

# U.S. Nuclear Weapons Capability

In today's rapidly changing world, the U.S. nuclear weapons enterprise must be, in the words of President Donald Trump, "*modern, robust, flexible, resilient, ready and appropriately tailored to deter 21st-century threats and reassure our allies.*"<sup>1</sup> If the U.S. detects a game-changing nuclear weapons development in another country, the nuclear weapons complex must be able to provide a timely response.

After shifting focus away from maintaining nuclear dominance following the Cold War, the U.S. nuclear enterprise must again focus on its main mission. If it is going to continue its policy of deterrence through strength and assure its allies while promoting nuclear non-proliferation, the U.S. must overcome multiple challenges: an aging nuclear stockpile, aging infrastructure, and aging experts combined with an uncertain funding environment and issues surrounding overall force readiness.

The U.S. maintains an inactive stockpile that includes near-term hedge warheads that can be put back into operational status within six to 24 months. Extended hedge warheads purportedly can be made ready within 24 to 60 months.<sup>2</sup> The U.S. preserves upload capability on its strategic delivery vehicles, which means that in principle, the nation could increase the number of nuclear warheads on each type of its delivery vehicles if contingencies warrant. For example, the U.S. Minuteman III intercontinental ballistic missile (ICBM) can carry up to three nuclear warheads, although it is currently deployed with only one.<sup>3</sup>

While the United States preserves these capabilities, increasing capacity would be not only costly, but also difficult and

time-consuming in practice. Certain modernization decisions (e.g., 12 instead of 14 *Columbia*-class ballistic missile submarines, with 16 missile tubes per submarine instead of 24) will limit upload capacity on the strategic submarine force. U.S. heavy bombers will continue to retain a robust upload capability.

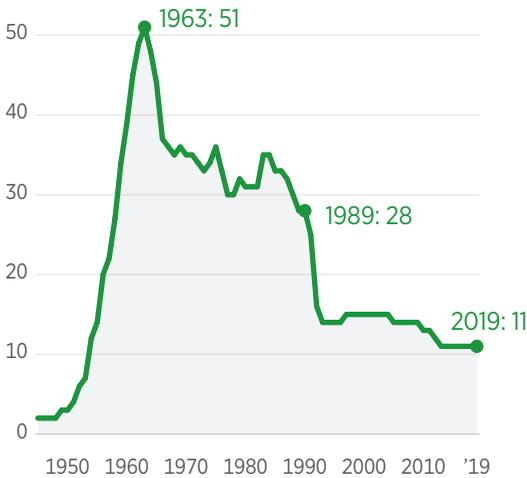
Presidential Decision Directive-15 (PDD-15) requires the U.S. "to maintain the ability to conduct a nuclear test within 24-to-36 months of direction by the President to do so."<sup>4</sup> However, successive governmental reports have noted the continued deterioration of technical and diagnostics equipment and the inability to fill technical positions supporting nuclear testing readiness.<sup>5</sup> A lack of congressional support for improvements in technical readiness further undermines efforts by the National Nuclear Security Administration (NNSA) to comply with the directive.

The nuclear weapons labs face demographic challenges of their own. Most scientists and engineers with practical hands-on experience in nuclear weapon design or testing experience (or both) are retired. This means that the U.S. must rely on the scientific judgment of designers and engineers who were involved neither in nuclear tests nor in weapons design and development and who must now continue to certify weapons designed and tested over 30 years ago.

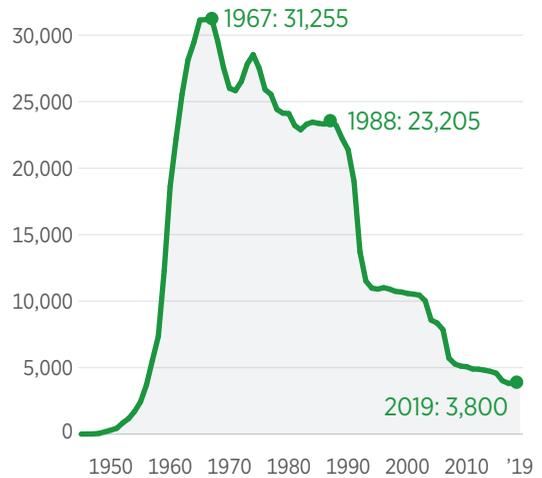
Not all of the existing inactive stockpile will go through life-extension programs (LEPs). Hence, the U.S.'s ability to respond to contingencies by uploading weapons kept in an inactive status will decline with the passage of time. This means that even with LEPs, the U.S. may not be able to sustain the necessary reliability.

## A Smaller and Less Diverse Nuclear Arsenal

TYPES OF WARHEADS IN THE U.S. NUCLEAR STOCKPILE



TOTAL WARHEADS IN THE U.S. NUCLEAR STOCKPILE



**SOURCES:** Robert S. Norris and Hans M. Kristensen, “U.S. Nuclear Warheads, 1945–2009,” *Bulletin of the Atomic Scientists*, 2009, <https://www.tandfonline.com/doi/full/10.2968/065004008> (accessed April 20, 2018); U.S. Department of Energy, *Report to Congress, “Stockpile Stewardship and Management Plan,”* November 2017, [https://www.energy.gov/sites/prod/files/2017/11/f46/fy18ssmp\\_final\\_november\\_2017%5B1%5D\\_0.pdf](https://www.energy.gov/sites/prod/files/2017/11/f46/fy18ssmp_final_november_2017%5B1%5D_0.pdf) (accessed April 23, 2018); U.S. Department of Energy, “Restricted Data Declassification Decisions, 1946 to the Present,” <https://fas.org/sgp/library/rdd-5.html> (accessed April 23, 2018); U.S. Department of Defense, “Stockpile Numbers,” [http://open.defense.gov/Portals/23/Documents/frddwg/2017\\_Tables\\_UNCLASS.pdf](http://open.defense.gov/Portals/23/Documents/frddwg/2017_Tables_UNCLASS.pdf) (accessed April 23, 2018); Hans M. Kristensen and Matt Korda, “United States Nuclear Forces, 2019,” *Bulletin of the Atomic Scientists*, April 29, 2019, <https://www.tandfonline.com/doi/pdf/10.1080/00963402.2019.1606503?needAccess=true> (accessed July 11, 2019); and Hans M. Kristensen and Matt Korda, “Status of World Nuclear Forces,” May 2019, <https://fas.org/issues/nuclear-weapons/status-world-nuclear-forces/> (accessed July 11, 2019).

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After the end of the Cold War, the shift in emphasis away from the nuclear mission caused the nuclear laboratories to lose a sense of purpose. They felt compelled to reorient and broaden their mission focus. According to a number of studies, their relationship with the government also evolved in ways that reduced output and increased costs. The NNSA was supposed to address these problems but has largely failed in this task, partly because “the relationship with the NNSA and the National security labs appears [to] be broken.”<sup>6</sup>

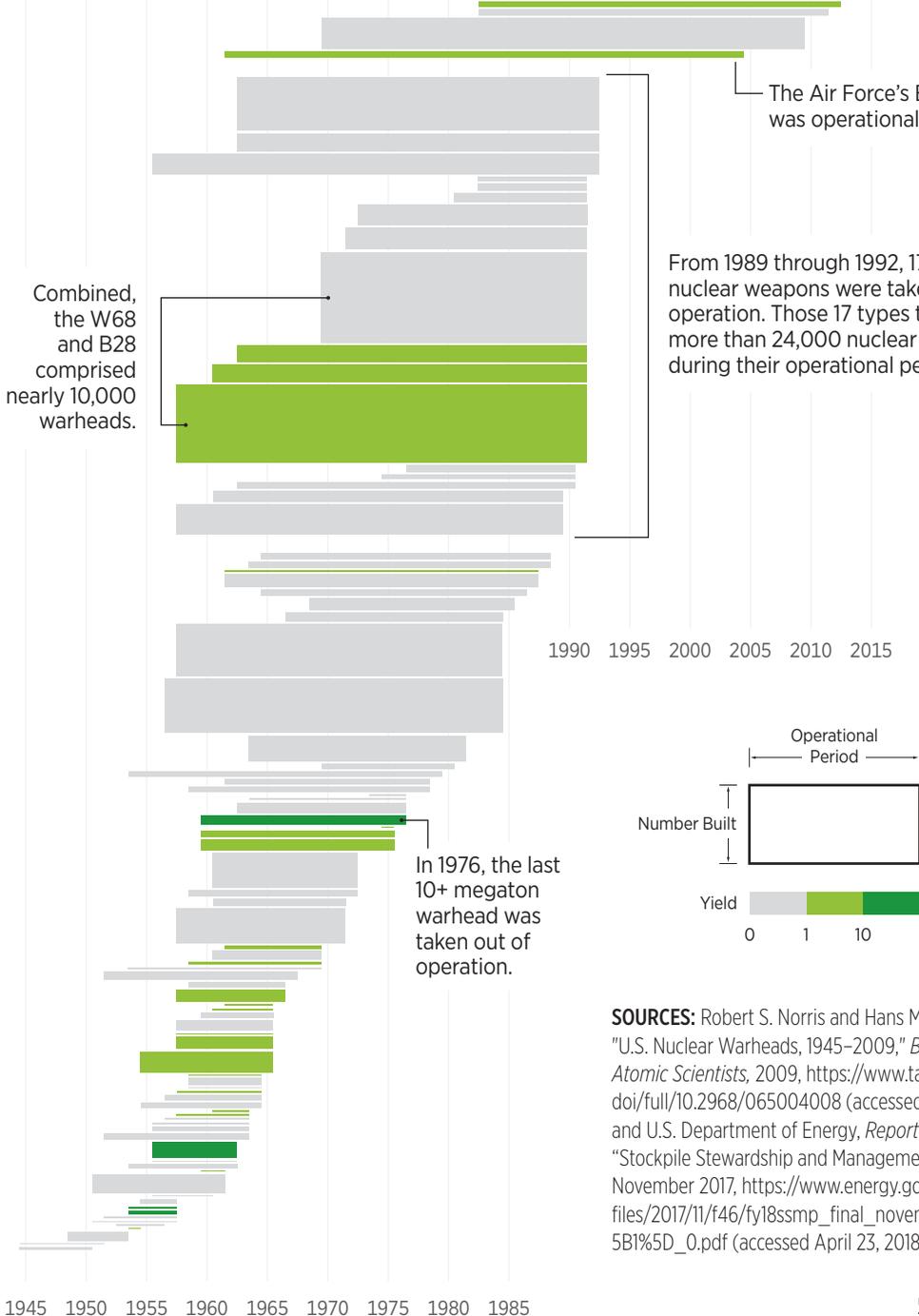
In 1999, the Commission on Maintaining U.S. Nuclear Weapons Expertise concluded

that 34 percent of the employees supplying critical skills to the weapons program were more than 50 years old. Almost 19 percent of the NNSA’s workforce is eligible for retirement, and the number will likely increase to 38.5 percent in fiscal year (FY) 2023.<sup>7</sup> On average, the U.S. high-technology industry has a more balanced employee age distribution.<sup>8</sup>

Both the lack of resources and the lack of sound, consistent policy guidance have undermined workforce morale. The Congressional Advisory Panel on the Governance of the Nuclear Security Enterprise recommended fundamental changes in the nuclear weapons

# A Brief History of the Shrinking U.S. Nuclear Arsenal

1945 1950 1955 1960 1965 1970



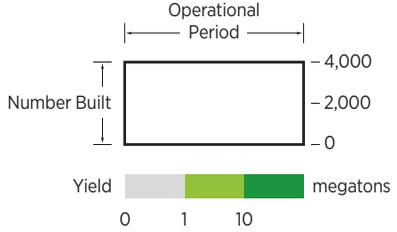
The bulk of the current nuclear arsenal was first developed in the 1980s.

The Air Force's B53 bomb was operational for 43 years.

From 1989 through 1992, 17 types of nuclear weapons were taken out of operation. Those 17 types totaled more than 24,000 nuclear warheads during their operational periods.

Combined, the W68 and B28 comprised nearly 10,000 warheads.

In 1976, the last 10+ megaton warhead was taken out of operation.



**SOURCES:** Robert S. Norris and Hans M. Kristensen, "U.S. Nuclear Warheads, 1945–2009," *Bulletin of the Atomic Scientists*, 2009, <https://www.tandfonline.com/doi/full/10.2968/065004008> (accessed April 20, 2018), and U.S. Department of Energy, *Report to Congress, "Stockpile Stewardship and Management Plan,"* November 2017, [https://www.energy.gov/sites/prod/files/2017/11/f46/fy18ssmp\\_final\\_november\\_2017%5B1%5D\\_0.pdf](https://www.energy.gov/sites/prod/files/2017/11/f46/fy18ssmp_final_november_2017%5B1%5D_0.pdf) (accessed April 23, 2018).

enterprise's culture, business practices, project management, and organization. Others proposed moving the NNSA to the Department of Defense (DOD).<sup>9</sup>

The U.S. nuclear laboratories must rediscover their mission focus so that they can be ready to meet the challenges that lie ahead.

The readiness of forces that operate U.S. nuclear systems is another important indication of the health of the overall force. Despite the changes instituted by the Air Force following mishaps in 2006 and 2007, success was limited, as evidenced by further mishaps. In January 2014, for example, the Air Force discovered widespread cheating on nuclear proficiency exams and charged over 100 officers with misconduct. The Navy had a similar problem, albeit on a smaller scale.<sup>10</sup>

The DOD conducted two nuclear enterprise reviews, one internal and one external. Both reviews identified a lack of leadership attention, a lack of resources with which to modernize the atrophied infrastructure, and unduly burdensome implementation of the personnel reliability program as some of the core challenges preventing a sole focus on accomplishing the nuclear mission.<sup>11</sup>

In 2014, the Secretary of Defense created the Nuclear Deterrent Enterprise Review Group (NDERG) to ensure the long-term health of the nuclear enterprise by addressing resourcing, personnel, organizational, and enterprise policy issues. In the past several years, the DOD has significantly improved morale throughout the nuclear weapons enterprise by forcefully stating (and at the highest levels) that nuclear deterrence is the DOD's "number one job" and that related modernization programs still receive the highest priority. Recently, the Government Accountability Office found that the DOD not only has made significant progress in implementing the recommendations from the 2014 nuclear enterprise reviews and a 2015 NC3 review, but also has improved its tracking and evaluation of this progress.<sup>12</sup>

Among other things, the ICBM Force Improvement Program was initiated and mostly implemented throughout 2014 and into 2015,

and the Air Force shifted over \$160 million to address problems, modernize certain facilities, and generally improve morale. The Air Force also has seen an increase in badly needed manpower, although not enough of an increase to alleviate manpower concerns. If changes in the nuclear enterprise are to be effective, leaders across the executive and legislative branches must continue to provide the resources and attention needed to mitigate readiness and morale issues within the force.

In the past, fiscal uncertainty and a steady decline in resources for the nuclear weapons enterprise have had a negative effect on the nuclear deterrence mission. As David Trachtenberg, Deputy Under Secretary of Defense for Policy, testified in March 2019:

For decades, the United States led the world in efforts to reduce the role and number of nuclear weapons.... Overall, the U.S. nuclear weapons stockpile has drawn down by more than 85 percent from its Cold War high.

Unfortunately Russia and China have chosen a different path and have increased the role of nuclear weapons in their strategies and actively increased the size and sophistication of their nuclear forces.

For this reason, a robust and modern U.S. nuclear deterrent helps ensure the United States competes from a position of strength and can deter nuclear attack and prevent large-scale conventional warfare between nuclear-armed states for the foreseeable future.<sup>13</sup>

In recent years, bipartisan congressional support for the nuclear mission has been strong, and additional funding has been provided for nuclear modernization. It is critical that this bipartisan consensus be preserved as these programs mature and begin to introduce modern nuclear systems to the force.

The Trump Administration has inherited an insufficiently funded comprehensive

modernization program for nuclear forces: warheads, delivery systems, and command and control. The Obama Administration included this program in its budget requests, and Congress has funded it to some extent while constraining the ability of the enterprise to execute its mission (e.g., by allocating inadequate funding for pit production). Because such modernization activities require consistent, stable, long-term funding commitments, it is essential that Congress continue to invest in the cornerstone of our nation's security.

The Trump Administration's 2018 NPR recognized worsening security conditions, the rise of competition with a revisionist and resurgent Russia, an increasingly threatening China, and other growing strategic threats.<sup>14</sup> It also called for the tailoring of U.S. nuclear deterrence strategies and rearticulated the importance of deterring any large-scale attack against the U.S., its allies, or partners as a key priority of U.S. nuclear weapons policy. To that end, the 2018 NPR called for modernization of nuclear weapons and the nuclear weapons complex, as well as significant reinvestments in the nuclear triad (intercontinental-range ballistic missiles, *Columbia*-class submarines, bombers, and associated infrastructure), and proposed two additional nuclear capabilities: a low-yield warhead for strategic submarine-launched ballistic missiles (SLBMs) in the near term and a low-yield, nuclear-armed, sea-launched cruise missile in the longer term.

### Implications for U.S. National Security

U.S. nuclear forces are not designed to shield the nation from all types of attacks from all adversaries. They are designed to deter large-scale attacks that threaten America's sovereignty, allies, and forward-deployed troops and to assure our allies and partners.

U.S. nuclear forces play an absolutely essential role in underpinning the broad non-proliferation regime by providing security guarantees that assure allies, including NATO, Japan, and South Korea, that they can forgo development of nuclear capabilities. In part, U.S. deterrence capabilities also enable the United

Kingdom and France to limit their numbers of nuclear weapons to levels to which they might not otherwise agree.

North Korea has demonstrated that a country with limited intellectual and financial resources can develop a nuclear weapon. Despite U.S. and international pressure, Iran appears to be continuing on a path that largely retains its ability to develop a nuclear weapon capability. In such an international climate, U.S. nuclear assurances to allies and partners become ever more important. If the credibility of American nuclear forces continues to degrade, for example, countries like Japan or South Korea could choose to pursue an independent nuclear option, adding to instability across the region.

Several negative trends could undermine the overall effectiveness of U.S. nuclear deterrence if not addressed. Adversaries—particularly Russia and China—are modernizing their nuclear forces. Additional challenges include increasingly aged nuclear warheads; an aging and crumbling nuclear weapons infrastructure; an aging workforce; and the need to fully recapitalize all three legs (land, air, and sea) of the nuclear triad, including the systems for nuclear command and control, while also conducting timely and cost-efficient life-extension programs—all while maintaining the nation's commitment to a testing moratorium under the signed (but rejected by the Senate) Comprehensive Test Ban Treaty.

The 2018 NPR notes a rapid deterioration of the threat environment since 2010 and identifies four enduring roles for U.S. nuclear capabilities:

- Deterring nuclear and non-nuclear attack;
- Assuring allies and partners;
- Achieving U.S. objectives if deterrence fails; and
- Providing the capacity to hedge against an uncertain future.<sup>15</sup>

Recognizing that capabilities can vary, the 2018 NPR emphasizes the need for tailored deterrence strategies to deal with each U.S. adversary. For example, Russia is engaged in an aggressive nuclear buildup, having added several new modern nuclear systems to its arsenal since 2010. According to General John Hyten, Commander, U.S. Strategic Command (STRATCOM), “Russia started their modernization program in 2006. They’re about 80 percent through completing the modernization of their triad. They’ll be pretty close to being through by about 2020.”<sup>16</sup> Concurrently, Russia is using its dual-capable (nuclear/conventional-capable) platforms to threaten the sovereignty of U.S. allies in Eastern Europe and the Baltics.

China is engaging in a similarly provocative nuclear buildup as it attempts to project power into the South China Sea, in part through illegally created islands on which China has installed offensive capabilities. North Korea “has accelerated its provocative pursuit of nuclear weapons and missile capabilities.”<sup>17</sup> Iran “retains the technological capability and much of the capacity necessary to develop a nuclear weapon within one year of a decision to do so” and is the world’s principal state sponsor of terrorism.<sup>18</sup>

Deterrence is an intricate interaction between U.S. conventional and nuclear forces and the psychological perceptions of both allies and adversaries with respect to the willingness of the U.S. to use such forces to defend its own interests and those of its allies and partners. Nuclear deterrence must reflect and be attuned to the mindset of any particular adversary that the U.S. seeks to deter. If an adversary believes that he can fight and win a limited nuclear war, the task for U.S. leaders

is to convince that adversary otherwise. The U.S. nuclear portfolio must be structured in terms of capacity, capability, variety, flexibility, and readiness to achieve these objectives. In addition, military roles and requirements for nuclear weapons will be inherently different depending on which actor is being deterred, what that actor values, and what kinds of action the U.S. is seeking to deter.

Due to the complex interplay among strategy, policy, and actions that any given state may take, as well as other actors’ perceptions of the world around them, it is not possible to know whether and when a nuclear deterrent or conventional forces provided by U.S. forces might be perceived as insufficient. Nuclear weapon capabilities take years or decades to develop, as does the infrastructure supporting them—an infrastructure that the U.S. has neglected for decades. We can be reasonably certain that a robust, well-resourced, focused, and reliable nuclear enterprise is much more likely to maintain the sense of the U.S. as a deterring force than is one that is outdated, questionable, or both.

The U.S. has demonstrated that it is capable of incredible mobilization when danger materializes. Today’s nuclear threat environment is evolving, dynamic, and proliferating in unpredictable ways, with new actors and resurgent old actors developing new capabilities. Meanwhile, the U.S. enterprise remains largely static (despite the promise of additional funding) and likely at a technological disadvantage.

This posture is worrisome and must be changed. Unless it is fixed, the implications, both for the security of the United States and for the security of its allies and the free world, are extremely serious.

## Scoring U.S. Nuclear Weapons Capabilities

The U.S. nuclear weapons enterprise is composed of several key elements that include warheads; delivery systems; nuclear command and control; intelligence, surveillance, and

reconnaissance (ISR); aerial refueling; and the physical infrastructure that designs, manufactures, and maintains U.S. nuclear weapons. The nuclear enterprise also includes and must

sustain the talent of its people, from nuclear designers to engineers, manufacturing personnel, securers, planners, maintainers, and operators, all of whom can help to ensure a nuclear deterrent that is second to none.

At the same time, assessing whether any one piece of this enterprise is sufficiently funded, focused, and/or effective with regard to the U.S. nuclear mission presents several challenges.

*First*, the United States is not taking full advantage of technologically available developments to field modern (often incorrectly referred to as “new”) warheads that could be designed to be safer, more secure, and more effective and that could give the United States better options for strengthening a credible deterrent. Rather the U.S. has elected to largely maintain aging nuclear warheads—based on designs from the 1960s, 1970s, and 1980s—that were in the stockpile when the Cold War ended.

*Second*, the lack of detailed publicly available data about the readiness of nuclear forces, their capabilities, and weapon reliability makes analysis difficult.

*Third*, the U.S. nuclear enterprise has many components, some of which are also involved in supporting other conventional military and extended deterrence missions. For example:

- Dual-capable bombers no longer fly airborne alert with nuclear weapons as they routinely did in the 1960s (although they are capable of resuming the practice if necessary).
- The three key national security laboratories (Los Alamos National Laboratory, Lawrence Livermore National Laboratory, and Sandia National Laboratories) no longer focus solely on the nuclear weapons mission. Although this remains their primary mission, they also perform extensive national security research related to nuclear nonproliferation, counterproliferation, intelligence, biological/medical research, threat reduction, and countering nuclear terrorism, including a variety of nuclear-related detection activities.

- The Nuclear Command, Control, and Communications (NC3) system “performs five crucial functions: detection, warning, and attack characterization; adaptive nuclear planning; decision-making conferencing; receiving Presidential orders; and enabling the management and direction of forces.”<sup>19</sup>

The factors listed and explained below are the most important elements of the nuclear weapons complex. They are judged on a five-grade scale according to which “very strong” means that a sustainable, viable, and funded plan is in place and “very weak” means that the U.S. is not meeting its security requirements and has no program in place to redress the shortfall—a situation that if left uncorrected could seriously damage vital national interests. The other three possible scores are “strong,” “marginal,” and “weak.”

### **Current U.S. Nuclear Stockpile Score: Strong**

U.S. warheads must be safe, secure, effective, and reliable. The Department of Energy (DOE) defines reliability as “the ability of the weapon to perform its intended function at the intended time under environments considered to be normal” and as “*the probability of achieving the specified yield, at the target, across the Stockpile-to-Target Sequence of environments, throughout the weapon’s lifetime, assuming proper inputs.*”<sup>20</sup> In the years since the cessation of nuclear testing in 1993, reliability has been determined through an intensive warhead surveillance program; non-nuclear experiments (that is, without the use of experiments producing nuclear yield); sophisticated calculations using high-performance computing; and related annual assessments and evaluations.

The reliability of nuclear warheads and delivery systems becomes even more important as the number and diversity of nuclear weapons in the stockpile decrease. Possession of fewer types of nuclear weapons means a smaller margin for error in the event that all of one

type is affected by a technical problem that might cause that type of weapon, its delivery system, or both to be decommissioned. Less diversity also means that a problem is more likely to affect multiple systems. America and its allies must have high confidence that U.S. nuclear warheads will perform as expected.

As warheads age, our uncertainty about their ability to perform their mission as expected could increase, significantly complicating military planning. Despite the impressive knowledge about nuclear weapons physics and materials chemistry that it has amassed, the U.S. could find itself surprised by unanticipated long-term effects on aging components of nuclear weapons. “The scientific foundation of assessments of the nuclear performance of US weapons is eroding as a result of the moratorium on nuclear testing,” argue John Hopkins, nuclear physicist and a former leader of the Los Alamos National Laboratory’s nuclear weapons program, and David Sharp, former Laboratory Fellow and a guest scientist at Los Alamos National Laboratory.<sup>21</sup>

The United States currently has the world’s safest and most secure stockpile, but concerns about overseas storage sites, potential problems introduced by improper handling, or the unanticipated effects of aging could compromise the integrity and reliability of U.S. warheads. In addition, nuclear warheads themselves contain security measures that are designed to make it difficult, if not impossible, to detonate a weapon without proper authorization.

**Grade:** The Department of Energy and Department of Defense are required to produce annual assessments of the nuclear stockpile’s reliability. Each of the three nuclear weapons labs (Los Alamos National Laboratory, Lawrence Livermore National Laboratory, and Sandia National Laboratories) reports its findings on the safety, security, and reliability of the nation’s nuclear warheads to the DOE and the DOD, which in turn brief the President. Detailed classified reports are also provided to Congress. While these assessments do not include the nuclear weapons delivery systems,

U.S. STRATCOM does assess the overall reliability of the U.S. nuclear weapons system, including both warheads and delivery platforms.

Absent nuclear weapons testing, the national laboratories’ assessment of weapons reliability, based on the full range of surveillance, scientific, and technical activities carried out in the NNSA’s stockpile stewardship program, depends on the expert judgment of the laboratory directors, which, although it is based on experience and non-nuclear experimentation and extensive modeling and simulation, is inherently subjective. While certainly a well-educated opinion, it cannot substitute for objective data obtained through direct nuclear testing.

Nuclear testing was used in the past to diagnose potential problems with warheads and to certify the effectiveness of fixes to those problems. It was also used originally to certify today’s nuclear warheads, as well as to detect potential problems and to confirm the effectiveness of fixes to those problems. Given that modern simulation is based on nuclear tests that were conducted primarily in the 1950s and 1960s, using testing equipment from that era, there is a great deal more that more modern nuclear testing and detection equipment could teach us about nuclear weapons physics.

In 2005, according to one authoritative account, “two DoD study teams, each looking at options for the future nuclear stockpile, reached similar conclusions—the U.S. approach to sustain its existing nuclear warhead stockpile needed to be redirected.”<sup>22</sup>

Continuing:

Both studies expressed concern over the prospect of long-term success of the plan to sustain the Cold War-era nuclear stockpile indefinitely through periodic refurbishments (e.g., life extension programs). The indefinite refurbishment plan will be extremely difficult to execute (because many warhead components can not [*sic*] be replicated as originally built), and would result in modifications on top of other modifications that will be

increasingly difficult to certify without nuclear testing. Both studies concluded that the Reliable Replacement Warhead (RRW) concept, if feasible, would be a preferred alternative to the indefinite refurbishment strategy.<sup>23</sup>

When the U.S. did conduct nuclear tests, it frequently found that small changes in a weapon's tested configuration had a dramatic impact on weapons performance. In fact, the 1958–1961 testing moratorium resulted in the introduction of weapons with serious problems into the U.S. stockpile.<sup>24</sup> These problems were discovered only after the resumption of U.S. nuclear weapons testing after the Soviet Union's unannounced breakout from the 1962 agreed moratorium.

America's commitment to sustaining its nuclear stockpile without nuclear testing creates inherent uncertainty concerning the adequacy of "fixes" to the stockpile when problems are found. The number of additional uncertainties is growing and includes updates made to correct problems that were found in the weapons or changes in the weapons resulting from life-extension programs. It is simply impossible to duplicate exactly weapons that were designed and built many decades ago. According to Dr. Stephen Younger, Director of Sandia National Laboratories, "[we have had to fix] a number of problems that were never anticipated" by using "similar but not quite identical parts."<sup>25</sup>

One of the results of having to certify weapons without nuclear testing, at least to date, has been fewer types of weapons (i.e., reduced diversity in the stockpile) and, consequently, a greater potential impact across the inventory of warheads should there be an unknown or misidentified error in the certification process. Loss of diversity in the stockpile also increases the risk that "common-mode" failure might affect multiple systems simultaneously, making the push for commonality with potential single points of failure in U.S. warheads worrisome.

"To be blunt," warned Secretary of Defense Robert Gates in October 2008, "there is absolutely no way we can maintain a credible

deterrent *and* reduce the number of weapons in our stockpile *without* either resorting to testing our stockpile or pursuing a modernization program."<sup>26</sup>

The U.S. is pursuing warhead life-extension programs that replace aging components before they can cause reliability problems. The number and scope of LEPs being carried out over the next two decades will stress the NNSA's warhead design and production complex and remains a concern, particularly given uncertainties regarding the congressional budget process. In spite of these concerns, in FY 2018 and FY 2019, the NNSA continued to assert that the stockpile "remains safe, secure, and reliable" (FY 2018) and "safe, secure, and effective" (FY 2019).<sup>27</sup>

In light of our overall assessment, we grade the U.S. stockpile conditionally as "strong," subject to continued strong support from Congress and the Administration.

### **Reliability of U.S. Delivery Platforms Score: Marginal**

Reliability encompasses not only the warhead, but strategic delivery vehicles as well. For ICBMs and SLBMs, in addition to a successful missile launch, this includes the separation of missile boost stages, performance of the missile guidance system, separation of the reentry vehicles from the missile post-boost vehicle, and accuracy of the final reentry vehicle in reaching its target.<sup>28</sup>

The U.S. conducts flight tests of ICBMs and SLBMs every year to ensure the reliability of its delivery systems with high-fidelity "mock" warheads. Anything from faulty electrical wiring to booster separations could degrade the reliability and safety of the U.S. strategic deterrent. U.S. strategic long-range bombers also regularly conduct continental United States and intercontinental exercises and receive upgrades to sustain a demonstrated high level of combat readiness. Nevertheless, challenges are on the horizon as platforms have to be modernized and replaced simultaneously and with little margin for error to allow for already significantly diminished gaps in capabilities.

**Grade:** The Air Force picked up the pace of its ICBM testing last year relative to the previously covered period. With four successes during the covered period, the Air Force also suffered its first unsuccessful ICBM test since 2001. The SLBM tests were successful in 2018 and 2019. To the extent that data from these tests are publicly available, they provide objective evidence of the delivery systems' reliability and send a message to U.S. allies and adversaries alike that the U.S. system works and the nuclear deterrent is ready if needed. The aged systems, however, occasionally have reliability problems, as evidenced by a July 2018 failed Minuteman III launch.<sup>29</sup>

Overall, this factor earns a grade of "marginal," the same grade as the previous year's score.

### **Nuclear Warhead Modernization Score: Marginal**

During the Cold War, the United States maintained a strong focus on developing new nuclear warhead designs, both to counter Soviet advances and modernization efforts and to leverage advances in the physics, chemistry, and design of nuclear weapons. Today, although it also seeks to retain the skills and capabilities required to design, develop, and produce new warheads, the United States is focused on sustaining its aging stockpile rather than on fielding new nuclear warheads. This could increase the risk of failure due to aging components and signal to adversaries that the United States is less committed to nuclear deterrence.

In FY 2016, the United States established the Stockpile Responsiveness Program (SRP) and charged it with building up and exercising all capabilities needed to "conceptualize, study, design, develop, engineer, certify, produce, and deploy nuclear weapons."<sup>30</sup> The Administration requested \$34 million for the SRP in FY 2019.

New weapon designs could allow American engineers and scientists to improve previous designs and devise more effective ways to address existing military requirements (e.g., the need to destroy deeply buried and hardened

targets) that have emerged in recent years. Future warheads could improve reliability (e.g., by remedying such ongoing aging concerns as the need to replace aged nuclear components) while also enhancing the safety and security of American weapons.

Working on new weapon design options would help to ensure that America's nuclear experts remain engaged and knowledgeable, would help to attract the best talent to the nuclear enterprise, and would help the nation gain additional insights into adversaries' nuclear weapons programs. Merely updating Cold War designs is not enough to constrain potential adversaries and current and future proliferators of nuclear technology, all of whom can seek designs apart from those of the U.S.

As the Panel to Assess the Reliability, Safety, and Security of the United States Nuclear Stockpile noted, "Only through work on advanced designs will it be possible to train the next generation of weapon designers and producers. Such efforts are also needed to exercise the DoD/NNSA weapon development interface."<sup>31</sup> The nuclear enterprise was able to display improved flexibility when it produced a low-yield version of the W76-2 warhead designed to counter Russia's perception of an exploitable gap within the U.S. nuclear force posture within a year. Other nations maintain their levels of proficiency by having their scientists work on new nuclear warheads and possibly by conducting very low-yield nuclear weapons tests.<sup>32</sup>

**Grade:** Despite continued nuclear policy restrictions and a preference for life-extension programs, U.S. efforts under the SRP and the NNSA's demonstrated ability to produce a low-yield version of the W76-2 warhead in a timely manner warrant improving this score to "marginal" this year. The success of the SRP will be an important consideration in future assessments.

### **Nuclear Delivery Systems Modernization Score: Strong**

Today, the United States fields a triad of nuclear forces with delivery systems that are

safe and reliable, but as these systems age, the risk of a significantly negative impact on operational capabilities increases, and any allowance for delay of platform replacement is significantly diminished. Age degrades reliability by increasing the potential for systems to break down or fail to respond correctly. The older weapons systems are, the more at risk they are that faulty components, malfunctioning equipment, or technological developments will limit their reliability in the operating environment.

Corrupted systems, defective electronics, or performance degradation due to long-term storage defects (including for nuclear warheads) can have serious implications for American deterrence and assurance. Because it cannot be assumed (especially with respect to systems approaching end of life) that a strategic delivery vehicle will always operate reliably, that vehicle's deterrence and assurance value may be significantly reduced, with consequent impact on the deterrence perceptions of both allies and adversaries.

The U.S. Air Force and Navy plan to modernize or replace each leg of the nuclear triad in the next few decades, but fiscal constraints, inconsistent levels of funding, and issues related to "continuing resolutions" will make such efforts difficult at best. Sustained leadership focus is imperative if the modernization program is to succeed.

The Navy is fully funding its programs to replace the *Ohio*-class submarine with the *Columbia*-class submarine, but issues early in the program that were identified last year have caused the margin for slippage in the overall schedule of the program itself to decrease.<sup>33</sup> The Air Force is funding the B-21 Raider long-range bomber. Existing ICBMs and SLBMs are expected to remain in service until 2032 and 2042, respectively.

Remanufacturing some weapon parts is difficult and expensive either because the manufacturers are no longer in business or because the materials that constituted the original weapons are no longer available (e.g., due to environmental restrictions). Modernization of the U.S. triad is a requirement validated by all

four of the NPRs since the end of the Cold War and will remain a must in all future deterrence scenarios. Plans for modernization of U.S. nuclear weapons benefited from the predictability associated with the FY2018/FY 2019 budget deal, but the return of sequestration threatens this progress.

The ability of the U.S. to produce sufficient numbers of solid-fuel rocket engines and possible U.S. dependence on Russia as a source of such engines are other significant long-range concerns.<sup>34</sup>

**Grade:** U.S. nuclear platforms are in dire need of recapitalization. Plans for modernization of the nuclear triad are in place, and Congress and the services have largely sustained funding for these programs, notwithstanding difficulties caused by the Budget Control Act of 2011. This demonstration of commitment to nuclear weapons modernization earns this indicator a grade of "strong," although possible delays in modernization could cause this score to be downgraded in the near future.

## Nuclear Weapons Complex Score: Marginal

Maintaining a reliable and effective nuclear stockpile depends in large part on the facilities where U.S. devices and components are developed, tested, and produced. These facilities constitute the foundation of our strategic arsenal and include the:

- Los Alamos National Laboratory,
- Lawrence Livermore National Laboratory,
- Sandia National Laboratories,
- Nevada National Security Site,
- Pantex Plant,
- Kansas City Plant,
- Savannah River Site, and
- Y-12 National Security Complex.

In addition to these government sites, the defense industrial base supports the development and maintenance of American delivery platforms.

These complexes design, develop, test, and produce the weapons in the U.S. nuclear arsenal, and their maintenance is of critical importance. As the 2018 NPR states:

An effective, responsive, and resilient nuclear weapons infrastructure is essential to the U.S. capacity to adapt flexibly to shifting requirements. Such an infrastructure offers tangible evidence to both allies and potential adversaries of U.S. nuclear weapons capabilities and thus contributes to deterrence, assurance, and hedging against adverse developments. It also discourages adversary interest in arms competition.<sup>35</sup>

Maintaining a safe, secure, effective, and reliable nuclear stockpile requires modern facilities, technical expertise, and tools both to repair any malfunctions quickly, safely, and securely and to produce new nuclear weapons if required to do so. The existing nuclear weapons complex, however, is not fully functional. The United States, for example, has not had a substantial plutonium-pit production capability since 1993. A plutonium pit is the heart of a nuclear weapon, and the NNSA currently plans to produce no fewer than 80 pits a year by 2030—a challenge by its own admission.<sup>36</sup> In 2005, it was reported that the U.S. cannot “serially produce many crucial components of our nuclear weapons.”<sup>37</sup>

If the facilities are not properly funded, the U.S. will gradually lose the ability to conduct the required high-quality experiments that are needed to ensure the stockpile’s reliability without nuclear testing. In addition to demoralizing the workforce and hampering recruitment, old and/or obsolete facilities and poor working environments make maintaining a safe, secure, reliable, and militarily effective nuclear stockpile difficult. Upwards of 50 percent of the NNSA’s facilities are more than 40

years old, nearly 30 percent date to the Manhattan Project of the 1940s, and 12 percent are considered excess or no longer needed.<sup>38</sup> The NNSA reported \$2.5 billion in deferred maintenance as of February 2019.<sup>39</sup>

The U.S. currently retains over 5,000 old plutonium pits in strategic reserve in addition to pits for use in future LEPS. There are disagreements as to the effect of aging on plutonium pits and on how long the U.S. will be able to depend on them before replacement. In 2006, then-NNSA Administrator Linton Brooks estimated that the life span of warhead plutonium is “somewhere between 45 and 60 years,” which means that in the near future, the United States may have to start replacing core components of its nuclear warheads.<sup>40</sup>

Current capacities to do so are insufficient because the U.S. has demonstrated an ability to produce only about 10 plutonium pits a year at the Los Alamos PF-4 facility. If executed as planned, infrastructure modernization plans for PF-4 as mandated by the 2018 NPR will boost that number to about 30 by the middle of the next decade.

A second plutonium-pit production facility is being planned to exploit the Mixed Oxide Fuel (MOX) facility that until last year was under construction at the Savannah River Plant in Tennessee. The MOX building is being repurposed for a production capacity of no fewer than 50 plutonium pits per year to be achieved by 2030 for an overall requirement of no fewer than 80 pits per year. The challenge of achieving this timeline is exacerbated by the fact that the NNSA is embarking on the most ambitious warhead sustainment program since the end of the Cold War, overhauling some five warhead types and stressing the demands on both workforce and facilities.

Manufacturing non-nuclear components can be extremely challenging either because some materials may no longer exist or because manufacturing processes have been forgotten and must be retrieved. There is a certain element of art to building a nuclear weapon, and such a skill can be acquired and maintained only through hands-on experience.

**Grade:** On one hand, the U.S. maintains some of the world’s most advanced nuclear facilities. On the other, some parts of the complex—importantly, the plutonium and highly enriched uranium component manufacturing infrastructure—have not been modernized since the 1950s. Plans for long-term infrastructure recapitalization remain essential, even as the NNSA is embarking upon an aggressive warhead life-extension effort. Sustaining and/or increasing critically essential tritium gas is likewise essential because tritium gas is subject to deterioration, and a delay in production increases the amount that must be produced to cover our baseline needs.

Significant progress has been made over the past year, however, both in recapitalizing uranium infrastructure and in getting funded plans in place to recapitalize plutonium-pit production capacity. The infrastructure is improved and therefore receives a grade of “marginal.”

## Personnel Challenges Within the National Nuclear Laboratories

### Score: Marginal

Combined with nuclear facilities, U.S. nuclear weapons scientists and engineers are critical to the health of the complex and the stockpile. The 2018 NPR emphasizes that:

The nuclear weapons infrastructure depends on a highly skilled, world-class workforce from a broad array of disciplines, including engineering, the physical sciences, mathematics, and computer science. Maintaining the necessary critical skills and retaining personnel with the needed expertise requires sufficient opportunities to exercise those skills.<sup>41</sup>

The ability to maintain and attract a high-quality workforce is critical to assuring the future of the American nuclear deterrent, and hiring the best and brightest is especially challenging in a strong employment atmosphere. Today’s weapons designers and

engineers are first-rate, but they also are aging and retiring, and their knowledge must be passed on to the next generation of experts. This means that young designers need meaningful and challenging warhead design and development programs to hone their skills.

The SRP offers one visible means by which to address such concerns. The NNSA and its weapons labs understand this problem and, with the support of Congress, are beginning to take the necessary steps through SRP and foreign weapon assessment to mentor the next generation. To continue this progress, SRP funding will need to be sustained and ideally increased from the current rate of about \$30 million a year.

The U.S. currently relies on non-yield-producing laboratory experiments, flight tests, and the judgment of experienced nuclear scientists and engineers, using robust modeling and simulation, to ensure continued confidence in the safety, security, effectiveness, and reliability of its nuclear deterrent. Without their experience, the nuclear weapons complex could not function. Few of today’s remaining scientists or engineers at the NNSA weapons labs have had the experience of taking a warhead from initial concept to a “clean sheet” design, engineering development, production, and fielding. The SRP is helping to remedy some of these shortfalls by having the workforce exercise most of the skills required for nuclear weapons design and engineering.

The average age of the NNSA’s workforce decreased slightly to 47.8 years as of September 2018.<sup>42</sup> Still worrisome, however, is that over a third of this workforce will be eligible for retirement in the next four years. Given the distribution of workforce by age, these retirements will create a significant knowledge and experience gap.

**Grade:** In addition to employing world-class experts, the NNSA labs have had some success in attracting and retaining talent. As many scientists and engineers with practical nuclear weapon design and testing experience retire, the annual assessment and certification of nuclear weapons will rely increasingly on

the judgments of people who have never tested or designed a nuclear weapon. In light of these issues, the complex earns a score of “marginal,” albeit with signs of improvement.

### **Readiness of Forces Score: Strong**

The people and units that operate U.S. delivery platforms are essential to the successful operation of America’s strategic forces. The military personnel operating the three legs of the nuclear triad must be properly trained and equipped, and the crews responsible for the nuclear mission must be maintained in an appropriate state of readiness.

During FY 2019, the services have continued to align resources in order to preserve strategic capabilities in the short term. Nevertheless, a return to sequestration could have major negative effects on the timely execution of programs. U.S. general-purpose forces help to ensure the overall effectiveness of our nuclear forces by, among other things, providing a pool of qualified candidates to operate nuclear weapon delivery systems. Changes prompted in part by the 2014 Navy and Air Force cheating scandals have addressed most morale issues and have recast the role of forces supporting the nuclear deterrent by providing additional funding for equipment purchases, creating more mid-career billets to help career-field continuity, focusing leadership attention, and changing training to focus on mission in the field rather than on a theoretical ideal. Sustained attention to the situation in the nuclear enterprise is critical.

**Grade:** Despite uncertainties regarding the future impact of budgetary shortfalls, the young men and women who secure, maintain, plan for, and operate U.S. nuclear forces are of extremely high caliber. Force readiness thus receives a grade of “strong.”

### **Allied Assurance Score: Strong**

The credibility of U.S. nuclear deterrence is one of the most important components of allied assurances. U.S. allies that already have nuclear weapons can coordinate actions with the United States or act independently. During

the Cold War, the U.S. and the United Kingdom cooperated to the point where joint targeting was included. France maintains its independent nuclear arsenal. The U.S. also deploys nuclear gravity bombs in Europe as a visible manifestation of its commitment to its NATO allies.

Similarly, the U.S. has an enduring extended deterrence role with its Asian allies. The United States provides nuclear assurances to Japan and South Korea, both of which are technologically advanced industrial economies that face aggressive nuclear-armed regional adversaries such as China, Russia, and North Korea. Continued assurances and guarantees of U.S. nuclear deterrence must therefore be perceived as credible. Both Japan and South Korea have the capability and basic know-how to build their own nuclear weapons (even quickly) should they chose to do so. That would be a major setback for U.S. nonproliferation policies.

The 2018 NPR took a step in the right direction when it placed “[a]ssurance of allies and partners” second on its list of four “critical roles” (immediately following “[d]eterrence of nuclear and non-nuclear attack”) that nuclear forces play in America’s national security strategy. The 2018 NPR proposed two supplements to existing capabilities—a low-yield SLBM warhead and a new nuclear sea-launched cruise missile—as important initiatives to strengthen assurance, along with the Obama and Trump Administrations’ initiatives to bolster conventional forces in NATO. Work on the low-yield warhead is progressing, and deployment of this capability will be an important factor in deterring aggression against America’s Asian and NATO allies in the years ahead.

**Grade:** At this time, most U.S. allies are not seriously considering developing their own nuclear weapons. European members of NATO continue to express their commitment to and appreciation of NATO as a nuclear alliance even as they worry about the impact of Russia’s violations of the Intermediate Nuclear Forces Treaty and the regional implications of other arms control treaties, including the New Strategic Arms Reduction Treaty. Because uncertainties surrounding the purchase and

modernization of NATO's dual-capable aircraft and the time line for replacing existing U.S. nuclear weapons with the B61-12, as well as NATO's seeming lack of attention to the nuclear mission and its intellectual underpinnings, do not justify a score of "very strong," allied assurance receives a score of "strong."

### **Nuclear Test Readiness Score: Weak**

In the past, nuclear testing was one of the key elements of a safe, secure, effective, and reliable nuclear deterrent. Today, even though the U.S. is under a self-imposed nuclear testing moratorium, it is still required to maintain a low level of nuclear test readiness at the Nevada National Security Site (formerly Nevada Test Site).

"Test readiness" refers to a single test or a very short series of tests, not a sustained nuclear testing program, reestablishment of which would require significant additional resources. Specifically, under President Bill Clinton's 1993 PDD-15, "[i]n order to resume underground nuclear tests, a capability to conduct a nuclear test within 6 months up to FY 1996, and to conduct a nuclear test within 2–3 years after that time will be assumed by the Department of Energy [now NNSA]."<sup>43</sup> Because of a shortage of resources, the NNSA has been unable to achieve this goal. The test readiness program is supported by experimental programs at the Nevada National Security Site, nuclear laboratory experiments, and advanced diagnostics development.<sup>44</sup>

The ability of the U.S. to conduct yield-producing experiments in a timely manner if it should discover a flaw in one or more types of its nuclear weapons that requires experimentation to correct seems questionable. The U.S. might need to test to assure certain weapon characteristics that could possibly be validated only by nuclear testing and to verify render-safe procedures. The ability to conduct yield-producing experiments rapidly is likewise important, especially if the U.S. needs to react strongly to another nation's nuclear weapons tests and/or communicate unquestioned resolve.

As noted, current law requires that the U.S. must maintain a capability to conduct a nuclear test within 24 to 36 months of a presidential decision to do so. The NNSA states in its *Fiscal Year 2018 Stockpile Stewardship and Management Plan* that its "fundamental approach taken to achieve test readiness has also changed" and lists a general time frame of six to 10 months for a simple test with waivers and simplified processes.<sup>45</sup> The time frame "for a fully instrumented test to address stockpile needs with the existing stockpile" is 24 to 36 months, and "a test to develop a new capability" would take 60 months.<sup>46</sup> A test within 18 months might be possible, "but only if 'some domestic regulations, agreements and laws' were to be waived."<sup>47</sup> Because the United States is rapidly losing its remaining practical nuclear testing experience, including instrumentation of very sensitive equipment, "there is essentially no test readiness," and "[t]he whole testing process—whether to conduct one test or many—would in essence have to be reinvented, not simply resumed."<sup>48</sup>

**Grade:** As noted, the U.S. can meet the legally required readiness requirement through the NNSA only if certain domestic regulations, agreements, and laws are waived. In addition, the U.S. is not prepared to sustain testing activities beyond a few limited experiments because it no longer retains the deep drilling technology in Nevada and has only a few "holes" capable of containing a nuclear test if required. Thus, testing readiness earns a grade of "weak."

### **Overall U.S. Nuclear Weapons Capability Score: "Marginal" Trending Toward "Strong"**

It should be emphasized that "trending toward 'strong'" assumes that the U.S. maintains its commitment to modernization of the entire enterprise, from warheads to platforms to personnel to infrastructure, and allocates needed resources accordingly. Absent this commitment, this overall score will degrade rapidly to "weak." Continued attention to this mission is therefore critical.

Although a bipartisan commitment has led to continued progress on the modernization of U.S. nuclear forces and sustainment of warheads, these programs remain seriously threatened by potential future fiscal uncertainties. The infrastructure that supports nuclear programs is very aged, and nuclear test readiness has revealed troubling problems within the forces.

On the plus side, the 2018 NPR strongly articulates a core nuclear weapons policy grounded in the reality of today’s threats and growing international development concerns.

The 2018 NPR clearly and strongly articulates our continued commitment to extended deterrence. The commitment to warhead life-extension programs, the exercise of skills that are critical for the development of new nuclear warheads under the SRP, and the just-in-time modernization of nuclear delivery platforms represent a positive trend that must be maintained.

Averaging the subscores across the nuclear enterprise in light of our concerns about the future results in an overall score of “marginal.”

### U.S. Military Power: Nuclear

	VERY WEAK	WEAK	MARGINAL	STRONG	VERY STRONG
Nuclear Stockpile				✓	
Delivery Platform Reliability			✓		
Warhead Modernization			✓		
Delivery Systems Modernization				✓	
Nuclear Weapons Complex			✓		
National Labs Talent			✓		
Force Readiness				✓	
Allied Assurance				✓	
Nuclear Test Readiness		✓			
<b>OVERALL</b>			✓		

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