered problems in manufacturing an important material that NNSA refers to as "Fogbank." In March 2009, we reported that NNSA had lost knowledge of how to manufacture the material because it had kept few records of the process when the material was made in the 1980s, and almost all staff with expertise on production had retired or left the agency, leaving the production process for Fogbank dormant for about 25 years. As we reported, NNSA's loss of the technical knowledge and expertise to manufacture Fogbank resulted in a 1-year delay in the W76-1 LEP and an unexpected cost increase of nearly $70 million. According to NNSA officials, production challenges with Fogbank have since been resolved, and the last production unit for the W76-1 LEP was completed in December 2018.

W76 warhead.

Sources: NNSA documents and GAO-09-385; NNSA (image). | GAO-19-449

NNSA's supply of certain highly specialized explosive materials is dwindling.[31] These materials have specific chemical and physical characteristics that fulfill precise performance requirements in nuclear weapons, such as detonation within nanoseconds, according to contractor representatives. One such material, titanium sub-hydride potassium perchlorate (THKP), is used in actuators to open valves, among other things, according to contractor representatives.[32] TATB, the IHE molecule used in main charges, is another such material, according to contractor representatives. In some cases, contractor representatives said that only one container or production lot of specialized material was ever produced that met NNSA's specifications. The inventories of these materials have dwindled as ongoing LEPs, modernization efforts, and research and development activities draw on them. For example, only a small container of THKP remains. Additional inventory will be required to meet the needs of four of the five ongoing LEPs and modernization efforts, as well as for any future needs, according to contractor representatives from Sandia. Similarly, although Pantex has a stockpile of legacy TATB for the B61-12 LEP, contractor representatives said that new material will be needed to meet the requirements of planned and future LEPs and modernization efforts.[33]

NNSA officials stated that reproducing and procuring these highly specialized materials presents challenges for the agency. According to NNSA documents and officials, lost recipes and a fragile supplier base contribute to these challenges (see sidebar).

[31]According to NNSA officials and contractor representatives, some highly specialized materials are referred to as "magic barrel" materials because of their difficulty to produce, unique performance, and limited inventory quantities.

[32]An actuator is a component that initiates or performs physical work, such as opening a valve by filling an area with gases, according to contractor representatives.

[33]Contractor representatives use "legacy material" to refer to explosives that were produced years ago and are currently held in inventory.

Lost Recipes

Some specialized materials were created decades ago, and the knowledge base to successfully produce them is now gone. According to NNSA documents, technical knowledge of material production processes can be lost when long intervals occur between production orders. In some cases, processes were not well documented or were infrequently practiced and proven. Thus, NNSA sites must spend considerable effort to recreate the recipes and techniques for producing these materials. Sandia representatives explained that sometimes a single company or even an individual created these materials and has since ceased production or is now deceased. For example, THKP was produced exclusively for Sandia by DOE's Mound Site near Dayton, Ohio, which closed in 1994. The THKP production process was designed by an individual at the Mound Site who is now deceased. In some cases, according to contractor representatives, a single container of explosives (or a single production lot) met anticipated future needs for quality and quantity when it was originally produced, so production was discontinued. Contractor representatives explained that replicating the material exactly is nearly impossible because of the large number of variables, such as the mixing speed and temperature, that must be controlled for, even if the ingredients are identical to those used many years ago, which is not often the case.

To address the challenge of lost recipes, Los Alamos, Sandia, Livermore, and Pantex are all working to reproduce materials with performance and physical properties similar to those of legacy materials and prepare for their full-scale production. For example, Livermore scientists said they are conducting research to synthesize new TATB that is uniquely suited to NNSA's needs. According to NNSA contractor representatives, the synthesis process will be refined until it can be replicated by Holston for the W80-4 LEP. Additionally, Los Alamos scientists are researching the formulation process with legacy TATB for the B61-12 main charges. The chemical formulation of binder material used in the past has slightly changed, affecting the structural strength of formulated TATB.[34] Without the proper strength, this formulated explosive cannot be pressed effectively, according to contractor representatives. Sandia is also working to re-establish the THKP production process.

[34]The company that manufactured the legacy TATB binder changed the formulation in 2000 to comply with environmental restrictions.

NNSA is also working to address the challenge of lost recipes by developing a comprehensive master list for explosive materials. The list tracks information such as the suppliers involved and specific production challenges. According to NNSA and contractor officials, collecting and sharing such information across the sites related to explosive production processes, specifications, and performance will help prevent lost recipes in the future.

Fragile Supplier Base

Even if the sites can replicate lost recipes for explosive materials, NNSA's supplier base for those materials is fragile. As previously reported and according to NNSA documentation, finding suppliers willing and able to provide required parts and materials can be difficult.[35] Contractor representatives told us that this difficulty arises because of the small quantities of explosive parts and materials NNSA procures, the irregular nature of NNSA's procurements, and the agency's exacting performance requirements. For example, neutron generators contain explosive parts that Sandia orders irregularly, in batches numbering only in the hundreds. These parts have such exacting requirements for size and timing that they are hand-made under microscopes. Sandia contractor representatives explained that sometimes the laboratory's part and material orders may represent only 1 to 3 percent of a company's total production.

To address this challenge, NNSA is working to purchase materials more consistently to ensure that companies can rely on NNSA as a steady customer and be comfortable working to meet NNSA's exacting requirements. Contractor representatives said that ensuring consistency in production can help maintain the expertise needed to avoid having to reconstitute a specialized process, which can be costly. For example, the effort to restart TATB synthesis and formulation cost approximately $13 million and added 3-1/2 years to the original TATB production schedule, according to Los Alamos contractor representatives. Contractor representatives at Pantex and Los Alamos said that they plan to support continuous production of synthesized TATB and formulated explosives at Holston in the future to avoid delays in restarting production (see sidebar).

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

A Fragile Supplier Base for Other Material

The National Nuclear Security Administration (NNSA) has identified challenges with a fragile supplier base for other specialized materials that are used in explosives-related experiments and research. For example, Los Alamos National Laboratory (Los Alamos) in New Mexico requires highly specialized test vessels to conduct essential nuclear weapons research. Specifically, Los Alamos's Dual-Axis Radiographic Hydrodynamic Test Facility (DARHT) uses X-ray machines to record three-dimensional interior images of mock nuclear materials that are imploded using explosives. The exploding components are contained in steel vessels. This facility is unique because it is the world's most powerful X-ray machine for analysis of these implosions (called hydrodynamic tests). The vessels used at DARHT are made of specialized steel that does not need to be heat-treated during repairs, allowing the laboratory to easily repair them after explosive testing. There is currently a small supplier base (domestic and international) for manufacturing these vessels. Los Alamos contractor representatives are concerned with vendor availability, capability, and willingness to produce vessels because of the small number the laboratory has purchased in the past—they currently have seven operational vessels. Also, contractor representatives said they are concerned that the workforce which knows how to create this specialized steel is nearing retirement. To help ensure a continued future supply of the vessels, Los Alamos is working with Lawrence Livermore National Laboratory in California and the Nevada National Security Site, which use similar vessels, to develop a multi-year procurement plan to encourage suppliers to continue to produce the specialized steel used in their manufacture.

Steel vessel at Los Alamos's DARHT facility.

Sources: GAO analysis of NNSA documents; NNSA (photo). | GAO-19-449

NNSA supplier challenges are complicated further when a supplier is foreign or there is only one domestic supplier. According to NNSA documentation, using a foreign supplier may leave NNSA vulnerable to a potential national security risk. Even when the only supplier is domestic, single-point failure is a concern should that supplier delay or cease production, according to contractor representatives. NNSA officials provided an example involving Holston, NNSA's sole supplier of TATB. According to NNSA officials and contractor representatives, Holston also serves DOD customers that order far larger quantities of explosives, and Holston is required to prioritize those customers' orders using DOD procurement priority ratings, which may mean that NNSA orders are delayed.[36] For example, Livermore placed an order for the W80-4 main charge explosives at Holston that was to be fulfilled by March 2019, but that order was delayed while the plant worked to finish a DOD order with a higher-priority rating. In addition to this delay, Livermore's order will be further delayed because Holston had an explosive incident in January 2019 and ceased operations for 3 weeks, according to Livermore and DOD contractor representatives.[37] As a result of both these delays, the W80-4 LEP will have to postpone a hydrodynamic test and other studies, complicating an already tight design and development schedule. This will delay the W80-4 LEP at least 2 months, according to Livermore officials.

To minimize the potential for future production delays at Holston, NNSA is working to elevate the priority of all its orders for explosives. Some DOD nuclear weapon delivery platforms have the highest-priority DOD rating, and NNSA officials said they have received permission from DOD to apply this rating to the DOE explosives orders for the nuclear warheads associated with those delivery platforms, including explosive orders for

[36]Under the Defense Production Act and its implementing regulations, DOD orders receive priority ratings of DX or DO, or are unrated. DO-rated orders must be given production preference over unrated orders, if necessary to meet required delivery dates, even if this requires the diversion of items being processed or ready for delivery against unrated orders. Similarly, DX-rated orders must be given preference over DO-rated orders and unrated orders. 15 C.F.R. § 700.14(b).

[37]On January 3, 2019, Holston experienced a fire of unknown origin that resulted in the explosion of a packaging building and semi-truck trailer storing explosives. Following the incident, Holston ceased production operations to investigate the cause of the explosion and to determine the structural integrity of its buildings. According to Holston contractor representatives, it is believed that the fire began at approximately 7:45 am in an uninhabited building utilized at the time for temporary storage, and no injuries were sustained as no staff were present at the time of the event. Holston is currently investigating the cause of the fire that led to the explosion. The results of this assessment were not available at the time of our review.

the B61-12 LEP.[38] NNSA officials said they cannot currently use the highest-priority rating for orders associated with the W80-4 LEP because the delivery platform for that LEP does not have the highest-priority rating.[39] NNSA officials are working with DOD and DOE attorneys to obtain permission for using DOD's highest-priority rating. A contractor representative at Livermore said that in addition to NNSA's efforts, the Air Force is working separately to obtain permission to use the highest-priority rating for this delivery platform. If the Air Force is successful, NNSA could use that delivery platform's new high-priority rating for its W80-4 LEP orders. The Livermore contractor representative said that they believe the Air Force will receive permission to use the highest-priority rating before NNSA does.

In situations where a supplier cannot or will not produce a specialized material or related component, NNSA is exploring options for producing those materials or components itself. NNSA officials said that they are conducting an analysis of alternatives to meet synthesis, formulation, and production requirements to be completed by the spring of 2019. The analysis will include an option for in-house production of TATB at Pantex. NNSA documentation indicates that Pantex could independently produce the TATB needed for current and future LEPs and modernization efforts with a substantial investment, exact figures for which may be reported upon completion of the analysis of alternatives. Similarly, contractor representatives from Sandia said that in the absence of qualified suppliers, they are working to produce explosive materials, such as THKP as discussed above.

[38]Delivery platforms include the launch vehicles for nuclear warheads, such as ballistic missiles and cruise missiles. Aircraft can also serve as delivery vehicles for nuclear bombs.

[39]DOD is considering two options for the W80-4 delivery platform, known as the long-range standoff weapon. We are separately reviewing this DOD program.

NNSA Officials and Contractor Representatives Have Identified Infrastructure and Workforce Challenges and Are Taking Actions to Address Them, but NNSA Has Not Fully Addressed the Accuracy of Infrastructure Data

NNSA has also identified challenges with its explosives infrastructure, infrastructure data, and workforce. Specifically, NNSA's infrastructure is aging and deteriorating, some infrastructure data are inaccurate, and some storage areas are near capacity. In addition, recruiting and training qualified staff have presented a challenge to NNSA. As we have previously reported, these challenges are shared across the nuclear security enterprise and are not confined to explosives activities.[40] NNSA is taking several actions to address these challenges, as described below, but data inaccuracies remain related to NNSA's explosives-related assets.

Infrastructure Is Aging and Deteriorating

According to NNSA documentation, no mission risk is greater than the state of the agency's aging infrastructure. The *NNSA 2019 Master Asset Plan* states that 40 percent of the explosives infrastructure of NNSA's sites is insufficient to meet mission needs, which can lead to contamination of explosive products or limit the use of facilities.[41] Contractor representatives told us that such contamination has occurred. For example, Pantex contractor representatives said that batches of explosives have been contaminated in its main formulation building by rust falling from the rafters and grass blowing through cracks in the walls. Similarly, Los Alamos contractor representatives said that detonator subassemblies have been rejected at the laboratory because of contamination from foreign debris, such as dust particles that enter through cracks in exterior doors.

In addition, older facilities were not built to modern safety standards and pose risks to explosives activities and employees, according to contractor representatives and NNSA documents. At Los Alamos, the design of several older facilities is insufficient to meet current needs, which negatively affects both productivity and safety. For example, the Los Alamos's High Explosives Chemistry Laboratory is a 1950s era building that is difficult to adapt to modern instrumentation, and electrical and other system failures cause approximately 20 percent downtime,

[40]GAO, *Department of Energy: Continued Actions Needed to Modernize Nuclear Infrastructure and Address Management Challenges*, GAO-18-374T (Washington, D.C.: Feb. 6, 2018). Also see GAO-15-305, GAO-11-188, and GAO-19-126.

[41]NNSA's Office of Safety, Infrastructure and Operations, *Master Asset Plan 2019* (March 2019).

according to contractor representatives. This building is also under a state of continuous limited operation because the laboratory must work under a decreased net explosive limit to keep employees safe while handling explosive materials because the facility lacks adequate blowout walls, according to contractor representatives.[42] Contractor representatives at Los Alamos said that the decreased explosive limits in this facility have hampered their productivity levels. Contractor representatives at Pantex stated that the intrusion of water in key facilities poses electrocution risks, can damage expensive equipment, and can affect production because of downtime when explosives activities must be suspended because of severe weather. Further, we observed facilities at Pantex with water leaks in the roof and floor; some of these facilities house expensive equipment that must be stored under plastic sheeting to prevent water damage. One such facility is Pantex's Analytics and Chemistry Laboratory, built in 1943 and shown in figures 4 and 5.

Figure 4: Weather Damage in the Analytics and Chemistry Laboratory at the Pantex Plant

The photo on the left shows water leaking below electrical boxes and being collected into a plastic bin connected to a hose. The photo on the right shows ceiling damage caused by rainwater leaks from the roof.

Source: Pantex Plant. | GAO-19-449

[42]Blowout walls are designed purposefully to give way in the event of an accidental explosion, directing shock waves outward to minimize damage to other parts of the facility and workers in the area. The configuration of the blowout walls for Los Alamos's High Explosives Chemistry Laboratory blow into the hallway that workers use and not into a safe zone, which affects safety and limits the amount of explosives handled in the laboratory rooms, according to contractor representatives and a senior NNSA official.

Figure 5: Equipment Covered to Protect It from Rainwater in the Analytics and Chemistry Laboratory at the Pantex Plant

Expensive testing equipment is covered with a plastic sheet to protect it from water damage.

Source: Pantex Plant. | GAO-19-449

Note: The microwave digestion system at the Pantex Plant's Analytics and Chemistry Laboratory Building combines samples and acids in a pressurized container with high operating temperatures and supports many types of explosives analyses. This system is connected to a mass spectrometer, which determines the composition of the explosive samples.

NNSA and its sites have taken some actions to address this infrastructure challenge. For example, Los Alamos plans to replace its High Explosives Chemistry Laboratory by 2026, and Pantex recently constructed a new building to replace an aging pressing facility and has plans to begin construction on a new analytical laboratory and a formulation building in the 2020s. NNSA documentation states that the new pressing facility will improve operational safety and security thereby enhancing the quality and efficiency of operations. Pantex's planned analytical laboratory and formulation buildings, however, will not be completed in time to support the currently scheduled B61-12 LEP and W88 alteration modernization effort. Further, according to NNSA officials and contractor representatives, site infrastructure modernization plans are budget dependent and funding for infrastructure modernization efforts is not always certain.

Some Infrastructure Data on Explosives-Related Assets Are Inaccurate

Contractor representatives told us and we observed during site visits that some of the data on explosives-related assets in the FIMS real property database were inaccurate and out of date. NNSA policy and the FIMS user's guide state that NNSA and sites should review and update the capabilities, or programmatic mission(s) associated with each asset, such as being explosives-related, every 5 years, or more frequently if mission requirements change or there are changes in an asset's physical condition or use. However, 8 of the 22 randomly selected assets from the four sites that we observed contained data in FIMS that were inaccurate because either the information on an asset was out of date or the asset should never have been listed as explosives-related. Some contractor representatives told us that they did not understand why some of their sites' assets had been characterized as primary assets related to the high explosives mission. For example, an inert storage closet at Pantex and a tool shed at Livermore were labeled as primary explosives-related assets, but according to contractor representatives, they can no longer be used to store explosives because they do not meet appropriate safety standards. Figure 6 illustrates the inert storage at Pantex, which officials said had not been used for any explosives operations for at least 20 years, despite "explosives storage" labeling on the door, but was still characterized as a primary explosives-related asset. However, according to NNSA officials, NNSA was, at the time of our review, in the process of revising guidance on how to associate capabilities with assets. The contractor representatives may not have been aware of the initial guidance the asset was characterized under or of the change underway at the time of our site visit.

Figure 6: Inert (Non-explosives) Storage Closet at Pantex Plant that Is Characterized as an Explosives-Related Asset

The asset is the small room through the open door and does not include the hallway into which the door opens. The other side of the closet opens to the outside. The gross area is estimated to be 101 square feet. Explosives can no longer be stored here because of safety concerns, despite the door labeling the room as "explosives storage."

Source: Pantex Plant. | GAO-19-449

In other cases, contractor representatives told us that the asset name did not indicate its current use. For example, FIMS data on explosives-related assets at Los Alamos has a "plastics building" that had not been used for manufacturing and assembling plastics for 20 years. Although it currently houses explosives-related work, the building's name in FIMS had not been updated. Additionally, Los Alamos's FIMS data indicated that the site had a "day room" that to contractor representatives' knowledge had never been used for any explosives activities although its purpose has changed over time.

We found additional inaccuracies related to various measures of explosives-related assets reported in FIMS. For example, we found at least 94 erroneous entries on the gross square footage of the 1,266 assets identified as having some type of explosives-related capability.[43]

[43]We identified these errors by analyzing data and testing for outliers and obvious errors.

For example, FIMS data indicated that a road at Livermore, a bunker at Sandia, and an asset named "recreational/fitness" at Pantex were 3, 1, and 2 gross square feet, respectively. The data listed replacement values of at least $1 million for each of these assets. Los Alamos's data contained similar errors, such as electrical cables recorded as measuring zero square feet.

NNSA officials and contractor representatives identified potential causes for inaccuracies in the FIMS data. For example, contractor representatives who work on explosives activities do not enter explosives-related asset information in FIMS, according to NNSA officials and contractor representatives. Instead, FIMS administrators, who manage information on infrastructure across NNSA sites, said they update FIMS using information that subject matter experts or building managers provide to them, typically in an annual data call. FIMS administrators may therefore not be aware of information that is dated or otherwise incorrect for explosives-related assets. In addition, entering information in certain data fields in FIMS was difficult for assets that were not buildings, according to one FIMS administrator. For example, piping and other utilities may be replaced or updated in sections over time, and it can be difficult to know which date to record for age in FIMS. Because our review included only a limited sample of explosives-related assets, we could not determine the full extent of the FIMS data inaccuracies.

NNSA managers use data from FIMS for planning purposes on infrastructure modernization decisions. According to NNSA officials, data from FIMS feeds into other databases that are used to inform infrastructure funding decisions, such as developing the Integrated Priority List that helps NNSA determine the most critical infrastructure modernization projects.[44] While NNSA relies on these data to make planning and funding decisions, our observations of explosives-related assets shows that these data may not be useful in informing the agencies' infrastructure modernization decisions. Federal internal control standards state that managers should make decisions using quality information that is appropriate, current, complete, accurate, accessible, and provided on a timely basis.[45] By taking steps to improve the accuracy of FIMS data—

[44]NNSA's Integrated Priority List ranks infrastructure modernization needs across NNSA. The Integrated Priority List uses information from NNSA's programs and the G2 database, according to NNSA officials.

[45]GAO, *Standards for Internal Control in the Federal Government*, GAO-14-704G (Washington, D.C.: Sept. 2014).

such as by reviewing and updating information about associations of assets with their primary and secondary programmatic missions, ensuring that those who provide asset information to FIMS administrators understand the data they need to provide, and clarifying how to accurately enter information in FIMS for assets that are not buildings—NNSA would have more reasonable assurance that officials, contractor representatives, and the enterprise manager have the quality information necessary to support management decisions on explosives-related activities.

Storage Areas for Explosives Are Filled to or Near Capacity

DOE's requirements for explosives storage limit the amount and type of explosives that can be stored in a single location, since certain explosives may react when stored together.[46] Explosives must be properly stored throughout their life cycles, from the synthesis of raw explosives to their use in weapon assembly or testing. According to a senior NNSA official and site contractor representatives, some sites are running out of space where they can safely store explosives. As contractor representatives from Pantex told us and we observed on our site visit, bunkers for storing explosives are filled to or near capacity, especially for storage in high-security areas. According to contractor representatives, this is problematic because Pantex has the greatest need of all NNSA sites for explosives storage because of its role in producing explosives, receiving and holding explosive parts from across the nuclear security enterprise prior to weapon assembly, and assembling and disassembling weapons. Contractor representatives from Los Alamos also voiced concern about being near their capacity to store detonator cable assemblies and other explosives awaiting shipment for installation in weapons or for testing.

NNSA officials and contractor representatives said that they are tracking the shortage of sufficient explosives storage and in some cases have plans to expand current capacity. Los Alamos contractor representatives also said that they are moving forward with constructing a small staging facility that will be collocated with their detonator production facility. It is expected to cost less than $5 million so it will not affect larger line item infrastructure projects. Contractor representatives at Pantex explained that although some storage areas have been identified for replacement, they are, as yet, unfunded projects. In the near term, contractor representatives said that they have other, more pressing infrastructure modernization project needs than explosives storage. They said that they

[46]DOE, *DOE Standard: Explosives Safety*.

are closely monitoring their storage capacity and expect ongoing modernization efforts to free up some storage space as weapons are assembled.

Difficulties in Contractors Recruiting and Training Skilled Staff

According to NNSA documents and contractor representatives, the contractor workforce at NNSA sites needs to grow to meet the demands of ongoing and future explosives work, but contractors face difficulty recruiting and training qualified new staff to perform this specialized work, which often requires a security clearance. In 2018, Pantex estimated that it needed 211 FTE contractor staff to adequately carry out the site's explosives activities. However, Pantex contractor representatives indicated that as of November 2018, they had 172 FTEs on board. A major recruitment challenge is competition from industry. Contractor representatives at multiple sites told us that they often compete with large corporations and industries in the local area that offer well-paying jobs for qualified new staff, such as for engineers. For example, site contractor representatives told us that Los Alamos and Sandia compete with Facebook in Albuquerque to attract qualified staff; and Pantex competes with various oil and gas companies in Texas. To address this challenge, contractor representatives from Pantex have recently expanded outreach to local colleges and universities, and NNSA has held job fairs to attract new staff.

Lengthy training and clearance processes that are required for specialized explosives work present another challenge. Pantex representatives said recent graduates are required to undergo on-the-job training that can take years before they are ready to safely engage in certain explosives activities. NNSA officials and contractor representatives said that this training challenge is exacerbated by the delays in processing security clearances. NNSA contractor representatives said that some new hires have waited more than a year, and some more than 2 years, to receive clearances to conduct required work or training. In December 2017, we identified delays in obtaining personnel security clearances as a government-wide risk.[47] We also added this issue to our March 2019 High-Risk List.[48] To mitigate this

[47]GAO, *Personnel Security Clearances: Additional Actions Needed to Ensure Quality, Address Timeliness, and Reduce Investigation Backlog*, GAO-18-29 (Washington, D.C.: Dec. 12, 2017).

[48]GAO, *High-Risk Series: Substantial Efforts Needed to Achieve Greater Progress on High-Risk Areas*, GAO-19-157SP (Washington, D.C.: Mar. 6, 2019). The High-Risk Series identifies federal programs at high risk for fraud, waste, abuse, and mismanagement.

challenge, contractor representatives from Pantex said that they are hiring students before they finish college so that security clearances can be granted by the time students are ready to begin their first day on the job or at least closer to that time. Los Alamos has decided to hire and train individuals without clearances, who must wear red vests and be escorted at all times while their clearances are finalized. We observed numerous workers in this temporary and escorted status during our site visit. Contractor representatives at Livermore said that they also use escorts for new staff without clearances. However, contractor representatives said that requiring additional staff as escorts is costly, can decrease productivity, and has safety impacts because additional staff must be present during activities involving high explosives.

NNSA's Strategic Plan for Explosives Does Not Describe Some Management Challenges and Is Not Fully Consistent with Leading Practices for Strategic Planning

NNSA's 2018 strategic plan for energetic materials describes some identified explosives-related challenges discussed above, as well as further actions to address these challenges, but does not describe other challenges NNSA officials and contractor representatives identified. This strategic plan incorporates some leading practices for strategic planning. However, some of the strategic plan's elements have not been fully developed consistent with selected leading practices for strategic planning.

NNSA's Defense Programs Strategic Plan for Energetic Materials Describes Some Challenges NNSA Officials and Contractor Representatives Have Identified but Not Others

The strategic plan for energetic materials, which includes comments from coordinating committee members, describes some of the challenges that NNSA officials and contractor representatives identified in conducting explosives activities, which we discussed above. Specifically, it describes some challenges related to the supply of explosive materials and to infrastructure modernization, including the following:

- **Supply of explosive materials.** The strategic plan describes both the supply of explosive materials as well as the supply of pre-cursor ingredients as a challenge facing NNSA. The strategic plan also identifies a number of actions NNSA is taking to bolster the supply chain, such as re-establishing the capability to manufacture THKP.

- **Infrastructure modernization.** The strategic plan notes that explosives-related "facilities require recapitalization to support LEP activities, improve efficiencies, reduce downtime, and maintain baseline capabilities." It also identifies several interrelated actions NNSA is taking to address infrastructure challenges, such as re-purposing some facilities and eliminating others that are inadequate, too costly to maintain, or no longer needed. In addition, the strategic plan describes the challenge of adequate storage for explosives and includes actions to annually monitor and track storage conditions at the sites as well as provide long-term, low-temperature, moisture-free storage for explosives.

However, based on our review of the strategic plan, it does not discuss three of the challenges that NNSA officials and contractor representatives had identified: the quality of data on infrastructure information, workforce levels, and safety. First, the data quality challenge related to infrastructure information, such as inaccuracies in FIMS, is not discussed in the strategic plan, although NNSA officials and contractor representatives we interviewed identified it as a challenge that may affect its planning and decision-making related to explosives activities.

Second, the strategic plan does not discuss workforce challenges. While the strategic plan states that NNSA "recognize(s) that staffing is an important aspect for supporting energetics, it assumes that ongoing efforts across the nuclear security enterprise related to workforce are successful." Since the enterprise manager does not track workforce levels across the enterprise, as previously noted, it is unclear how NNSA can determine if its contractors' workforce efforts across the enterprise are successful and whether levels are adequate to achieve the goals of the strategic plan for explosives over time.

Third, outside of infrastructure improvement, the strategic plan also does not directly discuss the challenge of safety, although it affects all explosives activities and challenges that NNSA has identified. Because of the inherent danger of explosives activities, safety is important, and even when protocols are followed, unintended events can occur that affect human safety—as illustrated by a safety incident last year. The incident occurred at a Los Alamos facility in April 2018 when a small explosive pellet deflagrated during pressing, causing two people to incur short-term

hearing loss.[49] One of those people was an escort and was only required to be present because of the delay in security clearance processing, a challenge discussed above. According to a December 2018 Los Alamos document, pressing operations had resumed at the facility. Although the cause of the incident is still unclear, it provided an opportunity to make safety improvements in the facility at Los Alamos, according to contractor representatives. According to a Los Alamos document about the incident, a key lesson learned was that safety records like maintenance logs, blast calculations, and materials safety testing results need to be archived and readily accessible to staff before the start of any work activities. The inherent challenge of safety in explosives and key lessons learned, such as this one, are not discussed in the strategic plan.

NNSA officials said that they are planning to revise the strategic plan for energetic materials in 2020 but did not state that they would include the challenges of data quality, workforce, or safety. All three of these challenges may impede NNSA's ability to achieve the goals described in the plan for explosives activities. We have previously identified selected leading practices in strategic planning. These practices specify that agencies should define strategies that address management challenges that threaten an agency's ability to meet its long-term strategic goals.[50] As NNSA revises its strategic plan for energetic materials, by discussing the data, workforce, and safety challenges it faces and the actions it plans to address them, as appropriate, or documenting the rationale for why the challenges were not included, NNSA would have better assurance that its strategies address these challenges.

[49]A deflagration is a flame that travels rapidly but slower than the speed of sound. In this case, the deflagration caused a loud noise, described as a mechanical sound, according to Los Alamos contractor representatives.

[50]GAO-12-77.

NNSA Followed Leading Practices for Strategic Planning, but Some Elements Present in Effective Strategic Plans Have Not Been Fully Developed

In developing its strategic plan for energetic materials, NNSA followed several key leading practices in strategic planning that we have identified in our past work, including the following:[51]

- **Involving stakeholders,** such as federal agencies, state governments, or others, in defining the mission and desired outcomes helps ensure that their expectations and interests are met and that resources and efforts are targeted at the program's highest priorities. When developing the strategic plan, NNSA shared a draft with members of the coordinating committee and incorporated their comments to ensure that their interests and expectations were met.
- **Assessing external and internal forces** helps managers anticipate future challenges and make adjustments before potential problems become crises. For example, external forces (e.g., emerging technological trends and new statutory requirements) and internal forces (e.g., culture, management practices, and business processes) may influence the program's ability to achieve its goals. When developing the strategic plan, NNSA officials and coordinating committee members considered external and internal forces. For example, the officials and members discussed the availability of explosives from external suppliers, such as Holston, compared to the potential costs or challenges related to internal NNSA production of explosives.
- **Covering at least a 4-year period,** while making adjustments as needed to reflect significant changes to the operating environment, is also a key strategic planning practice. The strategic plan covers more than 4 years of explosives activities. For example, there is a performance goal to re-establish a reliable THKP supply by 2024. In addition, NNSA officials have discussed their intention to update the plan as their operating environment changes.

[51]We have reported in the past on federal agencies' strategic planning efforts and have identified additional useful practices to enhance agencies' strategic plans. For example, see GAO-12-215R, GAO/GGD-97-180, and GAO/GGD-96-118. We judgmentally selected these three practices from among GPRA, OMB guidance, and our prior work because we found these practices to be the most relevant for evaluating NNSA's initial strategic planning actions for its explosives activities. We did not select leading practices that were relevant to agency-wide strategic plans rather than strategic plans for individual programs or sets of activities, such as the leading practice of coordinating with other federal agencies.

Our past work has also shown that effective strategic plans should include specific elements.[52] We reviewed NNSA's *Defense Programs Strategic Plan* for Energetic Materials and found that the strategic plan includes most of these elements, but we also found that some of the strategic plan's elements have not been fully developed. Specifically:

- **Mission statement.** According to leading federal strategic planning practices, a comprehensive mission statement should explain why a program exists and what it does.[53] The strategic plan does not clearly identify a mission statement but includes an overarching "strategy to ensure the availability of energetic materials and products for the stockpile." When asked to identify the energetics mission statement, the two contractor representatives who led the development of the strategic plan told us that they consider this "strategy" to be the energetics mission. However, a strategy cannot be a mission, since a strategy is how a mission may be achieved.
- **Long-term strategic goals and objectives, strategies, and performance goals.** There are several interrelated elements on long-term strategic goals, objectives, strategies, and performance goals, according to leading strategic planning practices.[54] These include that long-term strategic goals and objectives should specify how an agency will carry out its mission and explain what results are expected from the program. The strategic plan includes four long-term strategic goals for meeting its mission, some strategies for achieving its goals, and some performance goals to assess progress related to ensuring the availability of explosives. They are also logically linked to each other. For example, the strategic plan's goal to sustain and modernize the energetics infrastructure relates to the strategic plan's strategy to eliminate facilities that are inadequate, too costly to maintain, or no longer needed. However, we found that responsibilities for achieving the strategic plan's four goals are not clearly assigned within NNSA, and the four goals are not consistently quantifiable. For example, the third goal is to "manage the energetics supply chain," but the strategic plan does not specify who is responsible for achieving this goal within NNSA. Further, this long-term strategic goal is not quantifiable

[52]GAO, *U.S. Tsunami Preparedness: NOAA Has Expanded Its Tsunami Program, but Improved Planning Could Enhance Effectiveness*, GAO-10-490 (Washington, D.C.: Apr. 28, 2010). See also GAO-12-77, GAO-12-215R, and GAO/GGD-96-118.

[53]GAO-10-490.

[54]GAO-12-77.

because it describes a general process and does not define the expected results, which may make it difficult for NNSA to assess progress in meeting the goal.

According to leading strategic planning practices, strategies should be specific enough to allow an assessment of whether they will help achieve those goals, such as by describing the resources needed, including the staff responsible to achieve a program's goals and objectives.[55] We found that the strategic plan contains several strategies for achieving goals, but some of them are not specific enough to clearly identify the types of resources required, such as the parties responsible for achieving them. For example, under the goal of managing the energetics supply chain, there is a strategy to "plan, track and assess the energetics strategic posture," but the strategic plan does not specify what is meant by the energetics strategic posture or who is responsible for undertaking these actions. This strategy is also limited because it does not describe the resources needed to achieve the broader goal.

According to leading strategic planning practices, performance goals should be used to assess progress toward long-term goals and should include (1) the specific activities within the program that will be assessed for performance and (2) the level of performance to be achieved for each measure.[56] We found that the strategic plan has 50 performance goals, most of which were quantifiable—or able to be assessed for performance or progress. However, some were not quantifiable, such as to "enhance or advance energetics formulations for additive manufacturing." This performance goal also does not set milestones, such as a time frame for completion, or staff assigned to achieve it, contrary to leading strategic planning practices.[57] Further, the level of performance for some goals was not fully developed. For example, the performance goal "to reduce substandard mission-critical facilities below 10 percent" does not clarify whether the goal is to reduce the current number of inadequate and substandard facilities by 10 percent (a change of about 50 facilities) or reduce the total number of inadequate and substandard facilities to be less than 10 percent of all facilities (a change of about 500 facilities). This performance goal also does not set time frames for measuring

[55]GAO-10-490.

[56]GAO-10-490 and GAO-12-215R.

[57]GAO-12-215R.

performance or list responsible parties associated with it. Another performance goal that was not fully developed is to "manage the energetics supply chain," which falls under the long-term strategic goal of "sustaining and modernizing the infrastructure." In addition, this performance goal is identical to a long-term strategic goal in the strategic plan titled "manage the energetics supply chain." A performance goal should not replicate a strategic goal, since long-term strategic goals are broader in nature than performance goals. Moreover, this particular performance goal is not quantifiable, does not set a time frame for completion, and does not list a responsible party to carry out specific activities to achieve the goal.

- **External factors.** According to leading strategic planning practices, external factors that could significantly affect achievement of the strategic goals, such as economic trends or actions by Congress, state and federal agencies, or other entities, should be identified. The strategic plan identifies some external factors that could significantly affect the achievement of strategic goals. Specifically, the strategic plan notes that DOD's demand for explosives from Holston could affect NNSA's ability to achieve its goals. According to NNSA officials and documents, DOD's demand for explosives is increasing, and Holston is already struggling to meet DOD's needs. According to Holston contractor representatives, DOD is expanding Holston's production capabilities for HMX, research development explosive (RDX), and insensitive munitions explosive (IMX) which when completed will relieve pressure on TATB production. In addition, the strategic plan identifies challenges to its supplier base, such as the difficulty of sourcing explosive materials from non-U.S. suppliers and that the small size of NNSA's orders provides limited economic incentive for commercial vendors. However, the strategic plan does not identify other external factors that could significantly affect the achievement of strategic goals, such as actions taken or not taken by Congress. Specifically, modernizing the explosives infrastructure will require appropriations for the significant capital investment needed, but the uncertainty of future appropriations in a challenging fiscal environment is an external factor not identified in the strategic plan. In addition, the strategic plan does not acknowledge that other NNSA programs may compete for funds or affect infrastructure modernization priorities at a given site.

NNSA officials, including the enterprise manager, stated that they are aware that the strategic plan for energetic materials has limitations, such as performance goals that are not specific or are difficult to quantify. NNSA officials said that they released the strategic plan quickly as it was the first of its kind for explosives activities, and they believed the

explosives community would receive the most benefit it if it was published as soon as possible, though it was not fully complete. Further, they said that they intend to revise the strategic plan in the next year or so. As NNSA revises its strategic plan for energetic materials, including fully developed elements of an effective plan—such as a clear mission statement and quantifiable performance goals that set time frames for completion and list responsible parties who will carry out specific activities for all strategic goals—would help NNSA make the strategic plan useful in measuring goal achievement and assessing accountability.

Conclusions

NNSA is undertaking an extensive, multifaceted effort to sustain and modernize U.S. nuclear weapons, and explosives are essential to the functioning of these weapons. Five NNSA sites conduct a range of interdependent activities to design and produce explosives. NNSA has identified several challenges in carrying out these activities and is taking actions to address them. For example, NNSA officials and contractor representatives identified challenges related to producing highly specialized materials and are working to re-establish their supply. However, NNSA managers may be relying on inaccurate FIMS data on infrastructure related to explosives activities to make modernization decisions, because we found a number of inaccuracies in FIMS data on explosives activities. NNSA officials and contractor representatives identified a few potential causes for these inaccuracies; however, because our review included only a limited sample of explosives-related assets, we could not determine the full extent of the FIMS data inaccuracies. According to NNSA officials, NNSA has taken some initial steps to revise guidance, which we find encouraging as these revisions may help improve accuracy of FIMS data. By taking additional steps to improve the accuracy of FIMS data—such as reviewing and updating information about associations of assets with their primary and secondary programmatic missions, ensuring that those who provide asset information to FIMS administrators understand the data they need to provide, and clarifying how to accurately enter information in FIMS for assets that are not buildings—NNSA would have more reasonable assurance that officials, contractor representatives, and the enterprise manager have the quality information necessary to support management decisions on explosives-related activities.

In addition, the strategic plan for energetic materials—which represents a positive step toward managing explosives in a forward-looking, enterprise-wide approach—does not discuss three of the significant challenges that NNSA officials and contractor representatives identified

related to explosives activities. NNSA officials said that they are planning to revise the strategic plan in 2020 but did not state that they would incorporate data quality, workforce, or safety challenges. As the agency revises its strategic plan for energetic materials, by discussing these challenges and actions planned to address them, as appropriate, or documenting the rationale for why the challenges were not included, NNSA would have better assurance that it is effectively managing challenges that present risks to achieving its objectives.

The strategic plan for energetic materials also does not contain fully developed elements that we have previously reported that effective strategic plans should include, such as a fully developed mission statement and performance goals that are quantifiable, set time frames for completion, and list responsible parties to carry out specific activities. NNSA officials said that they intend to revise the strategic plan in 2020. As NNSA revises its strategic plan for energetic materials, by including fully developed elements of an effective strategic plan—such as a fully developed and clearly identified mission statement and performance goals that are quantifiable, have time frames for completion, and list responsible parties to carry out specific activities for all strategic goals—NNSA would help make the strategic plan more useful in measuring goal achievement and assessing accountability.

Recommendations for Executive Action

We are making the following three recommendations to NNSA:

NNSA's Energetic Materials Enterprise Manager and relevant NNSA officials and contractor representatives at NNSA sites should take steps to improve the accuracy of FIMS data related to NNSA's infrastructure supporting explosives activities. These steps should include reviewing and updating information about associations of assets with primary and secondary explosives missions; ensuring that those who provide asset information to FIMS administrators understand the data they need to provide; and clarifying how to accurately enter information in FIMS for explosives assets that are not buildings. (Recommendation 1)

NNSA's Energetic Materials Enterprise Manager, in consultation with members of NNSA's Energetics Coordinating Committee, should, as the agency revises its *Defense Programs Strategic Plan for Energetic Materials*, include discussion of identified challenges related to explosives activities, such as data quality, workforce levels, and safety as well as any actions to address them, as appropriate, or document the rationale for why identified challenges were not included. (Recommendation 2)

NNSA's Energetic Materials Enterprise Manager, in consultation with members of NNSA's Energetics Coordinating Committee, should, as the agency revises its *Defense Programs Strategic Plan for Energetic Materials*, include fully developed elements of an effective strategic plan, such as a clearly identified mission statement and performance goals that are quantifiable, set time frames for completion, and list responsible parties to carry out specific activities for all strategic goals. (Recommendation 3)

Agency Comments

We provided a draft of this report to DOE and NNSA for review and comment. In its written comments, which are summarized below and reproduced in full in appendix I, NNSA concurred with the report's recommendations and described actions that it intends to take in response to our recommendations. NNSA also provided technical comments, which we considered and incorporated in our report as appropriate. DOE did not comment on our findings and recommendations.

In response to our first recommendation, NNSA stated that it recognizes the need to improve infrastructure data consistency and accuracy and intends to complete several actions by March 31, 2020 to improve its infrastructure data. For example, DOE's Infrastructure Executive Committee is conducting a comprehensive review of the existing 178 data elements in FIMS and has proposed deleting or adjusting 66, which it believes will sharpen its focus on data quality for the remaining data elements. In addition, among other actions, NNSA stated it is implementing the Mission Dependency Index 2.0 initiative, which is expected to provide greater consistency and accuracy on reporting asset capability and determining consequence to mission.

In response to our second and third recommendations, NNSA stated that it is planning to revise its S*trategic Plan for Energetic Materials* by October 31, 2019. NNSA stated that the update to its plan will include a discussion of the identified challenges to explosives activities as well as fully developed elements of an effective strategic plan.

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

If you or your staff have any questions about this report, please contact me at (202) 512-3841 or at 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 are listed in appendix II.

Allison B. Bawden
Director,
Natural Resources and Environment

List of Committees

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

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

Appendix I: Comments from the National Nuclear Security Administration

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

May 30, 2019

Ms. Allison B. Bawden
Director, Natural Resources
and Environment
U.S. Government Accountability Office
Washington, DC 20548

Ms. Bawden:

Thank you for the opportunity to review the Government Accountability Office (GAO) draft report "Nuclear Weapons: Additional Actions Could Help Improve Management of Activities Involving Explosive Materials" (GAO-19-449). The Department of Energy's National Nuclear Security Administration (DOE/NNSA) appreciates GAO's recognition of the steps DOE/NNSA has taken to better manage and coordinate its high explosives activities across the nuclear security enterprise. We have made extraordinary progress over the past year in our Energetics Materials Program. Most notably, DOE/NNSA selected an Energetic Materials Enterprise Manager, stood up the Energetics Coordinating Committee, and issued the first *Strategic Plan for Energetic Materials*.

GAO's observations and recommendations are consistent with DOE/NNSA's recent efforts to centralize management of energetic materials across the Enterprise. The Office of Safety, Infrastructure, and Operations previously identified many of the infrastructure data issues presented in the report and developed a series of actions aimed at improving the accuracy of asset data. These efforts have already resulted in improved data quality, and the accuracy and consistency of data will continue to improve as additional actions are completed. With regard to the *Strategic Plan for Energetic Materials*, the auditors' recommendations reflect the logical next steps in enhancing the plan. When drafting the next iteration, DOE/NNSA will fully consider GAO's observations.

The attached management decision identifies the detailed actions planned and taken in regards to GAO's recommendations. Our subject matter experts have also provided technical and general comments under separate cover for your consideration. If you have any questions about this response, please contact Dean Childs, Director, Audits and Internal Affairs, at (301) 903-1341.

Sincerely,

Lisa E. Gordon-Hagerty

Enclosure

Enclosure

NATIONAL NUCLEAR SECURITY ADMINISTRATION

Response to Report Recommendations
"Nuclear Weapons: Additional Actions Could Help Improve Management of Activities Involving Explosive Materials" (GAO-19-449)

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

Recommendation 1: Take steps to improve the accuracy of Facilities Information Management System (FIMS) data related to DOE/NNSA's infrastructure supporting explosives activities. These steps should include reviewing and updating information about associations of assets with primary and secondary explosives missions; ensuring that those who provide asset information to FIMS administrators understand the data they need to provide; and clarifying how to accurately enter information in FIMS for explosives assets that are not buildings.

Management Response: Concur. DOE and DOE/NNSA recognize the need to improve FIMS data consistency and accuracy and are taking a number of steps to improve asset data quality. The DOE Infrastructure Executive Committee is conducting a comprehensive review of the 178 FIMS data elements for relevance and areas of improvement. DOE/NNSA, with program managers and site representatives, has reviewed and proposed deleting or adjusting 66 FIMS data elements. The revised data set will allow for greater focus on data quality for the remaining data elements.

DOE/NNSA is also focusing on quality improvements through other efforts:

- DOE/NNSA Asset Information Management Initiative – As a first step, this initiative recently created a community of program managers, analysts, and site representatives to coordinate and create new processes and consistent methodologies for capturing and reviewing asset data.
- U.S. Army Corps of Engineers BUILDER System – Once complete, DOE/NNSA's implementation of this system will ensure consistent, repeatable, and transparent reviews of asset condition, and will allow for automated transfer of key asset information directly into FIMS.
- DOE/NNSA Mission Dependency Index 2.0 – This initiative, when fully implemented, will provide greater consistency and accuracy on reporting asset capability and determining consequence to mission.

These actions are expected to fully address GAO's recommendation. The estimated date for completing all of these actions is March 31, 2020.

Recommendation 2: As the agency revises its *Strategic Plan for Energetic Materials*, include discussion of identified challenges related to explosives activities, such as data quality, workforce levels, and safety as well as any actions to address them, as appropriate, or document the rationale for why identified challenges were not included.

1

Enclosure

Management Response: Concur. DOE/NNSA will include a discussion of the identified challenges to explosives activities in the next update to the *Strategic Plan for Energetic Materials*, consistent with GAO's recommendation. The estimated date for completing this action is October 31, 2019.

Recommendation 3: As the agency revises its *Strategic Plan for Energetic Materials*, include fully developed elements of an effective strategic plan, such as a clearly identified mission statement and performance goals that are quantifiable, have a time frame for completion, and list a responsible party to carry out specific activities for all strategic goals.

Management Response: Concur. DOE/NNSA will include the identified elements in the next update to the *Strategic Plan for Energetic Materials*, consistent with GAO's recommendation. The estimated date for completing this action is October 31, 2019.

2

Appendix II: GAO Contact and Staff Acknowledgments

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