Second, the Air Force did not adequately review NNSA's design, engineering, and testing activities—a review that would have alerted it to the fact that NNSA was unable to meet all refurbishment objectives. According to Air Force officials, the Lead Project Officer failed to provide the necessary oversight because he lacked the technical and managerial expertise to do so. He did not alert the Air Force to significant concerns with the testing of the refurbished B61. In particular, the Air Force did not raise concerns about NNSA's failure to complete all agreed-upon tests until NNSA had completed a majority of its tests and was preparing for full-scale production. After NNSA entered production, the Air Force required NNSA to conduct additional tests to provide a greater level of assurance that the refurbished B61 would perform as intended and last in the stockpile for at least another 20 years. As we noted, NNSA agreed to conduct additional tests and plans to complete them by the end of 2009. Importantly, these tests will be completed after all the B61 bombs now being refurbished are back in the stockpile.

NNSA Did Not Adequately Address One of the Highest Risks to the W76 Program, Which Led to Cost Increases, Schedule Delays, and an Unrealistic Production Schedule

NNSA developed a risk mitigation strategy to avoid potential cost overruns and schedule delays related to the manufacture of Fogbank but failed to effectively implement it. As a result, NNSA's original plans to produce the first refurbished W76 weapon in September 2007 slipped to September 2008. In addition, NNSA spent $69 million to address Fogbank production problems, and the Navy faced logistical challenges in replacing old W76 warheads with refurbished ones on submarines owing to the delay. Furthermore, NNSA did not use the same criteria and accounting practices each fiscal year to develop a cost baseline for the W76 program, which makes it difficult to track refurbishment costs over time.

NNSA Failed to Address One of Its Highest Risks to the Program

At the beginning of the W76 life extension program in 2000, NNSA identified key technical challenges that would potentially cause schedule delays or cost overruns. One of the highest risks was manufacturing Fogbank because it is difficult to manufacture. In addition, 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. Finally, NNSA had to build a new facility at the Y-12 plant because the facilities that produced Fogbank ceased operation in the 1990s and had

since been dismantled, except for a pilot plant used to produce small quantities of Fogbank for test purposes.

To address these concerns, NNSA developed a risk management strategy for Fogbank with three key components: (1) building a new Fogbank production facility early enough to allow time to re-learn the manufacturing process and resolve any problems before starting full production; (2) using the existing pilot plant to test the Fogbank manufacturing process while the new facility was under construction; and (3) developing an alternate material that was easier to produce than Fogbank. However, NNSA failed to effectively implement these three key components. As a result, it had little time to address unexpected technical challenges and no guaranteed source of funding to support risk mitigation activities.

NNSA Started the New Facility Late

After determining that 2 years was sufficient time to test and perfect the Fogbank manufacturing process, NNSA set March 2005 as the target date to begin operations of the new facility at the Y-12 plant and worked backward from that date to establish a design, build, and test schedule for the new facility, according to the official in charge of the project. Working from lessons learned from the W87 life extension program, NNSA strove to achieve an early operations start date to allow sufficient time to address any potential problems in manufacturing Fogbank. In 2000, we reported that production problems resulting from such factors as restarting an atrophied production complex and addressing safety and technician training issues led directly to slippage in the W87 life extension program schedule and contributed to increased costs.[8] In addition, NNSA's own lessons learned report on the W87 program identified the need to demonstrate processes early and often and stated that, with limited resources, assumptions such as "we did it before so we can do it again" are often wrong.

NNSA started the new facility's operations about 1 year late because the schedule for building the facility was unrealistic, disagreements on the implementation of safety guidelines emerged, and the W76 program manager lacked authority to control the schedule. Focused on meeting an operations start date of March 2005, NNSA developed an aggressive construction and operation start schedule with no contingency for cost

[8]GAO, *Nuclear Weapons: Improved Management Needed to Implement Stockpile Stewardship Program Effectively*, GAO-01-48 (Washington, D.C.: Dec. 14, 2000).

overruns or schedule delays. This schedule increased risk to meeting the program schedule because any delay would leave less than 2 years to conduct test production runs, which NNSA determined were necessary for perfecting the process. In addition, the Fogank facility was the first new manufacturing facility to be built at Y-12 in 30 years; therefore, a lack of recent experience with construction project management and implementing safety guidelines heightened the potential for problems. In fact, the contractor building the facility underestimated the time needed to complete preparations for start-up, including training and certifying staff to use the equipment and calibrating instruments.

In addition, NNSA and the contractor disagreed on the interpretation and implementation of safety guidelines. A lack of clarity about which guidelines would apply and the proper interpretation of the guidelines caused confusion over the course of the project. At a late stage, NNSA directed the contractor to apply more conservative nuclear facility safety requirements. As a result, the contractor needed additional time to address safety concerns by, for example, installing weather- and earthquake-proof equipment.

When these issues emerged, the W76 NNSA program manager did not have the authority to manage the construction of the project or resolve the dispute over safety guidelines even though a key risk mitigation strategy was the timely start of facility operations. Construction and start-up of the facility was managed by Y-12, which reported to the Y-12 Site Office, a separate organization not under the authority of the program manager. As soon as the March 2005 new facility start date was missed, the program manager raised concerns and elevated them to the Deputy Administrator for Defense Programs, the cognizant management organization at NNSA headquarters, but the issues remained unresolved. Ultimately, start-up of the new facility was postponed by approximately 1 year, leaving NNSA with half the time originally planned to re-learn the Fogbank production process.

NNSA Did Not Make Full Use of the Pilot Plant

NNSA planned to use the Y-12 pilot plant to gain a better understanding of Fogbank properties and to test the production process on a small scale while the new facility was under construction. The pilot facility could only produce a small amount of Fogbank for the W76 program because it had only a few machines. Although NNSA used the pilot plant from 2000 to 2003, it did not have funds to continue the effort because it shifted money from the W76 program to support higher priority programs at the time, such as the W87 and B61 life extension programs.

However, in 2004, anticipating delays in starting operations at the new facility and recognizing the importance of continuing work at the pilot plant, NNSA provided funding to pay for additional work at the pilot plant. By completing this work, NNSA learned that certain techniques significantly affected the quality of the end product and made adjustments to meet requirements. However, NNSA did not conduct as much work as originally planned and missed opportunities to learn more about the manufacturing process before starting operations.

NNSA Delayed the Development of an Alternate Material until Fogbank Manufacturing Problems Arose

In 2000, NNSA considered replacing Fogbank with an alternate material that was less costly and easier to produce but abandoned the idea because NNSA was confident that it could produce Fogbank since it had done so before. In addition, LANL's computer models and simulations were not sophisticated enough to provide conclusive evidence that the alternate material would function exactly the same as Fogbank. Still further, the Navy, the ultimate customer, had expressed a strong preference for Fogbank because of its proven nuclear test record. In response to the Navy's preference and the lack of sufficient test data on the alternate material, NNSA did not pursue the development of an alternate material until 2007.

In March 2007, however, NNSA again considered producing an alternative material when it was unable to produce usable Fogbank and was facing the prospect of significant schedule delays. Computer models and simulations had improved since 2001, enabling greater confidence in the analysis of alternate materials. Thus, NNSA began a $23 million initiative to develop an alternate material. LANL officials told us that NNSA plans to certify the use of the alternative material by the end of 2009 for the W76 warhead and if NNSA faced additional Fogbank manufacturing problems during full-scale production, the alternate material could then be used instead of Fogbank. Had NNSA continued research and development of an alternate material during the program, it would have had more information on the viability of using the alternate material in the weapon before March 2007. This additional information also might have provided the Navy greater assurance that an alternate material performed as well as Fogbank.

Ineffective Risk Management Led to Schedule Delays and Cost Increases

A failure to implement the three components of NNSA's risk management strategy for Fogbank led to a 1-year schedule delay and a $69 million cost overrun. This cost overrun included $22 million to resolve Fogbank production problems, $23 million to develop the alternate material, and $24 million to maintain Pantex's production capabilities. Regarding Fogbank production problems, in March 2007, NNSA discovered that final

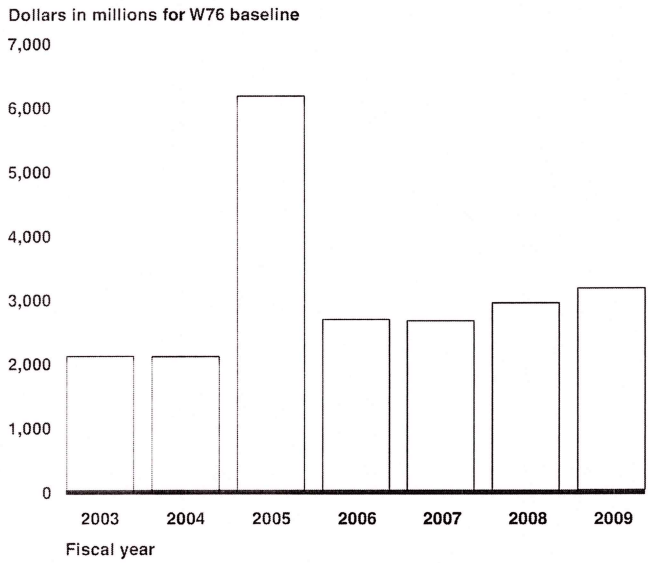
batches of the material had problems. To address the problems and try to meet its September 2007 date for producing the first refurbished weapon, NNSA launched a major effort—"Code Blue"—that made the manufacture of Fogbank a priority for the design laboratories and production facilities. However, this effort failed, and, as a result, NNSA delayed producing the first refurbished weapon from September 2007 to September 2008, and it began its efforts to develop an alternate material to Fogbank. Finally, while Pantex was unable to begin assembling refurbished units in September 2007 as planned, it still spent $24 million in fiscal year 2008 to remain in "stand-by" mode, which includes maintaining the skills of the technicians who will assemble refurbished W76 weapons.

The 1-year delay led to logistical challenges for the Navy and an aggressive production schedule of refurbished W76 warheads to make up time. The Navy originally planned to start replacing old W76 warheads with refurbished ones on submarines in April 2008. However, owing to W76 production delays, the Navy had to replace aging parts of W76 warheads in its current arsenal and has had to delay replacing old warheads with newly refurbished weapons until April 2009. Furthermore, to make up for initial schedule setbacks caused by Fogbank production problems, NNSA has increased the rate at which it plans to produce refurbished W76 weapons. NNSA will produce more weapons per year than originally planned, an annual increment that over time will enable it to still finish production at the originally planned end date. However, a higher rate of production requires more resources and leaves less room for error because any slowdown will have a greater impact on the larger number needed to be produced. NNSA production officials have indicated that they may not be able to meet this more compressed schedule if they do not receive extra resources or if they encounter any production problems, both considered realistic possibilities.

NNSA Lacks a Consistent Approach to Developing the W76 Cost Baseline

NNSA does not have a consistent approach for developing a cost baseline for the W76 program. NNSA has changed its baseline almost every year since 2001 to reflect changes in the number of warheads needed in the stockpile and changes in NNSA reporting guidelines. For example, in fiscal year 2004, the cost estimate for the W76 program was $2.1 billion;[9] in fiscal year 2005, it was $6.2 billion; and in fiscal year 2006, it was $2.7 billion (see fig. 2).

Figure 2: W76 Cost Baseline



Source: GAO analysis of NNSA data.

Changes in the baseline were the result of changes in the percent of the stockpile to be refurbished, which ranged from 25 percent to 86 percent. As the number of weapons to be refurbished changed, the baseline moved correspondingly because it costs more to refurbish more weapons. For example, NNSA planned to refurbish significantly more weapons in 2005 than 2004, based on official guidance, accounting for part of the $4.1 billion differential between those years.

Significant changes in the baseline were also driven by inconsistent NNSA accounting practices. For example, in fiscal year 2005, NNSA required program managers to include all indirect costs, such as the overhead costs

[9]This estimate excludes construction costs.

of operating facilities, as well as direct costs in the baseline. The next year it dropped this requirement. Prior to fiscal year 2005, NNSA did not tie overhead costs to specific weapon systems. However, in an attempt to provide a more accurate estimate of total costs by weapon, NNSA created accounts for the W76 warhead that captured a pro-rated portion of general costs, such as research and production support at the laboratories and production facilities. For example, NNSA included the pro-rated cost of forklift operators, who load and unload trucks for all weapon systems. Thus, a portion of these overhead costs was added to the 2005 baseline to better account for the full the costs of the program. However, NNSA discovered that this approach constrained flexibility. If priorities shifted and changes needed to be made to overhead activities, resources could not be easily redirected to different weapon systems. Any change would require congressional approval because such overhead costs were tied to a specific weapon system as a budget line item. Consequently, in fiscal year 2006, NNSA reported the production and research support accounts separately. While this change restored some flexibility for overall NNSA complex management, the transition reduced clarity about the total cost of a weapon system. Accounting changes have persisted, with, for example, some baseline years including large expense items, such as employee benefits, and other baseline years excluding such costs. A lack of a consistent baseline approach with similar cost assumptions and criteria makes it difficult to track the costs of the program over time and determine how well NNSA develops cost estimates.

Conclusions

Refurbishing the nuclear weapons stockpile is a difficult task. NNSA must draw on the scientific expertise of the nuclear weapons laboratories and the manufacturing and engineering expertise of the nuclear weapons production facilities. Recognizing this challenge, NNSA and DOD have developed multiple tools for managing the refurbishment effort: Phase 6.X, risk management strategies, test and evaluation plans, and a lessons learned document from the W87 life extension program.

By selectively using these guidance documents, however, NNSA has incurred significant cost increases and schedule delays that it could have avoided. In addition, NNSA did not include any cost or schedule contingencies in its baseline to address the unforeseen technical challenges that arose. If NNSA had more carefully followed the Phase 6.X process, it might have had sufficient time in its schedule to develop and test key materials that it had not manufactured in decades and address unforeseen technical issues.

Moreover, NNSA did not fully implement its risk management strategy to address one of the highest risks to the W76 life extension program—the manufacturing of Fogbank. If NNSA had effectively implemented its risk management strategies, schedule delays and cost increases might have been avoided or mitigated. Most importantly, if NNSA had started operations of the new facility on schedule, it would have had more time to address manufacturing challenges. In fact, the 1-year delay in the startup of the new Fogbank facility corresponded almost exactly to the 1-year program delay. In addition, without the authority to control the construction and start of operations of the new facility, the W76 program manager could not help resolve the disagreement over the safety regulations needed at the facility. Potentially compounding these problems, NNSA committed to an ambitious production schedule to make up for delays related to Fogbank—a schedule that does not leave time to address any future production problems. Furthermore, NNSA cannot be held accountable to meeting its cost targets without a consistent approach in developing a cost baseline for the W76 program. The ability to track cost over time and assess how well an agency holds to a cost baseline is fundamental for proper management and oversight.

Finally, because DOD failed to adequately oversee the B61 refurbishment program, as Phase 6.X requires, NNSA spent unnecessary time and money trying to find an alternative material. In addition, because the Lead Project Officer for the B61 bomb did not adequately monitor NNSA's activities during critical phases or have the technical expertise to do so, the Air Force did not have sufficient time to ask NNSA to conduct additional tests before NNSA entered full-scale production.

All of these management issues raise significant questions about NNSA's ability not only to complete life extension programs on time and on budget that meet all refurbishment objectives, but also its ability to manage the design and production of new weapons, such as the proposed reliable replacement warhead. NNSA and DOD state that the reliable replacement warhead is a way to replace the nation's aging stockpile with a safer, more reliable, and more secure warhead than those currently in our stockpile, and plan to use the Phase 6.X process to design and manufacture this warhead. Because NNSA did not properly follow the Phase 6.X process, meet all refurbishment objectives for the B61 bomb, and conduct all planned tests, it raises questions about NNSA's ability to design a new weapon that meets DOD's needs and also provides sufficient confidence to DOD that a new weapon will perform as expected without conducting underground nuclear tests. In addition, NNSA's failure to implement its risk mitigation strategy for the highest risk to the program and implement lessons learned from prior life

extensions, like the W87 warhead, does not inspire confidence in its ability to achieve the program's goals on time and on budget.

Recommendations

To improve the management of the stockpile life extension program, we recommend that the Administrator of NNSA direct the Deputy Administrator for Defense Programs to take the following six actions:

- Develop a realistic schedule for the W76 warhead and future life extension programs that allows NNSA to (1) address technical challenges while meeting all military requirements and (2) build in time for unexpected technical challenges that may delay the program.
- Assess the cost and include funding in the baseline for risk mitigation activities that address the highest risks to the W76 and future life extension programs.
- Before beginning a life extension program, assess the risks, costs, and scheduling needs for each military requirement established by DOD.
- Ensure that the program managers responsible for overseeing the construction of new facilities directly related to future life extension programs coordinate with the program managers of such future programs to avoid the types of delays and problems faced with the construction and operation of the Fogbank manufacturing facility for the W76 program.
- Ensure that program managers for the construction of new facilities for future life extensions base their schedule for the construction and start-up of a facility on the life extension program managers' needs identified in their risk mitigation strategies.
- Develop and use consistent budget assumptions and criteria for the baseline to track costs over time.

To improve DOD's oversight over NNSA's life extension activities and ensure that refurbished weapons meet all military requirements, we recommend that the Secretary of Defense take the following three actions:

- Direct STRATCOM and the Secretary of the responsible Service to comprehensively review military requirements for a weapons system prior to entering Phase 6.2A of a life extension program.
- Direct STRATCOM and the Secretary of the responsible Service to work with NNSA to assess the cost and schedule implications for meeting each military requirement prior to entering Phase 6.3.

- Direct the Secretaries of the Air Force and the Navy to ensure that their respective Lead Project Officers have the technical and managerial expertise and resources to review NNSA's progress and technical challenges throughout the life extension program.

Agency Comments and Our Evaluation

We provided NNSA and DOD with draft copies of our classified report for their review and comment. In addition to their official comments, which are reprinted in appendixes I and II, NNSA and DOD provided technical comments, which we incorporated as appropriate. As discussed in our classified report, NNSA agreed with our recommendations and plans to take a number of steps to implement them. First, NNSA plans to assess the risks, costs, and scheduling needs for each military requirement DOD establishes during the early phases of a life extension program. NNSA will consult officials from the production facilities to better understand the potential impact on cost and schedule of manufacturing critical nuclear and non-nuclear materials. In addition, NNSA plans to adopt an Integrated Phase Gate process that establishes well-defined milestones, or gates, throughout the Phase 6.X process. Before proceeding to the next gate, NNSA and DOD officials must identify any risks to cost and schedule and can opt to delay the life extension program if the risks are too high and additional actions, such as testing, should be taken. Second, NNSA will include funding needs for risk mitigation activities that address the highest risks to future life extension programs in budget reports to Congress. Third, NNSA plans to better coordinate construction activities at the production facilities with the needs of life extension program activities. Last, according to NNSA, it developed a methodology to establish a baseline with consistent budget assumptions and criteria to track costs over time. We believe that these actions could significantly improve the management of the life extension program.

DOD partially agreed with our recommendations. DOD agreed with our two recommendations directed at the department, but asked us to make modifications to the language of the recommendations to better target the responsible service or agency that has authority to implement them. We modified our recommendations by (1) including the Department of the Navy because it is responsible for reviewing NNSA's refurbishment activities for certain nuclear weapons, such as the W76, and (2) specifying during which phase of the phase 6.X process DOD should comprehensively review its military requirements and assess the cost and schedule implications for meeting each military requirement. DOD also expressed concern that the report placed an undue burden of responsibility for program delays for the B61 life extension program on DOD and that there were other technical issues NNSA faced that were not discussed in this report that led to program delays. We