U.S. Nuclear Weapons Capability

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U.S. nuclear weapons have played a critical role in preventing conflict between major powers since the end of World War II. Given their ability to deter large-scale attacks that threaten the U.S. homeland, allies, and forward-deployed troops and to assure allies and partners, nuclear deterrence has remained the number one U.S. national security mission.[1] Operationally, all U.S. military operations rely on the backstop of U.S. nuclear deterrence.[2] It is therefore critical that the United States maintain a modern and flexible nuclear arsenal that can deter a diverse range of threats from a diverse set of potential adversaries.

An Increasingly Threatening Global Environment

The nuclear threat environment has changed drastically from a stability paradigm based on mutually assured destruction involving the United States and the Soviet Union during the Cold War to a multipolar nuclear threat environment that presents complex challenges. As the threat increases, several negative trends, if not addressed, could undermine the overall effectiveness of U.S. nuclear deterrence. Today, U.S. nuclear forces face three great challenges:

- Aging nuclear warheads, their associated delivery systems, and systems for their command and control;
- An aging and crumbling nuclear weapons infrastructure; and
- An aging workforce.

The United States must 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 warhead life-extension programs—all while operating under the current nuclear testing moratorium. Despite these challenges, the United States must ensure that its nuclear capabilities are sufficient to address the rising nuclear threat for the decades to come.

For the first time in history, the United States must deter two nuclear peers—Russia and China—while contending with a larger number of nuclear weapons states. Russia is engaged in an aggressive nuclear buildup, having added several new nuclear systems to its arsenal since 2010. The United States is only beginning to modernize its existing nuclear systems, but Russia's modernization effort is about 86 percent complete.[3] Russia is also developing "novel technologies," such as a nuclear-powered cruise missile and nuclear-capable unmanned underwater vehicle, and arming delivery platforms with nuclear-tipped hypersonic glide vehicles.[4]

In addition, Russia maintains a stockpile of at least 2,000 non-strategic nuclear weapons, unconstrained by any arms control agreement.[5] Lieutenant General Robert Ashley, Director of the Defense Intelligence Agency, has said that Russia is expected to increase this category of nuclear weapons—a category in which it "potentially outnumber[s]" the United States by 10 to 1.[6] This disparity is of special concern because Russia's recent nuclear doctrine indicates a lower threshold for use of these tactical nuclear weapons. According to the 2018 Nuclear Posture Review (NPR), Moscow "mistakenly assesses that the threat of nuclear escalation or actual first use of nuclear weapons would serve to 'de-escalate' a conflict on terms favorable to Russia."[7]

China is engaging in what Admiral Charles A. Richard, Commander of U.S. Strategic Command (STRATCOM), has described as a "breathtaking" expansion of its nuclear capabilities as it attempts to project power into the South China Sea and throughout the world. China is well on its way to more than doubling its nuclear stockpile by the end of the decade. It is deploying advanced intercontinental ballistic missiles (ICBMs), completing its nuclear triad with the addition of a strategic nuclear-capable bomber, and deploying numerous theater-range ballistic missiles in the Indo-Pacific that can strike U.S. bases and allied territory with precision. Satellite imagery has also detected three ICBM silo construction sites in China that could hold at least 100 ICBM silos each.[8] STRATCOM has described this expansion as a "strategic breakout" and has stated that China's nuclear capabilities will eventually exceed those of Russia.[9] Current U.S. nuclear posture is not designed to deter two peer nuclear threats.

Evidence also suggests that China is shifting a portion of its nuclear forces to Launch-on-Warning posture as it improves its early warning systems.[10] Combined with a refusal to discuss its forces or intent with the United States, this shift in posture increases the likelihood of mistakes and miscalculations.[11]

North Korea is also advancing its nuclear weapons and missile capabilities. It continues to produce fissile material to build new nuclear weapons, recently paraded a new "monster" ICBM supposedly able to carry multiple warheads, and has recently tested ground-based and sea-based ballistic missiles.[12]

Iran, in addition to being the world's principal state sponsor of terrorism, continues to enrich uranium at dangerous levels and may be able to develop a nuclear weapon within just a few months. According to a recent report:

> A worst-case breakout estimate, which is defined as the time to produce enough WGU for one nuclear weapon, is as short as 2.3 months. Iran could produce a second significant quantity of WGU early in the fifth month after breakout commences, and a third quantity could be produced early in the seventh month. For comparison, if no explosion had occurred at the FEP [Natanz Fuel Enrichment Plant], the minimum breakout timeline would have been 1.75 months, reflecting a longer breakout by one month. However, it should be noted that the post-explosion breakout estimate has additional uncertainties that suggest that it may be lengthier.[13]

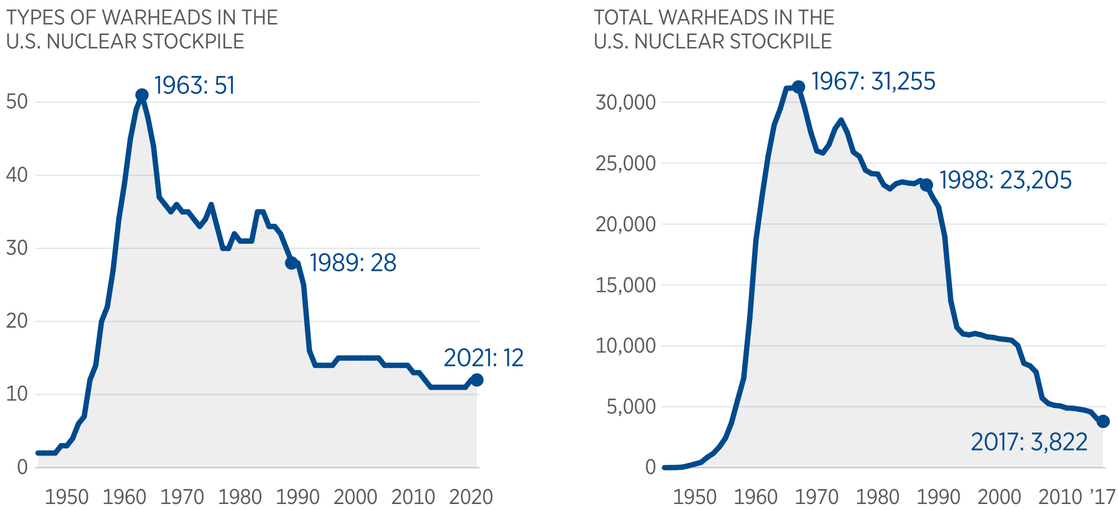
As current U.S. nuclear capabilities continue to age, the advancing nuclear threat increases the importance of nuclear weapons to U.S. national security. Noting this rapid deterioration of the threat environment since 2010, the 2018 NPR outlined four enduring roles for U.S. nuclear capabilities:

- Deterrence of nuclear and non-nuclear attack;
- Assurance of allies and partners;
- Achievement of U.S. objectives if deterrence fails; and
- Capacity to hedge against an uncertain future.[14]

To achieve these objectives, the U.S. nuclear portfolio must balance the appropriate levels of capacity, capability, variety, flexibility, and readiness. Deterrence in a multipolar world is more complicated than in a bipolar world, as it requires a U.S. nuclear force capable of deterring multiple separate adversaries at the same time. What matters most in deterrence is

CHART 12

A Smaller and Less Diverse Nuclear Arsenal



NOTE: The 2017 figure of 3,822 warheads reflects the last year the U.S. government declassified stockpile quantities. These quantities include deployed warheads and warheads in reserve, but the U.S. is limited by New START to only 1,550 deployed warheads.

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not necessarily what the United States thinks will be effective. What matters most are the psychological perceptions—among both allies *and* adversaries—of America's willingness to use nuclear forces to defend its interests. If an adversary believes that he can fight a limited nuclear war, for instance, U.S. leaders must convince that adversary otherwise. In addition, military roles and requirements for nuclear weapons will differ from adversary to adversary based on each country's values, strategy, and goals.

The United States also extends its nuclear umbrella to more than 30 allies and partners that rely on the U.S. to defend them from existential threats. This additional responsibility imposes requirements for U.S. nuclear force posture beyond defense of the U.S. homeland. U.S. nuclear forces underpin the broad nonproliferation regime by assuring allies—including NATO, Japan, South Korea, and Australia—that they can forgo their own development of nuclear capabilities. Erosion of the credibility of American nuclear forces could lead a country like Japan or South Korea to pursue an independent nuclear option, and this could have a profoundly negative impact on stability across the region.

In addition to deterrence and assurance, the United States historically has committed to achieving its political and military objectives if nuclear deterrence fails. As a result, U.S. forces must be postured to engage their targets successfully if such a failure makes it necessary to use nuclear weapons.

Finally, U.S. nuclear capabilities must have the capacity to hedge against an uncertain future. Nuclear weapon capabilities take years or decades to develop, as does the infrastructure supporting them—an infrastructure that the United States has neglected for decades until quite recently. Decisions regarding nuclear forces made today will impact the United States decades into the future. Since the United States cannot predict what the level of the threat will be decades in the future, it is critical that the U.S. maintain a nuclear enterprise that can respond to changes in the global security environment.

A robust, well-resourced, focused, and reliable nuclear enterprise that is able to respond to unforeseen contingencies is itself an important piece of deterrence and will enable a nuclear force that is resilient and adaptable. The U.S. nuclear enterprise today, however, is largely static, leaving the United States at what could well be a technological disadvantage. Such a posture puts the security of the United States, the security of its allies, and the entire free world at risk.

Challenges to Maintaining Nuclear Forces

To provide assurance against failures in the U.S. stockpile or changes in a geopolitical situation, the United States must maintain the ability to adjust its nuclear force posture. To this end, the United States maintains an inactive stockpile that includes near-term hedge warheads that "can serve as active ready warheads within prescribed activation timelines" and reserve warheads that can provide "a long-term response to risk mitigation for technical failures in the stockpile."[15]

The United States preserves upload capability on its strategic delivery vehicles, which means that the nation could increase the number of nuclear warheads on each type of its delivery vehicles. For example, the U.S. Minuteman III ICBM can carry up to three Mk12A/W78 nuclear warheads, although it is currently deployed with only one.[16] Certain modernization decisions (e.g., 12 versus 14 *Columbia*-class ballistic missile submarines with 16 rather than 24 missile tubes per submarine) will somewhat limit upload capacity on the strategic submarine force. U.S. heavy bombers will continue to retain a robust upload capability that can be used if a geopolitical or technical emergency requires more deployed nuclear warheads.

The United States has not designed or built a nuclear warhead since the end of the Cold War. Instead, the National Nuclear Security Administration (NNSA) uses life-extension programs (LEPs) to extend the service lives of existing weapons in the stockpile, some dating back to the 1960s. Not all of the existing inactive stockpile, however, will go through a life-extension program. Consequently, our ability to respond to contingencies by uploading weapons kept in an inactive status will inevitably decline with the passage of time.

In addition, while LEPs replace or upgrade most components in a nuclear warhead, all warheads will eventually need to be replaced because their nuclear components—specifically, plutonium pits that comprise the cores of warheads—are also subject to aging.[17] It is therefore unwise for the United States to rely solely on LEPs to sustain needed levels of reliability. Moreover, the United States is the only nuclear state that lacks the capability to produce plutonium pits in quantity. An effort is underway to restart plutonium pit production, but various challenges have been encountered that could upset U.S. plans to sustain its nuclear weapons.

Part of the U.S. hedge against uncertainty in deterrence is the ability to conduct a nuclear test if testing is ever required to ensure the safety and reliability of U.S. warheads. Presidential Decision Directive-15 (PDD-15) requires the United States to maintain the ability "to conduct a nuclear test within 2–3 years" of direction by the President.[18] However, "the steady degradation" of test readiness after three decades of no testing calls into question the U.S.'s ability to meet this goal.[19] The lack of congressional interest in funding any significant improvements in test readiness further undermines efforts by the NNSA to comply with the directive.

The nuclear weapons labs also face demographic challenges. Most scientists and engineers with practical hands-on experience in nuclear weapons design and testing are retired. This means that the certification of weapons that were designed and tested as far back as the 1960s depends on the scientific judgment of designers and engineers who have never been involved in either the testing or the design and development of nuclear weapons. According to former NNSA Administrator Lisa Gordon-Hagerty, more than 40 percent of the NNSA workforce will be eligible for retirement over the next five years, further adding to the loss of legacy nuclear weapons knowledge.[20]

The Stockpile Responsiveness Program (SRP), mandated by Congress and being implemented by NNSA, has been effective in exercising critical nuclear weapons design and development skills not fully exercised since the end of the Cold War. It is essential that those skills are available when needed to support modern warhead development programs for U.S. submarine-launched ballistic missiles (SLBMs) and ICBMs.

The shift in emphasis away from the nuclear mission after the end of the Cold War led to a diminished ability to conduct key activities at the nuclear laboratories. According to former Acting Administrator Dr. Charles Verdon:

> The U.S. nuclear weapons stockpile is currently safe, secure, and militarily effective. However, the legacy stockpile systems are aging, and NNSA's production infrastructure has atrophied considerably. America must invest in the weapons and infrastructure modernization programs to provide the capabilities needed to ensure the deterrent's viability into the future. Future American political leaders will not have the weapons and infrastructure in place to support the nuclear arsenal unless we reestablish that capability now.
>
> The need to modernize the nuclear weapons stockpile and recapitalize the supporting infrastructure needed to produce and maintain that stockpile has reached a tipping point. Approximately 60 percent of NNSA's facilities are more than 40 years old and more than 50 percent are in poor condition. Assessments of facilities throughout the enterprise have identified numerous single-point failures. Production capabilities allowed to lapse are needed once again and reestablishing these capabilities is both a priority and a challenge. If not appropriately addressed, the age and condition of NNSA's infrastructure will put at risk NNSA's missions, and the safety of its workforce, the public, and the environment.[21]

As a result of this neglect, at the same time the nation faces a great challenge in modernizing its aging nuclear warheads, "NNSA is undertaking a risk-informed, complex, and time-constrained modernization and recapitalization effort."[22]

In recent years, bipartisan congressional support for the nuclear mission has been strong, and nuclear modernization has received additional funding.[23] Preservation of that bipartisan consensus will be critical as these programs mature and begin to introduce modern nuclear systems to the force.

In its budget requests, the Trump Administration advanced the comprehensive modernization program for nuclear forces that was initiated by President Barack Obama. Despite some opposition, Congress funded the two previous Presidents' budget requests for these programs. Because such modernization activities require consistent, stable, long-term funding commitments, this continued bipartisan support has been critical.

The NNSA received $19.7 billion in fiscal year (FY) 2021, $3 billion more than it received in FY 2020, which included full funding for major efforts like modernization of plutonium pit production and five warhead modernization programs.[24] The FY 2022 budget would continue these efforts but with a flat NNSA topline of $19.7 billion.[25] Modernization programs to replace the triad—including the Ground Based Strategic Deterrent (GBSD); Long Range Stand Off Weapon (LRSO); *Columbia*-class nuclear submarine; and B-21 Raider bomber—also continue to progress in 2021 with the FY 2022 budget supporting these programs. The 2018 NPR proposed two supplements to nuclear capabilities in light of the worsened security environment with Russia and China: a low-yield warhead for SLBMs in the near term, which was deployed in 2020, and a low-yield, nuclear-armed, sea-launched cruise missile, for which funding was first included in the FY 2022 budget request after the completion of a preliminary analysis of alternatives.[26]

Assessing U.S. Nuclear Weapons Capabilities

Assessing the state of U.S. nuclear weapons capabilities presents at least three serious difficulties.

- The United States has not taken full advantage of technologically available developments to field modern warheads (often incorrectly termed "new" warheads) that could be designed to be safer, more secure, and more effective and could give the United States better options for strengthening a credible deterrent. Instead, the United States has largely elected to extend the life of aging nuclear warheads based on designs from the 1960s, 1970s, and 1980s that were in the stockpile when the Cold War ended.
- The lack of detailed publicly available data about the readiness of nuclear forces, their capabilities, and the reliability of their weapons makes analysis difficult.
- The U.S. nuclear enterprise has many components, some of which are also involved in supporting other military (e.g., conventional) and extended deterrence missions. For example, U.S. strategic bombers perform a significant conventional mission and do not fly airborne alert with nuclear weapons today, as they did routinely during the 1960s, nor stand at quick-reaction strip alert as they did up until the early 1990's.

Additionally, the three key national security laboratories no longer focus solely on the nuclear weapons mission; they also focus extensively on nuclear nonproliferation and counterproliferation, intelligence, biological/medical research, threat reduction, and countering nuclear terrorism, which includes a variety of nuclear-related detection activities. Moreover, the Nuclear Command, Control, and Communications System entails many assets such as early warning and communications satellites that serve non-nuclear missions, such as routine military communications and detecting and tracking conventional missiles.

Thus, it is hard to assess whether any one piece of the nuclear enterprise is sufficiently funded, focused, and/or effective with regard to the nuclear mission.

The U.S. nuclear weapons enterprise is composed of several key elements that include warheads; delivery systems; and the physical infrastructure that designs, manufactures, and maintains U.S. nuclear weapons. The nuclear enterprise also includes and must sustain the talent of people: the nuclear designers, engineers, manufacturing personnel, planners, maintainers, and operators who help to ensure a nuclear deterrent that is second to none. The nuclear weapons enterprise entails additional elements like nuclear command and control; intelligence, surveillance, and reconnaissance; and aerial refueling, all of which also play a major role in conventional operations.

The factors selected below are the most important elements of the nuclear weapons complex. They are judged on a five-grade scale that ranges from "very strong," defined as meeting U.S. national security requirements or having a sustainable, viable, and funded plan in place to do so, to "very weak," defined as not meeting current security requirements and with no program in place to redress the shortfall. The other three possible scores are "strong," "marginal," and "weak."

Reliability of Current U.S. Nuclear Stockpile Score: Strong

U.S. warheads must be safe, secure, effective, and reliable. The Department of Defense defines reliability as "the probability that a weapon will perform in accordance with its design intent or military requirements."[27] Since the cessation of nuclear testing in 1992, reliability has been assessed and maintained through the NNSA's Stockpile Stewardship Program, which consists of an intensive warhead surveillance program; non-nuclear experiments (i.e., experiments that do not produce a 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. Fewer types of nuclear weapons results in a smaller margin of error if all of one type are affected by a technical problem that might cause a weapon type or its delivery system to be decommissioned. Loss of diversity in the stockpile also increases the risk of "common-mode" failure that could affect multiple systems simultaneously, making the push for commonality with potential single points of failure in U.S. warheads worrisome. America and its allies must have high confidence that U.S. nuclear warheads will perform as expected.

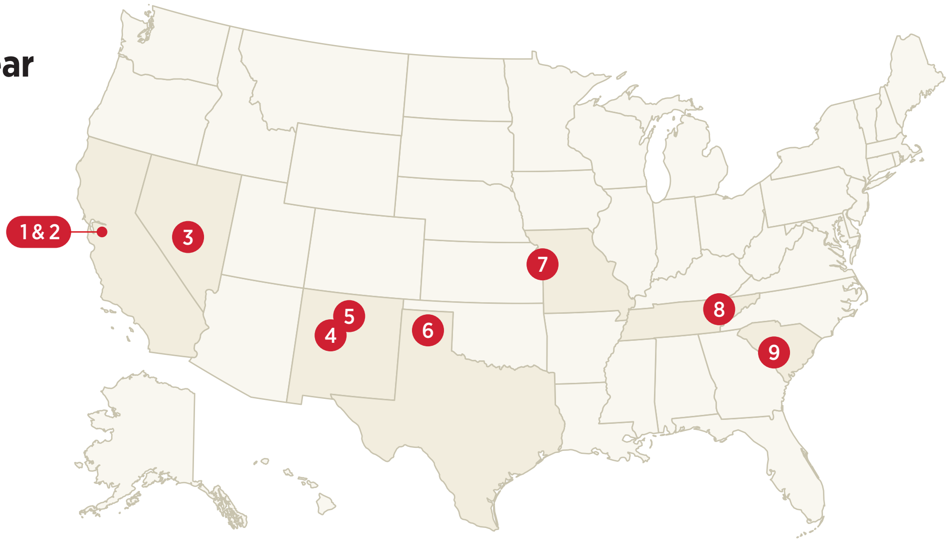
As warheads age, uncertainty about their ability to perform their mission as expected could increase and significantly complicate military planning. Despite creating impressive amounts of knowledge about nuclear weapons physics and materials chemistry, the United States could find itself surprised by unanticipated long-term effects on aging components that comprise a nuclear weapon. "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.[28]

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 unanticipated effects of aging could compromise the integrity or reliability of U.S. warheads. The nuclear warheads themselves contain security measures that are designed to make it difficult, if not impossible, to detonate a weapon without proper authorization. Some U.S. warheads have modern safety features that provide additional protection against accidental detonation; others do not.

Grade: 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 NNSA's Stockpile Stewardship Program, depends on the expert judgment of the

MAP 18

U.S. Nuclear Weapons Complex



1 Lawrence Livermore National Laboratory
Livermore, CA
Nuclear weapons R&D

2 Sandia National Laboratories
Livermore, CA
Nuclear weapons R&D and systems engineering

3 Nevada National Security Site
Nye County, NV
Subcritical experiments and test readiness

4 Sandia National Laboratories
Albuquerque, NM
Nuclear weapons R&D and systems engineering

5 Los Alamos National Laboratory
Los Alamos, NM
Nuclear weapons R&D and plutonium pit production

6 Pantex Plant
Panhandle, TX
Assembly of nuclear warheads

7 Kansas City Plant
Kansas City, MO
Production of non-nuclear components for nuclear warheads

8 Y-12 National Security Complex
Oak Ridge, TN
Manufacture of highly-enriched uranium parts for nuclear warheads

9 Savannah River Site
Aiken, SC
Pit production and tritium production

SOURCE: Heritage Foundation research.

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laboratories' directors and the weapons scientists and engineers on their staffs. This judgment, albeit based on experience, non-nuclear experimentation, and extensive modeling and simulation, does not benefit from the objective data that could be 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 also was used to certify current nuclear warheads, as well as to detect potential problems and confirm the effectiveness of fixes to those problems.

The sustained political decision to maintain the nuclear stockpile without nuclear testing—a decision made across multiple presidential Administrations—creates some inherent uncertainty concerning the adequacy of fixes to the stockpile when problems are found. These growing numbers of additional uncertainties include updates 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 former Sandia National Laboratories Director Dr. Stephen Younger, we have had to fix "a number of problems that were never anticipated" by using "similar but not quite identical parts."[29] However, while the United States does not test as part of its stockpile stewardship efforts, it has been U.S. policy to lift its test moratorium and conduct the required testing if the President deems it necessary to do so based on information from the lab directors, the Secretary of Defense, and the Secretary of Energy.

In light of concerns that are inherent in a lack of nuclear testing, the United States maintains the most advanced Stockpile Stewardship Program in the world and continues to make scientific and technical advances to help certify the stockpile. For example, NNSA is working on upgrades to the Enhanced Capabilities for Subcritical Experiments facility in Nevada (such as adding the capability to produce high-speed, high-fidelity X-ray images of subcritical experiments) to improve our understanding of plutonium.[30] In addition:

> The Exascale Computing Initiative (ECI) will provide NNSA with next-generation simulation capabilities to support weapons design, warhead assessment and certification, and continued development of the underpinning science needed to support the nuclear stockpile long-term. NNSA remains on track to accept and operate NNSA's first Exascale high performance computing system for program use in 2023.[31]

Such advanced capabilities can help the NNSA to certify the stockpile more accurately and without testing. As Deborah Rosenblum, President Biden's nominee to serve as Assistant Secretary of Defense for Nuclear, Chemical, and Biological Defense Programs, explained in her confirmation hearing, "The modernization of the NNSA infrastructure is critical to keeping our stockpile safe, secure, and reliable without testing."[32] She also highlighted the importance of producing new plutonium pits to help avoid the need to test if confidence in aging warheads decreases.

To assess the reliability of the nuclear stockpile annually, each of the three nuclear weapons labs (Los Alamos National Laboratory, Lawrence Livermore National Laboratory, and Sandia National Laboratory) reports its findings with respect to the safety, security, and reliability of the nation's nuclear warheads to the Secretaries of Energy and Defense, who then brief the President. Detailed classified reports are provided to Congress as well. The Commander of U.S. Strategic Command also assesses overall nuclear weapons system reliability, including the reliability of both warhead and delivery platforms.

In spite of concerns over aging warheads, "[i]n FY 2021, the science-based Stockpile Stewardship Program allowed the Secretaries of Energy and Defense to certify to the President for the 25th consecutive year the nuclear weapons stockpile remains safe, secure, and militarily effective."[33] Admiral Richard stated in 2021 "that there are no identified conditions at this point that would require nuclear weapons testing to restore that confidence."[34]

In light of our overall assessment, and based on the results of the existing method used to certify the stockpile's effectiveness, we grade the U.S. stockpile conditionally as "strong." This grade, however, will depend on whether support for an adequate stockpile, both in Congress and in the Administration, remains strong.

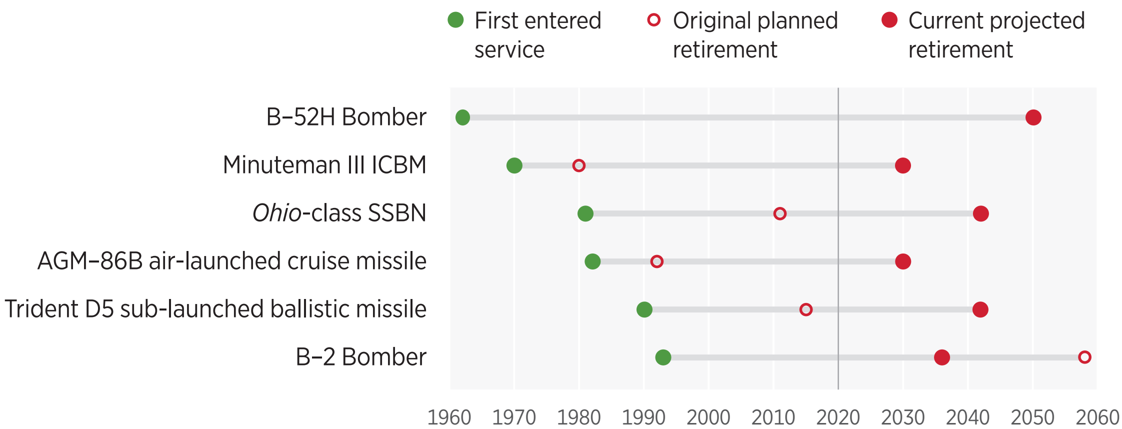
Reliability of Current U.S. Delivery Platforms Score: Strong, Trending Toward Marginal or Weak

Reliability encompasses not only the warhead, but strategic delivery vehicles as well. For ICBMs, SLBMs, and air-launched cruise missiles (ALCMs), in addition to a successful missile launch, this includes the separation of missile boost stages, performance of the missile guidance system, separation of the

FIGURE 5

U.S. Nuclear Delivery Systems Outdated

Current U.S. nuclear delivery systems are between 28 and 59 years old, and some are expected to be retired within a decade.



NOTES: The original retirement date for the B-2 was set at 2058, but in the FY 2019 budget, the Air Force moved up the retirement date by 22 years to 2036. That move could have been caused by projected threats, the cost of sustainment, or both. The original programmed retirement date for the B-52H is not known, but the Air Force recently stated that it plans to continue flying this jet into the 2050s. The average B-52H bomber has logged approximately 20,300 hours, and based on airframe component lifetime estimates and 350 hours of flying time each year, it could continue flying until 2067.
SOURCE: Heritage Foundation research.

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reentry vehicles from the missile post-boost vehicle, accuracy of the final reentry vehicle in reaching its target, and the ability of weapons systems (cruise missiles, aircraft carrying bombs, and reentry vehicles) to penetrate to their targets.[35]

The United States 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. The Air Force tested the AGM-86B ALCM, launched from the B-52H bomber, most recently in 2017.[36] The DOD must perform upgrades to existing platforms and develop their replacement programs simultaneously, and already diminished capabilities make this task more difficult.

Grade: In July 2018, the Air Force suffered its first unsuccessful ICBM test since 2011,[37] but it has conducted six successful tests since then. These successes include a test in February 2020—the first one to be hosted by Vandenberg Air Force Base since it became part of the U.S. Space Force[38]—and a test in August 2020 that launched a missile armed with three reentry vehicles.[39] However, the May 2020 test experienced a ground abort prior to the launch, which has provoked speculation about the reliability of the Minuteman III missile as it approaches its retirement starting at the end of the decade.[40] The SLBM tests were successful in 2019 and 2020 and have been thus far in 2021.[41]

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 U.S. systems work and the U.S. nuclear deterrent is ready if needed. The aged systems, however, occasionally have reliability problems, as evidenced by the failed July 2018 and May 2020 Minuteman III launches. Although delivery systems are likely reliable enough today, the evidence indicates that this reliability could dwindle with aging. For instance, because of its obsolescence against Russian air defense systems, the B-52H bomber already no longer carries gravity bombs.[42] Despite the fact that the AGM-86B passed its most recent public test in 2017, General John Hyten has stated that because of its age, "it's a miracle that [the missile] can even fly" and that the current ALCMs "do meet the mission, but it is a challenge each and every day."[43] Admiral Richard has also stated that "Minuteman-III is increasingly challenged in its ability" to "fly and make it to the target."[44]

Aging will continue to affect delivery platform reliability until platforms are replaced, but no publicly released data or statements from senior leaders have thus far indicated that U.S. delivery systems cannot currently meet mission requirements. Until that changes, this factor receives the grade of "strong." However, this grade will trend to "marginal" if not "weak" in just a few years if modernization programs are not fully pursued and these aging systems are not replaced on time.

Nuclear Warhead Modernization
Score: Marginal

During the Cold War, the United States focused on designing and developing modern nuclear warheads to counter Soviet advances and modernization efforts and to leverage advances in our understanding of the physics, chemistry, and design of nuclear weapons. Today, the United States focuses on extending the life of its aging stockpile rather than on fielding modern warheads while trying to retain the skills and capabilities needed to design, develop, and produce such warheads. Relying only on sustaining the aging stockpile could increase the risk of failure caused both by aging components and by not exercising critical skills. It could signal to adversaries that the United States is less committed to nuclear deterrence.

Meanwhile, potential U.S. adversaries and current and future proliferants are not limited to updating Cold War designs and can seek designs outside of U.S. experiences. Other nations can maintain their levels of proficiency by having their scientists work on new nuclear warheads.[45] As recently reported by the Department of State, "Russia has conducted nuclear weapons experiments that have created nuclear yield and are not consistent with the U.S. 'zero-yield' standard," and evidence points to China's potential lack of adherence to this standard as well.[46]

Fortunately, the NNSA has made noticeable improvements in this category in recent years. In FY 2016, Congress established the Stockpile Responsiveness Program to "exercise all capabilities required to conceptualize, study, design, develop, engineer, certify, produce, and deploy nuclear weapons."[47] Congress doubled funding for the SRP from $34 million in FY 2019 to $70 million in FY 2020 and appropriated $70 million again in FY 2021.[48] The budget request for FY2022 also includes $70 million for the SRP.[49]

Although it has been operating for only a few years, the SRP has demonstrated some important accomplishments in ensuring critical skills retention. The design and development work planned for the Navy's W93/Mark 7 warhead for the Trident II D5 SLBMs and the W87-1 warhead for GBSD will build on the success of the SRP in exercising these skills on modern warhead programs.

Fielding modern weapons like the W93 would allow American engineers and scientists to improve previous designs and devise more effective means to address evolving military requirements (e.g., adaptability to emerging threats and the ability to hold at risk hard and deeply buried targets). Future warheads could improve reliability (i.e., remedy some ongoing aging concerns) while also enhancing the safety and security of American weapons. The ability to work on modern warhead design options would help to ensure that today's experts and those of the next generation remain engaged and knowledgeable, help to attract the best talent to the nuclear enterprise, and help the nation to gain additional insights into adversaries' nuclear weapon programs.

The nuclear enterprise displayed improved flexibility when it produced the W76-2 warhead, a low-yield version of the W76 warhead designed to counter Russia's perception of an exploitable gap in the U.S. nuclear force posture, within a year. Such efforts warranted an improvement in this score from "weak" to "marginal" in 2019. Additionally, in FY 2021, Congress appropriated initial funding for the W93/Mark 7 warhead program, which will eventually replace the W76-1 and W88 warheads carried by the Trident II D5 SLBMs.[50] The FY 2022 budget continues funding for the W93 program with $72 million requested for NNSA in line with the FY 2022 projection in the FY 2021 budget.[51]

The effort to restore the ability to produce plutonium pits for future warheads has likewise progressed after Congress provided the NNSA with its full funding request for FY 2021. The NNSA reached the first critical milestone for pit production at Los Alamos National Laboratory in April 2021 and at the Savannah River Site in June 2021.[52] While production at Los Alamos remains on schedule, the plan to produce 50 plutonium pits per year at the Savannah River Site by 2030 has shifted, and the goal is now somewhere between 2032 and 2035.[53]

Grade: Before the score for this category can move up to "strong," the NNSA, with the support of Congress, will need to achieve enough progress in the W93/Mk 7, W87-1, and plutonium pit production projects to demonstrate that those projects will be completed on schedule and that the delay in pit production at the Savannah River Site will not significantly affect the ability to meet warhead requirements. An improved score will also depend on other advancements in nuclear warhead modernization.

Specifically, in addition to the W93/Mark 7 program to replace existing SLBM warheads, the NNSA will need to begin a program for a future strategic land-based warhead to succeed the W87-1, a program that remains notional.[54] Future assessments will also need to examine whether the NNSA's current warhead modernization effort is sufficient to address the increasing threat. For instance, an earth-penetrating warhead is not part of the NNSA's warhead modernization plan, despite Russian progress in hardening and deeply burying facilities to withstand strikes by current U.S. weapons.[55]

For now, the score for this category remains at "marginal," but it could trend toward "strong" in future years.

Nuclear Delivery Systems Modernization Score: Strong

All U.S. delivery systems were built during the Cold War and are overdue for replacement. The Obama Administration, in consultation with Congress, initiated a plan to replace current triad delivery systems within the constraints of the New Strategic Arms Reduction Treaty (New START) with Russia. President Trump advanced this modernization program in his budget requests with bipartisan support from Congress. Under this modernization program:

- The Navy is fully funding the *Columbia*-class submarine to replace the *Ohio*-class submarine;
- The Air Force is funding the B-21 Raider Long-Range bomber, which will replace conventionally armed bombers before

they become certified to replace nuclear-capable bombers, and the Long-Range Standoff weapon, which will replace the aging air-launched cruise missile;

- Existing Minuteman III ICBMs are expected to remain in service beyond the end of the decade, 50 years after their intended lifetime, and in 2029 will start to be replaced by the GBSD; and
- Existing Trident II D5 SLBMs have been life-extended to remain in service until 2042 through the end of the last *Ohio*-class submarine's lifetime.[56]

All of these programs have remained on track for the past few years, but they face high risks of delay. For instance, the U.S. Government Accountability Office (GAO) found risks in the GBSD schedule related to technology maturation, the complexity of concurrently operating Minuteman III missiles and GBSD missiles during the transition, limited schedule margin for testing, and an aggressive plan for construction activities.[57] Additionally, issues involving cost estimates and potential industrial base impacts caused by the COVID-19 pandemic could make it harder to achieve the goal of deploying the first *Columbia*-class submarine in 2031.[58] After a contract for development of the LRSO was awarded early, Congress reduced funding in FY 2021 by $89 million.[59] Fortunately, the budget for FY 2022 would boost funding for the LRSO beyond what was previously projected for that year.

These risks in schedule are especially dangerous because modernization programs have zero margin for delay after the United States has deferred recapitalization for years. In September 2020, then-Under Secretary of Defense for Acquisition and Sustainment Ellen Lord testified that even a minor cut in funding for the GBSD would affect its schedule.[60] Since these modernization programs are just-in-time, they would be significantly affected by any continuing resolution.

The impacts of schedule delays are significant. As systems like the Minuteman III, AGM 86-B, and *Ohio*-class submarines continue to age, they take on greater risks. Age degrades reliability by increasing the potential for systems to break down or fail to respond correctly. Corrupted systems, defective electronics, or performance degradation caused by long-term storage defects can have serious implications for U.S. deterrence and assurance. Should GBSD fail to reach initial operating capability by 2029, the United States will be left with a less-capable—and therefore less credible—ICBM fleet, which will also begin to dip below 400 missiles as the Air Force continues to use missiles for annual testing. With respect to the Navy, the GAO has reported that the consequence of failing to deliver the first *Columbia*-class submarine on time would be a failure for the Navy to meet STRATCOM's force-generation operational requirement, which means a weaker sea-based deterrent.[61]

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. Moreover, some aspects of these programs have progressed in 2021. For instance, the Air Force awarded a contract for GBSD to Northrop Grumman in 2020.[62] Congress did not cut any major funding for nuclear recapitalization systems in FY 2021, and the budget for FY 2022 would provide the funding necessary to continue these programs on schedule.

Despite these successes, potential modernization delays and congressional funding cuts still hold nuclear delivery system modernization at risk, especially as some Members of Congress push for major funding cuts and unilateral reductions in U.S. nuclear forces.[63] Moreover, this plan simply replaces the force structure designed by the Obama Administration in 2010 before China commenced its strategic breakout and the strategic environment was assumed to be much more benign than it is today. Future U.S. nuclear posture will need to adjust to the drastic change in the threat environment since 2010 and account for two nuclear peers. The FY 2022 budget includes funding for the initial stages of a program to develop a nuclear-armed sea-launched cruise missile that, if fielded, would introduce additional regional nuclear capabilities beyond current non-strategic gravity bombs to address the rising threat.

Based on the commitment to nuclear weapons modernization demonstrated by Congress and the Administration this year, this category (for now) again earns a grade of "strong."

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 Laboratories (nuclear weapons research and development, or R&D, and plutonium pit production);
- Lawrence Livermore National Laboratories (nuclear weapons R&D);
- Sandia National Laboratory (nuclear weapons R&D and systems engineering);
- Nevada National Security Site (subcritical experiments, test readiness);
- Pantex Plant (assembly of nuclear warheads);
- Kansas City Plant (production of non-nuclear components for nuclear warheads);
- Savannah River Site (second site for pit production, tritium production); and
- Y-12 National Security Complex (manufacture of highly enriched uranium parts for nuclear warheads).

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 stated:

> 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.[64]

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. According to the 2010 NPR, "As the United States reduces the numbers of nuclear weapons, the reliability of the remaining weapons in the stockpile—and the quality of the facilities needed to sustain it—become more important."[65]

The existing nuclear weapons complex, however, is not fully functional. The United States cannot produce some of the nuclear components needed to maintain and modernize the stockpile.[66] For instance, the United States has not had a substantial plutonium pit production capability since 1993. A plutonium pit is the core of a nuclear weapon that contains the nuclear material. The NNSA currently plans "to produce no fewer than 80 pits per year during 2030, consistent with federal law, national policy, and DoD requirements," which is a challenging timeline by the agency's own admission.[67]

If the NNSA's facilities are not properly funded, the U.S. will gradually lose the ability to conduct the high-quality experiments needed to ensure the reliability of the stockpile without nuclear testing. In addition to demoralizing the workforce and hampering recruitment, old or obsolete facilities and poor working environments make maintenance of a safe, secure, reliable, and militarily effective nuclear stockpile difficult. The NNSA's facilities are old: About 40 percent date back to World War II, about 60 percent are over 40 years old, and more than half are in poor condition.[68] As a consequence, the NNSA had accumulated about $5.8 billion in deferred maintenance as of FY 2020.[69] Aging facilities have also become a safety hazard: In some buildings, for example, chunks of concrete have fallen from the ceiling.[70]

The U.S. currently retains more than 5,000 old plutonium pits in strategic reserve in addition to pits for use in future LEPs. Uncertainties regarding the effect of aging on plutonium pits and how long the United States will be able to depend on them before replacement remain unresolved. In 2006, a JASON Group study of NNSA assessments of plutonium aging estimated that, depending on pit type, the minimum pit life was in the range of 100 years.[71] A work program was recommended to address additional uncertainties in pit aging, but that did not reach fruition. Moreover, numerous pits have been in the stockpile for decades—some for more than 50 years—and will need to be replaced. Depending on the rate at which NNSA can produce new pits, replacement will need to start sooner rather than later.

Today, the production rate is insufficient to replace aging pits. The United States has only demonstrated an ability to produce about 10 plutonium pits a year at the Los Alamos PF-4 facility. If executed as planned, infrastructure modernization of PF-4, as mandated by the 2018 NPR, will boost that number to 30 by 2026.

A second plutonium pit production facility is being planned to exploit the Mixed Oxide Fuel (MOX) facility that was being constructed at the Savannah River Site in South Carolina. The MOX building is being repurposed for plutonium pit production with a required production of no fewer than 50 pits per year by 2030 for an overall requirement of no fewer than 80 per year. Unfortunately, the NNSA reported this year that it will not be able to meet the required timeline for the Savannah River Site. Achieving this timeline is difficult because the NNSA is concurrently embarking on the most ambitious warhead sustainment program since the end of the Cold War, overhauling some five warhead types and stressing the capacity of both workforce and facilities. Meanwhile, certain warhead types will require modern pits.

Aside from plutonium, the NNSA must also maintain production of several other key materials and components that are used to build and maintain nuclear weapons. For instance, NNSA plans to increase the supply of tritium as demand increases. Other projects currently underway include a new lithium processing facility and the new Uranium Processing Facility at Y-12. So far, this facility is moving forward on schedule and cost.

Grade: Modernizing U.S. nuclear facilities is critical because the NNSA's warhead modernization plans depend on the ability to produce certain components like plutonium pits. The W87-1, for example, will be composed of all newly manufactured components.[72]

On one hand, the United States maintains some of the world's most advanced nuclear facilities. On the other, some parts of the complex have not been modernized since the 1950s. Plans for long-term infrastructure recapitalization remain essential even as the NNSA is embarking on an aggressive warhead life-extension effort. Sustaining or increasing critically essential but always decaying tritium gas is likewise essential; delays only increase production needs for its timely replenishment.[73]

Significant progress has been made over the past decade in getting funded plans in place to recapitalize plutonium pit production capacity and uranium component manufacturing in particular. This effort, however, faces great technical challenges in addition to the challenge of ensuring stable funding to support it. The recent shift in deadline for plutonium pit production at the Savannah River Site from 2030 to the 2032–2035 range is one example. After years of deferred modernization, any unexpected failure or disruption at a critical facility could significantly affect schedules for nuclear warhead modernization.[74]

According to former Acting NNSA Administrator Charles Verdon, "Continued recapitalization is imperative, otherwise there will be a point at which no amount of money will be able to mitigate the operational risks and losses to infrastructure capabilities that accrued over time."[75] Until demonstrable progress has been made toward completion of infrastructure modernization, the grade for this category will therefore remain at "marginal."

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. The U.S. is currently under a self-imposed nuclear testing moratorium, but 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 the 1993 PDD-15 (which is still U.S. policy), "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]."[76] Because of a shortage of resources, the NNSA has been unable to achieve this goal. Test readiness has not been funded as a separate program since FY 2010 and is instead supported by the Stockpile Stewardship Program that exercises testing elements at the Nevada National Security Site and conducts subcritical nuclear laboratory experiments.[77]

However, whether this approach can assure that the United States has the timely ability to conduct yield-producing experiments to correct a flaw in one or more types of its nuclear weapons is open to question. The United States might need to test to assure certain weapon characteristics that only nuclear testing can validate or potentially to verify render-safe procedures. The ability to conduct timely yield-producing experiments is likewise important, especially if the United States needs for political reasons to respond to another nation's nuclear weapons tests or communicate its unquestioned resolve.

The NNSA is mandated to maintain a capability to conduct a nuclear test within 24 to 36 months of a presidential decision to do so. However, the FY 2020 Stockpile Stewardship and Management Plan (SSMP) states that "[a]ssuring full compliance with domestic regulations, agreements, and laws relating to worker and public safety and the environment, and international treaties, would significantly extend the time required for execution of a nuclear test."[78] According to the FY 2018 SSMP, it would take 60 months to conduct "a test to develop a new capability."[79] Because the United States is rapidly losing its remaining practical nuclear testing experience, including instrumentation of very sensitive equipment, the process would likely have to be reinvented from scratch.[80]

Grade: As noted, the United States can meet the legally required readiness requirement only if certain domestic regulations, agreements, and laws are waived. In addition, the United States 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" that are able to contain a nuclear test. In recognition of these concerns, Admiral Richard testified in 2021 "that I am concerned about the Nation's test-readiness and that I endorsed the [NNSA] lab director's calls… for a national review of our test-readiness to understand where we sit."[81]

The Senate-passed version of the FY 2021 National Defense Authorization Act (NDAA) included an additional $10 million within existing budgets to practice test readiness capabilities, which would have made only a minor improvement in test readiness.[82] A July 2020 amendment to the House bill would have prohibited the use of funds to conduct nuclear tests.[83] The conference report on the NDAA did not include either provision.[84]

Opposition to a mere $10 million for test readiness and willingness to prohibit testing altogether are matters of great concern. The effort to improve the NNSA's technical and scientific capabilities to certify the stockpile without testing for the foreseeable future is worthwhile, but the United States must maintain at least the mandated level of test readiness so that it can deal with an emergency that requires testing if one should arise.

Thus, testing readiness earns a grade of "weak."

Personnel Challenges Within the National Nuclear Laboratories Score: Marginal but Trending Toward Strong

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, 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. Should a technical or geopolitical development demand a new nuclear weapon, it is crucial that the nuclear weapons workforce possess the skills and the knowledge needed to design, develop, and manufacture warheads of different design in a timely manner.[85]

The ability to maintain and attract a high-quality workforce is critical to ensuring the future of the American nuclear deterrent, especially when a strong employment atmosphere adds to the challenge of hiring the best and brightest. 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 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 should be maintained if not increased.

The United States currently relies on non-yield-producing subcritical experiments and other 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 "clean sheet" design, engineering development, production, and fielding. The SRP is remedying some of these shortfalls by having its workforce exercise many of the nuclear weapon design and engineering skills that are needed.

The average age of the NNSA's enterprise-wide workforce had decreased slightly to 46.9 years as of September 2018, the most recent year for which data are available.[86] Still worrisome, however, is that NNSA sites are reporting rates of retirement eligibility "from 15 percent to 44 percent, which will likely increase over the next 5 years."[87] Given the distribution of workforce by age, these retirements, if not addressed in plans for the hiring and mentoring of new hires, will create a significant knowledge and experience gap.

Grade: In addition to employing world-class experts, the NNSA labs have had good success in attracting and retaining talent (e.g., through improved college graduate recruitment efforts). As many scientists and engineers with practical nuclear weapon design and testing experience are retired, continued annual assessments and certifications of nuclear warheads will rely increasingly on the judgments of people who have never tested or designed a nuclear weapon. Moreover, demand for skilled personnel will increase as NNSA ramps up production capabilities and moves some operations to around-the-clock, seven-days-a-week scheduling.[88] Admiral Richard has emphasized the importance of investing in the workforce now: If "[w]e lose those talent bases, you can't buy it back, it will take five to ten years to...retrain and redevelop the people."[89]

In light of these issues, the NNSA workforce earns a score of "marginal," but will trend toward "strong" with these continued improvements.

Readiness of Forces Score: Strong

The readiness of forces that operate U.S. delivery platforms is a vital component of America's strategic forces. The military personnel operating the three legs of the nuclear triad must be properly trained and equipped. It is also essential that the crews responsible for the nuclear mission are maintained in an appropriate state of readiness.

During FY 2021, the services have continued to align resources to preserve strategic capabilities in the short term. Nevertheless, long-term stable funding will be essential for the timely execution of programs and associated readiness activities.

U.S. general-purpose forces are critical to ensuring the overall effectiveness of our nuclear forces (e.g., by 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, for example, 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.[90] Sustained attention to this issue remains critical to ensuring the strong recruitment and training of personnel.

Grade: Despite uncertainties regarding the future impacts of budgetary shortfalls, the young men and women who secure, maintain, plan for, and operate U.S. nuclear forces are of an extremely high caliber. General Timothy Ray, Commander of Air Force Global Strike Command, has testified that "our combat mission readiness rates among our bomber aircrews is at its highest in the history of the command."[91] Nuclear force commanders have provided assurance that the COVID-19 pandemic has had no impact on force readiness and the ability to launch nuclear weapons.[92]

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. The United States extends nuclear assurances to more than 30 allies who in turn have maintained the commitment to forgo nuclear programs of their own. If allies were to resort to building their own nuclear weapons because their confidence in U.S. extended deterrence had been degraded, the consequences for nonproliferation and stability could become dire.

In Europe, the United States can coordinate with France and the United Kingdom, which already have nuclear weapons. The U.S. also deploys B-61 nuclear gravity bombs in Europe as a visible manifestation of its commitment to its NATO allies and retains dual-capable aircraft that can deliver those gravity bombs. The United States provides nuclear assurances to Japan, South Korea, and Australia, all of which face increasingly aggressive nuclear-armed regional adversaries: China, Russia, and North Korea. Continued U.S. nuclear deterrence assurances are critical and must be perceived as credible. Both Japan and South Korea have the capability and basic know-how to build their own nuclear weapons quickly. A decision to do so would be a major setback for U.S. nonproliferation policies.

The 2018 NPR took a positive step when it placed "Assurance of allies and partners" second on its list of four "critical roles" 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.[93] The recent successful deployment of the W76-2 low-yield warhead is an important component of America's ability to deter regional aggression against its Asian and NATO allies.

Grade: At this time, 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 growing non-strategic nuclear capabilities not limited by New START. The NATO Secretary General's annual report and the recent NATO summit in the United Kingdom reiterated NATO's commitment to remaining a nuclear alliance as long as nuclear weapons exist.[94] While significant percentages of South Koreans continue to express support for an indigenous nuclear weapons capability or nuclear-sharing agreement with the United States,[95] neither South Korea nor Japan has expressed serious concern about the U.S. commitment to extended deterrence.

Allied assurance will likely remain strong as long as the United States remains committed to modernizing its own nuclear deterrent and rejects calls to reduce its nuclear forces unilaterally. The Biden Administration has emphasized a renewed focus on allies and partners in American foreign policy; achieving this goal will require the prioritizing of extended deterrence. Continued commitment from the Administration and Congress to development of the nuclear sea-launched cruise missile, which can be deployed as a regional nuclear capability in both the European and Indo-Pacific theaters, is one important way to meet this goal.[96] Rejecting calls for a "no first use" or "sole purpose" declaratory policy will also be critical, as such policies are not popular with most of our allies because, among other things, they could call into question America's commitment to extending its nuclear deterrent for non-nuclear, but still existential, attacks on its allies.[97]

The score for allied assurance therefore remains "strong."

Overall U.S. Nuclear Weapons Capability Score: Strong but Trending Toward Marginal or Weak

It is necessary to emphasize that the grade of "strong" assumes that the United States maintains its commitment to modernization of the entire nuclear enterprise—warheads, platforms, command and control, personnel, and infrastructure—and allocates needed resources accordingly. Without this commitment, this overall score will degrade rapidly to "weak." Since every other military operation—and therefore overall national defense—relies on a strong nuclear deterrent, the United States cannot afford to fall short in fulfilling this imperative mission.

There have been major issues with nuclear capabilities since the end of the Cold War, ranging from degraded infrastructure to the inability to produce plutonium pits to delivery platforms at risk from aging. Yet progress in modernization efforts, combined with assurances from senior leaders that the forces remain reliable, warrants an improvement to the grade of "strong" this year.

Although modernization programs have yet to produce many tangible results (e.g., delivery systems have not yet entered production), a sustained bipartisan commitment to nuclear modernization extending through the previous two Administrations reflects a positive trend. Both the 2010 and 2018 NPRs strongly articulate a core nuclear weapons policy that is solidly grounded in the realities of today's threats and growing international concerns, as well as a continued commitment to extended deterrence. Moreover, presidential budgets and congressional appropriations in recent years have continued to provide the necessary funding for modernization programs. As a result, this is a more optimistic assessment of the nuclear portfolio than we have been able to provide in previous editions.

That being said, this score of "strong" with a conditional trend toward "marginal" or "weak" reflects a greater risk than in previous years of a degradation in nuclear deterrence. Current forces are assessed as reliable today, but nearly all components of the nuclear enterprise are at a tipping point with respect to replacement or modernization and have no margin left for delays in schedule. Failure of on-time appropriations and lack of Administration support for nuclear modernization could lead to a rapid decline in this portfolio to "weak" in future editions.

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		✓			
OVERALL				✓	

Endnotes

1. All of the past six confirmed Secretaries of Defense—including current Secretary of Defense Lloyd Austin—have affirmed U.S. nuclear deterrence as the department's number one mission.
2. Admiral Charles A. Richard, Commander, United States Strategic Command, statement before the Committee on Armed Services, U.S. Senate, April 20, 2021, p. 3, https://www.armed-services.senate.gov/imo/media/doc/Richard04.20.2021.pdf (accessed June 23, 2021).
3. President of Russia, "Events: Expanded Meeting of the Defence Ministry Board," December 21, 2020, http://en.kremlin.ru/events/president/news/64684 (accessed June 23, 2021).
4. Peter Brookes, "Responding to Troubling Trends in Russia's Nuclear Weapons Program," Heritage Foundation *Backgrounder* No. 3601, March 26, 2021, https://www.heritage.org/defense/report/responding-troubling-trends-russias-nuclear-weapons-program.
5. New START limits warheads deployed on strategic ICBMs, SLBMs, and bombers but excludes an entire category of non-strategic warheads. While there is no legal definition of a non-strategic warhead, such a warhead can be described as tactical and more suited to use in a regional conflict or as any warhead not defined as strategic by New START. Russia's arsenal of non-strategic warheads includes systems ranging from artillery, land mines, torpedoes, and anti-ship missiles to short-range and intermediate-range missiles. For further information, see Amy F. Woolf, "Nonstrategic Nuclear Weapons," Congressional Research Service *Report for Members and Committees of Congress* No. RL32572, updated March 16, 2021, https://fas.org/sgp/crs/nuke/RL32572.pdf (accessed June 23, 2021).
6. "Transcript: The Arms Control Landscape ft. DIA Lt. Gen. Robert P. Ashley, Jr.," Hudson Institute, May 29, 2019, p. 24, https://s3.amazonaws.com/media.hudson.org/Hudson%20Transcript%20-%20The%20Arms%20Control%20Landscape.pdf (accessed June 23, 2021).
7. U.S. Department of Defense, Office of the Secretary of Defense, *Nuclear Posture Review 2018*, February 2018, p. 8, https://media.defense.gov/2018/Feb/02/2001872886/-1/-1/1/2018-NUCLEAR-POSTURE-REVIEW-FINAL-REPORT.PDF (accessed June 23, 2021).
8. Joby Warrick, "China Is Building More than 100 New Missile Silos in Its Western Desert, Analysts Say," *The Washington Post*, June 30, 2021, https://www.washingtonpost.com/national-security/china-nuclear-missile-silos/2021/06/30/0fa8debc-d9c2-11eb-bb9e-70fda8c37057_story.html (accessed September 11, 2021); William J. Broad and David E. Sanger, "A 2nd New Nuclear Missile Base for China, and Many Questions About Strategy," *The New York Times*, July 26, 2021, https://www.nytimes.com/2021/07/26/us/politics/china-nuclear-weapons.html (accessed September 11, 2021); and Rod Lee, "PLA Likely Begins Construction of an Intercontinental Ballistic Missile Silo Site Near Hanggin Banner," U.S. Air Force, Air University, August 12, 2021, https://www.airuniversity.af.edu/CASI/Display/Article/2729781/pla-likely-begins-construction-of-an-intercontinental-ballistic-missile-silo-si/ (accessed September 11, 2021).
9. See Aaron Mehta "STRATCOM Chief Warns of Chinese 'Strategic Breakout,'" *Breaking Defense*, August 12, 2021, https://breakingdefense.com/2021/08/stratcom-chief-warns-of-chinese-strategic-breakout/ (accessed September 11, 2021), and Michael Martina, "China Will Soon Surpass Russia as a Nuclear Threat—Senior U.S. Military Official," Reuters, August 27, 2021, https://www.reuters.com/world/china/china-will-soon-surpass-russia-nuclear-threat-senior-us-military-official-2021-08-27/ (accessed September 11, 2021).
10. Launch-on-Warning posture allows launch of nuclear weapons against an opponent as soon as early warning sensors detect an incoming attack.
11. Richard, statement before Senate Armed Services Committee, pp. 6–8.
12. Mary Beth D. Nikitin, "North Korea's Nuclear Weapons and Missile Programs," Congressional Research Service *In Focus* No. 10472, updated April 14, 2021, https://fas.org/sgp/crs/nuke/IF10472.pdf (accessed June 23, 2021).
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