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BACKGROUNDER

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Aged U.S. Nuclear Stockpile and Infrastructure Must Evolve to Address 21st-Century Threats

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Abstract

The U.S. nuclear weapons stockpile has changed dramatically throughout the course of its existence. From a handful of nuclear weapons of relatively simple design throughout the second half of the 1940s to a peak number of 31,255 warheads in the 1970s, the variety and capabilities of warheads in the U.S. nuclear stockpile have differed throughout the past half century. Today, the U.S. nuclear warhead stockpile is the least diverse it has been for decades, and the technical skills supporting it are in a dire need of reinvigoration. The current U.S. nuclear arsenal has been adjusted based on assumptions that are now demonstrably wrong, for example that Russia will be friendly to the United States and its allies. The future remains dangerous and uncertain, which places a premium on the flexibility and resilience of the U.S. nuclear enterprise as a whole. The U.S. approach to its stockpile must evolve so it can continue to fulfill its deterrence and assurance roles. U.S. and allied security depend on the strength of the U.S. nuclear stockpile and the skills and infrastructure necessary to support it.

The U.S. nuclear weapons stockpile has changed dramatically throughout the course of its existence. From a handful of nuclear weapons of relatively simple design throughout the second half of the 1940s to a peak number of 31,255 warheads in the 1970s, the variety and capabilities of warheads in the U.S. nuclear stockpile have differed throughout the past half century.[1] Today, the U.S. nuclear warhead stockpile is the least diverse it has been for decades, and the technical skills supporting it are in a dire need of reinvigoration.

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Key Points

- The United States' nuclear weapons infrastructure is in dire need of modernization. The U.S. has not produced a new nuclear warhead in about 30 years and would unlikely be able to do so within a time frame meaningful enough to respond to unforeseen circumstances or geopolitical surprises.
- The current U.S. nuclear arsenal has been adjusted based on assumptions that are now demonstrably wrong, for example that Russia will be friendly to the United States and its allies.
- Today, there are more nuclear-weapon-armed states than at any time in history—and among them are U.S. adversaries, such as Russia, China, and North Korea.
- The future remains dangerous and uncertain, which places a premium on the flexibility and resilience of the U.S. nuclear enterprise as a whole. The U.S. approach to its stockpile must evolve so that it can continue to fulfill its deterrence and assurance roles.

This paper, in its entirety, can be found at **http://report.heritage.org/bg3311**

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prise as a whole. The current U.S. nuclear arsenal has been adjusted based on assumptions that are now demonstrably wrong, for example, that Russia will be friendly to the United States and its allies. Fortunately, the stockpile has had a built-in hedge capability, supported by all U.S. Presidents since the end of the Cold War, that allows the United States to adjust the stockpile to some extent in the case of a worsening security environment. The U.S. approach to its stockpile must evolve so it can continue to fulfill its deterrence and assurance roles. U.S. and allied security depend on the strength of the U.S. nuclear stockpile and the skills and infrastructure necessary to support it.

The U.S. Nuclear Stockpile: Then and Now

The U.S. nuclear weapons stockpile includes warheads that are actively deployed, as well as warheads in storage facilities. Warheads stored in facilities are in different states of readiness. The relatively large number of U.S. nuclear warheads reflects the U.S. inability to design new warheads and constitutes a hedge that allows the United States to increase the number of actively deployed warheads in the case of a technical failure or geopolitical surprise. It does not include retired warheads that await dismantlement. The Cold War nuclear warhead stockpile differed from today's stockpile in several important aspects, including diversity, manpower, funding, and approach to sustaining it. Today, the United States no longer has the luxury of continuing on the same path that has led to the atrophy of the nuclear infrastructure needed to support U.S. warhead efforts in the first place.

The Evolution of the Threat. During the Cold War, the United States worried mostly about one state actor: the Soviet Union. The United States implicitly assumed that if it can deter the Soviet Union, it will be able to deter lesser nuclear-armed actors, such as China or India. The United States invested incredible amounts of resources—monetary, technological, and intellectual—into trying to understand the Soviet Union, developing capabilities to deter a nuclear war, threaten credibly what the Soviet Union values, and think through different aspects of persevering and winning a nuclear war. The U.S. thought through strategic-forces signaling, and the interplay between conventional and nuclear forces.

The perception of the threat environment understandably changed after the dissolution of the Soviet Union. U.S. policymakers were more optimistic about the direction of the Russian foreign and defense policy than they were about the Soviet Union. Following the revelations pertaining to the Iraqi nuclear weapons program following the first Gulf War, they also became more focused on risks associated with nuclear weapons and proliferation of weapons-grade material. Both Russia and the United States significantly reduced the number of deployed weapons, both conventional and nuclear, from their Cold War peaks.

The perception of a safer environment took its intellectual toll. Nuclear strategy issues fell from the radar of U.S. leaders and decision makers. Resources spent on the infrastructure supporting the nuclear weapons complex dwindled, and nuclear weapons modernization programs were scaled down or canceled entirely. According to Lisa Gordon-Hagerty, Under Secretary for Nuclear Security and Administrator of the National Nuclear Security Administration, "More than half of NNSA's [National Nuclear Security Administration's] facilities are over 40 years old, and roughly 30% date back to the Manhattan Project era. If left unaddressed, the condition and age of NNSA's infrastructure will put NNSA's missions, the safety of its workforce, the public, and the environment at risk."[2] Perhaps more important, the nation failed to develop a successor generation of nuclear thinkers and took an intellectual vacation from nuclear matters and nuclear strategy.

Threats to the United States and its allies, however, have not diminished and have been making quite an unpleasant comeback. Today, there are more nuclear-weapon-armed states than at any time in history. Russia has launched the most extensive nuclear weapons modernization program since the end of the Cold War—*after* it signed the New Strategic Arms Reduction Treaty (New START), an arms-control

1. Office of the Deputy Assistant Secretary of Defense for Nuclear Matters, *Nuclear Matters Handbook 2016*, "Chapter 2: Evolution of the Nuclear Deterrent—a History," https://www.acq.osd.mil/ncbdp/nm/nmhb/chapters/chapter_2.htm (accessed March 22, 2018).
2. "Statement of Lisa E. Gordon-Hagerty Administrator, National Nuclear Security Administration, U.S. Department of Energy," testimony before Subcommittee on Energy and Water Development, Appropriations Committee, U.S. House of Representatives, March 20, 2018, https://plus.cq.com/doc/testimony-5285581?16&searchId=rgqnKrXH (accessed March 26, 2018).

CHART 1

How the New START Treaty Affects U.S., Russian Arsenals

BALLISTIC MISSILES
Deployed ICBMs, deployed SLBMs, and deployed heavy bombers

WARHEADS
Warheads on deployed ICBMs, on deployed SLBMs, and nuclear warheads counted for deployed heavy bombers

LAUNCHERS
Deployed and non-deployed launchers of ICBMs, deployed and non-deployed launchers of SLBMs, and deployed and non-deployed heavy bombers

NOTES: Figures are biannual except for 2018, which are for February.
SOURCE: U.S. Department of State, Bureau of Verification, Compliance, and Implementation, "New START: Fact Sheets," http://www.state.gov/t/avc/newstart/c39906.htm (accessed April 10, 2018).

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treaty with the United States that was supposed to help to "reset" relations between the two countries.[3] Under New START, the United States agreed to a significant majority of nuclear weapons reductions, while Russia was bound to making barely any cuts to its nuclear forces, but has also at times deployed hundreds of nuclear warheads above the treaty limits.[4] Russia is building a diverse nuclear arsenal with warheads of different attributes, including small nuclear warheads and warheads with special effects.[5]

In 2015, the press reported an existence of an undersea autonomous torpedo weapon system that might carry a very large nuclear warhead, up to 100 megatons.[6] In its strategic doctrine, Russia considers a use of nuclear weapons de-escalatory in certain circumstances.[7] Russia's foreign policy of the past sever-

3. Bill Gertz, "Russia Sharply Expanding Nuclear Arsenal, Upgrading Underground Facilities," *The Washington Free Beacon*, December 13, 2017, http://freebeacon.com/national-security/russia-sharply-expanding-nuclear-arsenal-upgrading-underground-facilities/ (accessed March 22, 2018).
4. For the initial data declaration and an example of accountable Russian nuclear warhead deployments well above treaty limits, see U.S. Department of State, Bureau of Arms Control, Verification, and Compliance, "New START Treaty Aggregate Numbers of Strategic Offensive Arms," February 5, 2011, https://2009-2017.state.gov/t/avc/rls/164722.htm (accessed March 23, 2018).
5. Mark B. Schneider, "The Nuclear Posture Review, New START, and the Russian Nuclear Buildup," *Real Clear Defense*, June 5, 2017, http://www.nipp.org/wp-content/uploads/2017/06/Schneider_The-NPR-New-START-and-the-Russian-Buildup.pdf (accessed March 23, 2018).
6. Bill Gertz, "Pentagon Confirms Russia Building Underwater Nuclear Drone," *The Washington Free Beacon*, January 17, 2018, http://freebeacon.com/national-security/pentagon-confirms-russia-building-underwater-nuclear-drone/ (accessed March 23, 2018).
7. Mark B. Schneider, "Escalate to De-escalate," *Proceedings Magazine*, February 2017, https://www.usni.org/magazines/proceedings/2017-02/escalate-de-escalate (accessed March 23, 2018).

al years is particularly troubling because it indicates that on some levels, Russia is not deterred. The 2008 invasion of Georgia and the 2014 invasion of Ukraine present a challenge to the post–Cold War status quo.

More concerning are Russia's capabilities outside of New START. It has a superior short-range nuclear weapons arsenal and its warfighting doctrine blends the difference between nuclear and conventional weapons, including indicating a willingness to use nuclear weapons preemptively.[8] Russia is "building a large, diverse, and modern set of non-strategic systems" that can be armed with both conventional and nuclear weapons.[9] It encompasses many diverse types of delivery systems, such as cruise missiles and underwater vehicles. During Vladimir Putin's state-of-the nation speech on March 1, 2018, the Russian leader announced a successful test of "a cruise missile that was propelled by a nuclear powered engine… [which] gave the cruise missile an effective unlimited range,"[10] unlike the typical cruise missile range of 600 miles. According to Putin, "the missile would be able to fly close to the ground and follow an unpredictable path, rendering existing missile defenses 'useless.'"[11] The Russian president also announced new weapons, such as the "nuclear-powered underwater drone and new hypersonic missile that have no equivalent elsewhere in the world."[12] Clearly, the talk was meant to impress his domestic audience before Russia's presidential elections, but also to send a message to the United States. Russia also exercises its nuclear capabilities during military drills.

China has also exhibited a concentrated effort to modernize its military and nuclear forces. Specific to nuclear forces, China aims to increase the size, capability, and protection of its nuclear arsenal.[13] Most of the details regarding the scope and scale of its nuclear modernization program have long been shrouded in mystery, and Beijing has resisted U.S. efforts to include it in the arms control process. The lack of transparency increases the uncertainty regarding China's exact intentions with its nuclear weapons. China's nuclear arsenal is estimated to contain 264 warheads.[14] Some experts estimate the number to be higher. The 2018 Nuclear Posture Review (NPR) highlights the Chinese nuclear weapons modernization program: "China has developed a new road-mobile strategic intercontinental ballistic missile (ICBM), a new multi-head version of its DF-5 silo-based ICBM, and its most advanced ballistic missile submarine armed with new submarine-launched ballistic missiles (SLBM)."[15]

China plans to add strategic bombers to its nuclear forces, acquiring a nuclear triad. Additionally, it plans to build a nuclear-powered aircraft carrier according to the China Shipbuilding Industry Corporation's (CSIC's) statement on its plans to "speed up key breakthroughs such as the realization of nuclear-powered aircraft carriers, new-style nuclear submarines, quiet submarines, and unmanned intelligent underwater defense systems."

Although a fledgling nuclear nation, the rogue regime of North Korea has increasingly ramped up its development of nuclear weapons and missile capabilities while doubling down on explicit threats against the United States and its allies.[16] North Korea increased its missile testing to 16 tests in 2017, with 23 missiles fired in the course of those tests. These

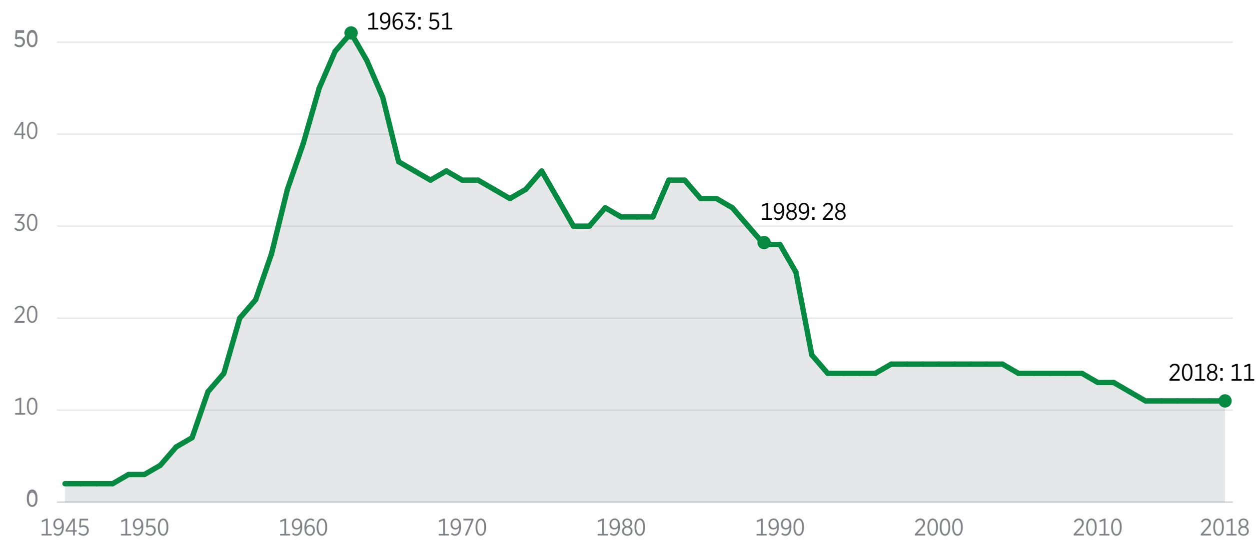
8. Mark B. Schneider, "Russian Nuclear Weapons Policy," *Real Clear Defense*, April 28, 2017, https://www.realcleardefense.com/articles/2017/04/28/russian_nuclear_weapons_policy_111261.html#_ednref16 (accessed March 23, 2018).
9. U.S. Department of Defense, Office of the Secretary of Defense*, 2018 Nuclear Posture Review*, February 2018, p. 9, https://media.defense.gov/2018/Feb/02/2001872886/-1/-1/1/2018-NUCLEAR-POSTURE-REVIEW-FINAL-REPORT.PDF (accessed April 12, 2018).
10. Anton Troianovski, "Putin Claims Russia Has Nuclear Arsenal Capable of Avoiding Missile Defenses," *The Washington Post*, March 1, 2018, https://www.washingtonpost.com/world/europe/putin-claims-russia-has-nuclear-arsenal-capable-of-avoiding-missile-defenses/2018/03/01/d2dcf522-1d3b-11e8-b2d9-08e748f892c0_story.html?utm_term=.0cbff08b6319 (accessed March 1, 2018).
11. Ibid.
12. "Russia Now Has an Underwater Drone that Can Hold Nuclear Warhead," *NY Daily News*, March 1, 2018, http://www.nydailynews.com/news/world/russia-underwater-drone-hold-nuclear-warhead-article-1.3848407 (accessed march 1, 2018).
13. U.S. Department of Defense, Office of the Secretary of Defense, *2018 Nuclear Posture Review*, p. 11.
14. Zachary Keck, "The Big China Nuclear Threat No One Is Talking About," *The National Interest*, June 2, 2017, http://nationalinterest.org/blog/the-buzz/the-big-china-nuclear-threat-no-one-talking-about-20983 (accessed March 1, 2018).
15. U.S. Department of Defense, Office of the Secretary of Defense, *2018 Nuclear Posture Review*, p. 11.
16. Ibid.

CHART 2

A Less Diverse Nuclear Arsenal

Even as the complexity of U.S. nuclear deterrent requirements increased as new nuclear-armed states like North Korea and Pakistan emerged, the number of types of nuclear weapons in the U.S. arsenal dramatically decreased and is set to decrease further in the future.

TYPES OF 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), and U.S. Department of Energy, "Stockpile Stewardship and Management Plan," *Report to Congress*, November 2017, https://www.energy.gov/sites/prod/files/2017/11/f46/fy18ssmp_final_november_2017%5B1%5D_0.pdf (accessed April 23, 2018).

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efforts have resulted into the first flight of the Hwasong-15, at the end of November 2017, with a "lofted" range of a height of 4,500 kilometers and a distance of 950 km away from the launch site.[17] Coupled with North Korea's ability to "miniaturize a nuclear warhead,"[18] the regime may now be "only months away from the capability to strike the U.S. with nuclear armed ballistic missiles."[19]

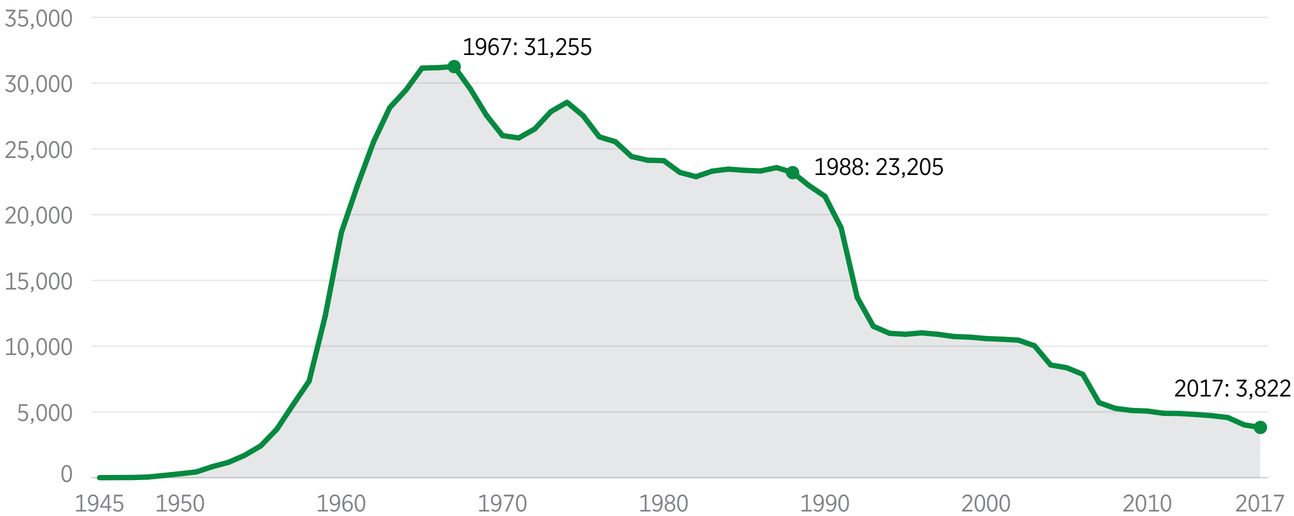
Additionally, North Korea has chemical, biological, and conventional capabilities and continues to produce plutonium and highly enriched uranium. Not only does the rogue state pose a direct threat to world order, it also "poses a 'horizontal' proliferation threat as a potential source of nuclear weapons or nuclear material for other proliferations."[20] It is not implausible that North Korea is providing or selling its nuclear weapon testing data to third parties.

In July 2015, the Joint Comprehensive Plan of Action (JCPOA) was signed, imposing "restrictions

17. Ankit Panda, "The Hwasong-15: The Anatomy of North Korea's New ICBM," *The Diplomat*, December 6, 2017, https://thediplomat.com/2017/12/the-hwasong-15-the-anatomy-of-north-koreas-new-icbm/ (accessed March 5, 2018).
18. Michaela Dodge, "Keeping Up with North Korea's and Iran's Bad Ballistic Missiles," *Investor's Business Daily*, November 27, 2017, https://www.investors.com/politics/commentary/keeping-up-with-bad-ballistic-missiles/ (Accessed March 5, 2018).
19. U.S. Department of Defense, Office of the Secretary of Defense, *2018 Nuclear Posture Review*, p. 11.
20. Ibid., p. 12.

CHART 3

Total Nuclear Warheads in the U.S. Stockpile



SOURCES: 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), and U.S. Department of Defense, "Stockpile Numbers," http://open.defense.gov/Portals/23/Documents/frddwg/2017_Tables_UNCLASS.pdf (accessed April 23, 2018).

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on Iran's stockpiles of uranium and its ability to enrich it."[21] Since then, Iran "has been caught cheating at the margins on centrifuge development, heavy water restrictions, technology procurement, and export controls" and "was caught red-handed trying to purchase nuclear technology and restricted ballistic-missile technology from German companies."[22] Even with the JCPOA in place, Iran can still "produce higher enriched uranium within 48 hours"[23] and "retains the technological capability and much of the capacity necessary to develop a nuclear weapon within one year."[24]

Iran also continues to develop its long-range ballistic missiles, improving the missiles' accuracy and lethality in an apparent effort to threaten U.S. forward-deployed forces and Iran's neighbors.[25] While Iran has not yet developed a missile capable of reaching the U.S. homeland, its aggressive behavior and nuclear and missile capabilities spur the potential for proliferation among Middle Eastern states. Iran is a potential source for the illegal attainment of nuclear weapons and technologies by extremist groups.[26]

India possesses an arsenal of between 120 and 130 plutonium-based nuclear warheads[27] and has

21. Zachary Laub, "The Impact of the Nuclear Agreement," Council on Foreign Relations, October 13, 2017, https://www.cfr.org/backgrounder/impact-iran-nuclear-agreement (accessed March 6, 2018).
22. James Phillips, "Time to Decertify the Iran Nuclear Agreement," Heritage Foundation *Issue Brief* No. 4768, October 2, 2017, https://www.heritage.org/defense/report/time-decertify-the-iran-nuclear-agreement.
23. David Brennan, "Iran Nuclear Program Can Restart Within 48 Hours If Deal Collapses, Official Claims," *Newsweek*, March 5, 2018, http://www.newsweek.com/iran-48-hours-higher-enriched-uranium-if-nuclear-deal-collapses-official-830543 (accessed March 5, 2018).
24. U.S. Department of Defense, Office of the Secretary of Defense, *2018 Nuclear Posture Review*, p. 13.
25. Center for Strategic and International Studies, "Missiles of Iran," CSIS Missile Defense Project, https://missilethreat.csis.org/country/iran/ (accessed March 5, 2018).
26. U.S. Department of Defense, Office of the Secretary of Defense, *2018 Nuclear Posture Review*, p. 13.
27. Kelsey Davenport, "Nuclear Weapons: Who Has What at a Glance," Arms Control Association, January 2018, https://www.armscontrol.org/factsheets/Nuclearweaponswhohaswhat (accessed March 5, 2018).

acquired "a full nuclear triad of air-, land- and sea-based nuclear delivery platforms."[28] The country remains outside both the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) and the Comprehensive Nuclear Test Ban Treaty (CTBT).[29] Pakistan has between 130 and 140 nuclear weapons,[30] and a nuclear triad of its own. The air, land, and sea components of the triad are comprised of F-16A fighters; the Hatf series of mobile missiles (with ranges from 180 miles to 766 miles); and the Babur class of cruise missiles.[31]

Diversity. Since the dawn of the nuclear age, the United States has designed about a hundred different warhead types with different military capabilities for long-range, medium-range, and short-range delivery systems of various kinds, including aircraft, submarines, missiles, and artillery. While all U.S. warhead types have not been all deployed at the same time, with an average operational life cycle of about 10 years, the stockpile was much more diverse during the Cold War than it is today both in terms of delivery systems and warheads.

At their respective peaks, the United States actively deployed about 14,000 strategic nuclear weapons in 1988 and deployed more than 6,000 tactical nuclear weapons in the late 1970s.[32] The range of capabilities served to provide the President with options and flexibility to respond in-kind to nuclear weapons of various capabilities, yields, and attributes that the Soviet Union possessed. It also provided a technical hedge: Should a problem with one of the warheads require fixes that would require all warheads of the same type to be put out of service at the same time, the remaining warhead types would be able to continue the mission without significantly compromising U.S. military capabilities. The less diverse the nuclear stockpile is, the higher the risk, should a significant flaw in one of the warhead types be discovered.

Today, the United States deploys about 1,390 strategic warheads under New START.[33] The treaty's counting rules mean that the B-52 and B-2 bombers account for one warhead each, even though they can carry between 16 and 20 nuclear warheads, depending on type.[34] The United States also deploys about 200 short-range nuclear weapons to Europe, which is a far cry from the Cold War days of deploying thousands of warheads in multiple North Atlantic Treaty Organization countries.[35] Short-range nuclear weapons are sometimes referred to as tactical or even non-strategic nuclear weapons. Such designations, rooted in artificial distinctions necessitated by arms control treaties, are misleading because the use of a nuclear weapon, even a short-range one, would have a strategic effect.

The current stockpile includes the B61, W76, W78, W80, B83, W87, and W88 warheads.[36] Four of these are ballistic missile warheads—two for ICBMs (the W78 and W87) and two for SLBMs (the W76 and W88); two are gravity bombs—(the B61, which has multiple versions, and the B83), and one is for the cruise missile (the W80).[37] Some of these weapons

28. Sebastien Roblin, "A War Between India and Pakistan: Nuclear Weapons Could Fly (and Millions Could Die)," *The National Interest*, November 26, 2017, http://nationalinterest.org/blog/the-buzz/war-between-india-pakistan-nuclear-weapons-could-fly-23370 (accessed March 5, 2018).
29. Nuclear Threat Initiative, "India Overview," http://www.nti.org/learn/countries/india/ (accessed March 6, 2018).
30. Kelsey Davenport, "Nuclear Weapons: Who Has What at a Glance," Arms Control Association, January 2018, https://www.armscontrol.org/factsheets/Nuclearweaponswhohaswhat (accessed March 5, 2018).
31. Kyle Mizokami, "How Pakistan Is Planning to Fight a Nuclear War," *The National Interest*, March 25, 2017, http://nationalinterest.org/blog/the-buzz/how-pakistan-planning-fight-nuclear-war-19897 (accessed March 6, 2018).
32. Amy F. Wolf, "U.S. Strategic Nuclear Forces: Background, Developments, and Issues," Congressional Research Service *Report for Congress*, March 6, 2018, https://fas.org/sgp/crs/nuke/RL33640.pdf (accessed March 23, 2018), and Amy F. Wolf, "Nonstrategic Nuclear Weapons," Congressional Research Service *Report for Congress*, February 13, 2018, https://fas.org/sgp/crs/nuke/RL33640.pdf (accessed March 23, 2018).
33. U.S. Department of State, Bureau of Arms Control, Verification, and Compliance, "New START Treaty Aggregate Numbers of Strategic Offensive Arms," September 1, 2017, https://www.state.gov/t/avc/newstart/274550.htm (accessed March 23, 2018).
34. Kingston Reif, "NewSTART at a Glance," Arms Control Association, March 2018, https://www.armscontrol.org/factsheets/NewSTART (accessed March 23, 2018).
35. Hans M. Kristensen, "Non-Strategic Nuclear Weapons," Federation of American Scientists *Special Report* No. 3, May 2012, https://fas.org/_docs/Non_Strategic_Nuclear_Weapons.pdf (accessed March 23, 2018).
36. U.S. Department of Defense, The Office of the Deputy Assistant Secretary of Defense for Nuclear Matters, *Nuclear Matters Handbook 2016*, p. 33, https://www.acq.osd.mil/ncbdp/nm/nmhb/docs/NMHB_2016-optimized.pdf (accessed March 23, 2018).
37. Eryn Macdonald, "3+2= $60 Billion," Union of Concerned Scientists, July 17, 2013. https://allthingsnuclear.org/emacdonald/3plus2 (accessed February 15, 2018).

have now been deployed for over 40 years with the help of life-extension programs.

The diversity of the U.S. nuclear stockpile will shrink further if the current Stockpile Stewardship Plan does not change. In 2013, a memo from the Nuclear Weapons Council introduced the "3+2 Strategy." The strategy replaces aging weapons within a span of the next 30 years or so. The plan reduces the number of the types of warheads by merging them into interoperable warheads for the land-based and sea-based legs of the Triad, and modernizes strategic-bomb and cruise-missile warheads for the air-based leg.[38]

The "3" part of the strategy will replace the ICBMs and the SLBMs with three types of interoperable warheads that have adaptable non-nuclear components to fit land-based and sea-based ballistic missiles. The "2" part addresses the air-based leg of the Triad and will modernize four types of B61 gravity bombs into one B61-12 gravity bomb, and also reflects plans to retire the B83—the last megaton-class weapon in America's arsenal. The 2018 NPR delays the decision to retire the B83 warhead. The "3+2 Strategy" will also modernize the W80-1 cruise missile into the W80-4 warhead that could fit on the new Long Range Stand Off (LRSO) cruise missile.[39] The 2018 NPR also proposes two supplemental capabilities: a low-yield warhead for the submarine-launched missile in the near term (within the next five years or so), and a sea-launched cruise missile in the long run. These capabilities use existing warhead types and do not require new nuclear weapon designs. They are designed to provide additional survivability and diversity when it comes to U.S. low-yield options. As the 2018 NPR states, these capabilities are meant to "counter any mistaken perception of an exploitable 'gap' in U.S. regional defense capabilities."[40]

The long-term impact of these capabilities on the U.S. stockpile remains to be determined. The new strategy allows a reduction of the number of weapons the United States has in the nuclear stockpile, as well as a more streamlined arsenal that is safe, secure, and reliable.

New Nuclear Weapon Designs. The exploration of nuclear warhead science, the continued interests of each of the military Services, and the need to keep the workforce proficient and engaged led to a periodical development of new nuclear weapon designs. Each warhead was perfectly mated to its delivery system under stringent conditions that included considerations of implications of nuclear environments for both the warhead and the delivery system. Judgments about these environments were made based on the best available analysis of U.S. adversaries' technological capability and weapons designs, as well as data obtained through a rigorous and robust underground nuclear testing program.

The newest warhead in the U.S. nuclear stockpile is the W88, deployed in 1988 and designed for the Trident D-5 SLBM. The warhead is currently undergoing a life extension, with the first production unit to be delivered by the fiscal year (FY) 2020.[41] The oldest warhead in the U.S. nuclear arsenal, the B61 gravity bomb, which was deployed in 1963 and was originally designed for a 10-year operational life. It is air-delivered and currently deployed to Europe where it continues to be the strongest reminder of the U.S. commitment to transatlantic security.[42]

The United States has not produced a new nuclear warhead in about 30 years and would unlikely be able to do so within a meaningful time frame, such as in the case of a geopolitical surprise.[43] Most people with hands-on warhead design experience are

38. U.S. Department of Energy and National Nuclear Security Administration, "Fiscal Year 2018 Stockpile Stewardship and Management Plan," *Report to Congress*, November 2017, pp. 12–14, https://www.energy.gov/nnsa/stockpile-stewardship-and-management-plan-and-prevent-counter-and-respond-strategic-plan-reduce (accessed April 12, 2018).
39. Michaela Dodge and John Venable, "Why the United States Needs an LRSO Capability," Heritage Foundation *Issue Brief* No. 4580, June 17, 2016, https://www.heritage.org/arms-control/report/why-the-united-states-needs-lrso-capability.
40. U.S. Department of Defense, Office of the Secretary of Defense, *2018 Nuclear Posture Review*, p. 55.
41. National Nuclear Security Administration, "W88 Alteration 370 Program Successfully Moving Forward," January 16, 2018, https://nnsa.energy.gov/blog/w88-alteration-370-program-successfully-moving-forward (accessed March 23, 2018).
42. Michaela Dodge, "U.S. Nuclear Weapons in Europe: Critical for Transatlantic Security," Heritage Foundation *Backgrounder* No. 2875, February 18, 2014, https://www.heritage.org/defense/report/us-nuclear-weapons-europe-critical-transatlantic-security.
43. Thomas K. Scheber and John R. Harvey, "Assessment of U.S. Readiness to Design, Develop and Produce Nuclear Warheads: Current Status and Some Remedial Steps," *Comparative Strategy*, Vol. 35, No. 3 (2016), p. 180, https://www.tandfonline.com/doi/abs/10.1080/01495933.2016.1194654 (accessed April 12, 2018).

either close to retirement, retired, or dead. This situation presents a challenge in several ways. For one, the United States is limited in the essential skills that would be required if a decision to pursue a new nuclear warhead was made. Such a decision could be made in response to geopolitical developments that undermine the U.S. nuclear deterrent or because the United States discovered a serious flaw in a warhead in the current stockpile that rendered the warhead unsafe or unusable. As the diversity of the U.S. nuclear stockpile decreases, a discovery of a flaw could affect a large part of a nuclear arsenal and undermine U.S. deterrence and assurance.

Granted, a very simple new warhead design may not require nuclear weapons testing, but it is unlikely that such a design would be sufficient to deter the threats the United States would face given current technological trends in countries that are most likely to become adversaries. Regardless of policies today, however, the United States will have to build new nuclear weapons in the future. "We cannot life extend these forever. And we better know how to do it when we get there. And the only way to be assured of that is to exercise that muscle in the near term," stated General Kevin Chilton (ret.), former Commander of the U.S. Strategic Command.[44]

During the Cold War, the United States prioritized the maximization of yield over other warhead design concerns. While security of nuclear warheads (internal safety features, as well as storing and deploying) was a concern, it was not a primary weapons design concern. U.S. warheads would be different today if security was prioritized over yield-to-weight performance. Designing and building nuclear warheads requires a different set of skills than maintaining them and assessing their performance using computer models. Today, the United States is at great risk of losing the skills necessary to develop new nuclear warhead designs, should the international security situation require them.

The United States recently started working on improving the abysmal state of its nuclear infrastructure responsiveness through a program that exercises a majority of nuclear weapon design and production skills. The Stockpile Responsiveness Program creates opportunities for young weapons scientists and engineers to build a more "responsive weapons production infrastructure and technical workforce."[45] The program, started under the provisions of the FY 2016 National Defense Authorization Act, allows weapons scientists more opportunity to exercise the full range of skills required to develop nuclear weapons.[46] "Prototyping, involving design and development of a modern warhead for the express purpose of exercising skills, is one way to achieve this [stockpile responsiveness]. A few warheads could be developed, produced and put on the shelf, but not necessarily deployed to the stockpile," explains John Harvey, former Principal Deputy Assistant Secretary of Defense for Nuclear, Chemical, and Biological Defense Programs.[47] Congress should support, fund, and expand the program.

Manpower. The NNSA's manpower issues are to some extent related to the current approach to the maintenance of the U.S. nuclear stockpile. Warhead life extensions "do not provide designers the opportunity to exercise the skillset of making trades among the entirety of design attributes (manufacturing, performance, safety, cost, military requirements)," because they are based on legacy designs.[48] Maintaining aged warheads is an incredible technological challenge requiring a degree of innovation, but pales in comparison to the skills necessary to make the nuclear infrastructure responsive and resilient.

The Stockpile Responsiveness Program described above, as well as the warhead design competition

44. Jennifer-Leigh Oprihory, "Chilton on US Nuclear Posture, Deterring Russia, Apollo Astronaut John Young's Legacy," *Defense and Aerospace Report*, January 18, 2018, https://defaeroreport.com/2018/01/23/chilton-us-nuclear-posture-deterring-russia-apollo-astronaut-john-youngs-legacy/ (accessed March 23, 2018).

45. American Institute of Physics, "Trump Nuclear Review Calls for a More 'Responsive' Weapons Infrastructure and Workforce," February 7, 2018, https://www.aip.org/fyi/2018/trump-nuclear-review-calls-more-%E2%80%98responsive%E2%80%99-weapons-infrastructure-and-workforce (accessed March 13, 2018).

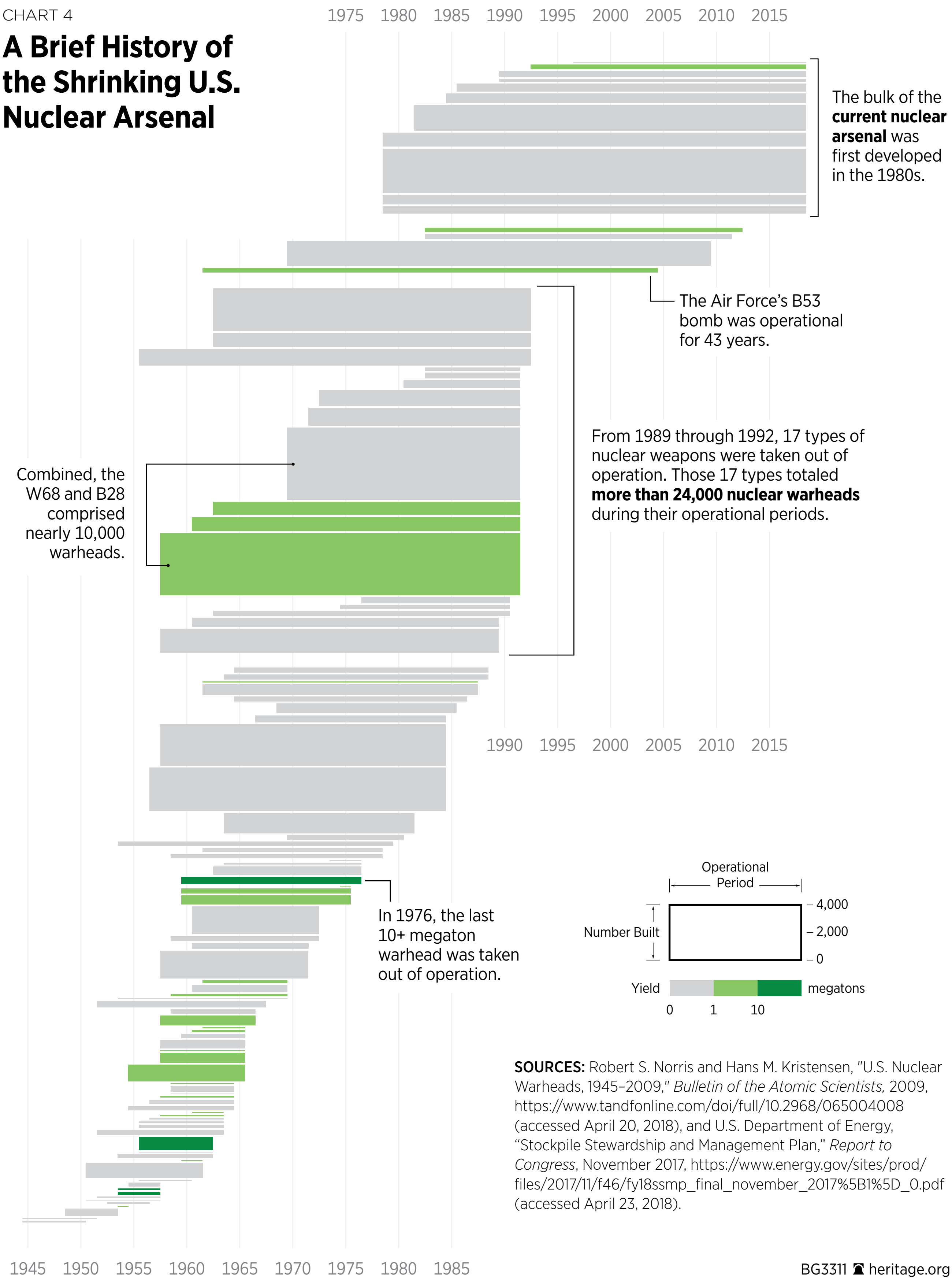
46. American Institute of Physics, "Nuclear Weapons R&D Programs Boosted in Trump Budget," June 2, 2017, https://www.aip.org/fyi/2017/nuclear-weapons-rd-programs-boosted-trump-budget (accessed March 12, 2018).

47. John Harvey, "Implementing the 2018 Nuclear Posture Review," presented at 12th annual Strategic Weapons of the 21st Century Conference, Washington, DC, March 7, 2018.

48. Ibid.

CHART 4

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



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, "Stockpile Stewardship and Management Plan," *Report to Congress*, November 2017, https://www.energy.gov/sites/prod/files/2017/11/f46/fy18ssmp_final_november_2017%5B1%5D_0.pdf (accessed April 23, 2018).

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between nuclear weapon laboratories, is meant to reinvigorate morale, enthusiasm, and innovative thinking among the national nuclear laboratories.[49] This is no small task considering that most scientists and engineers with nuclear warhead design experience are retired or will be retired very soon. The Panel to Assess the Reliability, Safety, and Security of the United States Nuclear Stockpile noted that "[o]nly 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."[50]

An additional concern is the aging workforce at the national nuclear laboratories. An aging workforce is an indication that the laboratories have a problem attracting and retaining new talent. The average age of the NNSA workforce approaches 50 years. That may not be a problem on its own considering the time it takes to develop expertise in this incredibly challenging field. The problem is that over a third or more of the workforce is eligible for retirement within the next four years and there simply are not enough younger scientists in training to fill the gap.[51] Developing young scientists and engineers along with those who have hands-on experience in building and maintaining the stockpile is of critical importance for the future health of U.S. nuclear deterrent, particularly as the United States plans on pursuing an ambitious delivery-platform modernization and warhead-sustainment program.

Nuclear Weapons Testing. The United States currently observes the Comprehensive Test Ban Treaty (CTBT). The Senate rejected the treaty after a full floor debate in 1999. Since then, the U.S. nuclear weapons complex atrophied and international conditions for the treaty to come into force worsened.[52] Despite the Senate's rejection, the treaty continues to shape U.S. nuclear weapon policy, including preventing U.S. nuclear laboratories from conducting very-low-yield nuclear weapon experiments entirely by self-imposed constraint. The CTBT does not define what "zero" means and it is entirely possible that the Russians and perhaps the Chinese hold themselves to a different interpretation. In the lead-up to CTBT signature, the directors of national nuclear laboratories "requested that the permitted test level should be set to a level of a few hundred tons of yield which is in fact lower than a one-kiloton limit, which would have allowed us to carry out some very important experiments...to determine whether the first stage of multiple stage devices was indeed operating successfully."[53] Observing a zero-yield interpretation of the CTBT was therefore not the best technical judgment but a policy decision. Even very-low-yield-producing experiments that can be performed in rooms no larger than a condominium can give weapons designers valuable weapon production skills.[54] The United States is not currently involved in any of these experiments.[55]

Others do not operate under the same constraints. Russia and China reportedly conduct nuclear yield-producing experiments, the kind of experiments that the United States has forsworn.[56] Additionally, some of the most irresponsible nuclear actors, like North Korea or Iran, are not even a party to the treaty.

While technical experts differ on the extent of the benefit that very-low-yield-producing experiments have in terms of improvement of warhead designs, they unquestionably sharpen skills necessary for nuclear weapons development that the United States has been sorely lacking. The situation will be worse as those with actual nuclear testing expe-

49. Ibid.

50. Panel to Assess the Reliability, Safety, and Security of the United States Nuclear Stockpile, "Expectations for the U.S. Nuclear Stockpile Program: FY 2001 Report," 2002, http://fas.org/programs/ssp/nukes/testing/fosterpnlrpt01.pdf (accessed June 13, 2017).

51. National Nuclear Security Administration, "Our Locations," https://nnsa.energy.gov/aboutus/ourlocations (accessed March 23, 2018).

52. Kathleen Bailey and Thomas Scheber, "The Comprehensive Ban Treaty: An Assessment of the Benefits, Costs, and Risks," National Institute for Public Policy, November 2011, http://www.nipp.org/wp-content/uploads/2014/12/CTBT-3.11.11-electronic-version.pdf (accessed April 12, 2018).

53. Ambassador C. Paul Robinson, John Foster, and Thomas Scheber, "The Comprehensive Test Ban Treaty: Questions and Challenges," Heritage Foundation, *Backgrounder* No. 1218, November 7, 2012, https://www.heritage.org/arms-control/report/the-comprehensive-test-ban-treaty-questions-and-challenges (accessed March 23, 2018).

54. Bailey and Scheber, "The Comprehensive Ban Treaty."

55. William J. Perry, "America's Strategic Posture," United States Institute of Peace, 2009, https://www.usip.org/sites/default/files/America's_Strategic_Posture_Auth_Ed.pdf (accessed March 23, 2018).

56. Ibid.

rience retire and the United States will have to re-invent the necessary skills.

Data obtained through underground nuclear weapons testing was limited by instrumentation available to the United States at the time when tests were conducted. Instrumentation was state-of-the-art at the time but the last yield-producing experiment was conducted in 1992.

Technology has advanced significantly since. Computer models are not able to capture the full complexity involved in warhead aging or its effects on materials surrounding the radioactive pits. Leaps in technology also mean that the process of safely resuming nuclear weapons tests would have to be re-invented as opposed to replicated.[57] The process would likely take more than three years, which might be too long, based on how rapidly events have unfolded in the past.[58] Experts argue that "[a] healthy nuclear readiness capability would enable the United States to respond to a reliability failure in a nuclear warhead or weapon system type, to an emerging vulnerability as the result of new adversary capabilities, or to presidential direction calling for an increase in the U.S. inventory of weapons."[59]

As technology advances and new materials are invented, conducting yield-producing experiments would allow the United States to obtain data on weapon effects on these new materials as well as new weapon systems. It is likely that some of this information can be modeled, but no computer simulation can take into account all the complexity involved in harsh environments produced in an underground nuclear weapon test. The importance of this consideration might increase as the United States embarks upon its delivery-systems-modernization program and modifies nuclear warheads to meet perfectly both military requirements and demands of their delivery systems.

Recommendations

Nuclear weapons are the most destructive weapons in the U.S. arsenal. They serve critical roles, including deterring a large-scale attack against the United States and assuring U.S. allies. Today's nuclear stockpile is nothing like its Cold War predecessor. It differs in many important attributes, including the quantity and diversity of nuclear warheads and approaches to ensuring its viability. The decrease in the resilience and capability of U.S. nuclear weapons infrastructure is particularly concerning in this respect. A lack of responsive and capable infrastructure can undermine the U.S. deterrent, particularly in the case of surprising technological and geopolitical developments. Congress and the Administration must work together to:

- **Modernize U.S. nuclear weapons infrastructure, including its human capital.** Despite the emphasis that post–Cold War Administrations placed on flexible and modern nuclear weapons infrastructure, the current state of the NNSA complex is discouraging. The infrastructure has atrophied for decades and is unlikely to be able to respond in a timely manner to a rapid change in the international environment or a technological surprise. Modernizing the complex, including its human component, is a critical task of the U.S. government.

- **Support programs to design new nuclear warheads.** These include the Stockpile Responsiveness Program and a warhead-design competition between the national nuclear laboratories. Developing a full range of skills and expert judgment through hands-on exercises and programs supports U.S. deterrence goals and improves morale at the national nuclear laboratories.

- **Improve nuclear-test readiness.** With the diversity of the U.S. nuclear arsenal shrinking further, the government must improve U.S. capability and timeline required to conduct a meaningful nuclear weapons experiment. Such experiments might be required for different purposes, including ensuring that changes introduced into them since the end of the Cold War have not compromised their performance. The government must consider benefits of nuclear weapons test-

57. National Security Science, "Nuclear Test Readiness," December 2016, https://www.lanl.gov/discover/publications/national-security-science/2016-december/_assets/docs/NSS-dec2016_nuclear-test-readiness.pdf (accessed March 23, 2018).

58. Ibid.

59. Scheber and Harvey, "Assessment of U.S. Readiness to Design, Develop and Produce Nuclear Warheads," p. 180.

ing in the light of new technological development as well as the planned nuclear-delivery-systems-modernization program. U.S. nuclear warheads cannot be sustained indefinitely, and the country must advance and preserve skills allowing it to build new nuclear weapons when required.

- **Strengthen U.S. capacity to understand foreign nuclear weapons designs.** Other nations are not bound by the same self-imposed constraints as the United States and take a dramatically different approach to modernizing their nuclear warheads. The United States must develop and maintain its capabilities to understand what these different approaches might mean for the U.S. nuclear deterrent and survivability of its weapon systems, both conventional and nuclear.

- **Address the emerging gap within the NNSA's workforce.** The NNSA must improve its efforts to attract and maintain young talent to work on U.S. nuclear warheads. Not only is it necessary for young people to have hands-on experience, the best way to gain such experience is to work with colleagues who have mastered and developed required skills over time. The current age gap between those projected to retire within the next four years and a lack of younger personnel to fill that gap does not bode well for the future of the U.S. nuclear weapons stockpile.

- **Support archival efforts regarding nuclear weapons design and testing.** In concurrence with other steps to increase the overall capability of the U.S. nuclear stockpile, the government ought to support efforts to document and catalog the technical experience of people with weapons design and weapons test experience. Even though not all skills and experience are transferable or are relevant in the current environment with current technological trends, understanding why U.S. weapons designers and engineers took certain steps in the past is an essential first step to rebuilding U.S. capabilities.

These proposed steps will help to address deficiencies in the current approach to the U.S. nuclear stockpile and infrastructure, and will ensure that both continue to fulfill their primary missions of deterring adversaries and assuring allies.

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