CHAPTER 1
OVERVIEW OF THE U.S. NUCLEAR DETERRENT

"Our nuclear deterrent is nearing a crossroads. To date, we have preserved this deterrent by extending the lifespan of legacy nuclear forces and infrastructure—in many cases for decades beyond what was originally intended. But these systems will not remain viable indefinitely. In fact, we are now at a point where we must concurrently modernize the entire nuclear triad and the infrastructure that enables its effectiveness."

General Paul Selva, USAF (Ret.), Former Vice Chairman of the Joint Chiefs of Staff

Nuclear deterrence is the bedrock of U.S. national security, serving as the backstop and foundation of U.S. national defense, the defense of U.S. allies since 1945, and underwrites every U.S. military operation. The U.S. nuclear deterrent is comprised of nuclear weapons and delivery systems, nuclear command, control, and communications (NC3), and the people and infrastructure that support it all. While U.S. nuclear weapons have not been employed since World War II, the United States uses its nuclear deterrent every day to maintain peace around the globe.

The nuclear age began with the use of the atomic bomb in 1945, followed by a nuclear arms race with the Soviet Union, and culminated with the last U.S. nuclear explosive test in 1992 after the end of the Cold War. In the post-Cold War era, the focus shifted to sustainment of nuclear deterrent systems in the absence of underground nuclear testing. The year 2010 marked a shift in nuclear posture for the United States, with the *2010 Nuclear Posture Review* (NPR) reducing the role of the nuclear deterrent in U.S. national security strategy citing a less dangerous security environment. However, the security environment did not improve, but rather grew more competitive over the next ten years. The 2018 NPR highlighted the resurgence of Russia and the rise of China as strategic competitors and potential adversaries. In recognition of these threats, the 2018 NPR stressed the need for the modernization of the U.S. nuclear deterrent.

Our strategic competitors have been modernizing, developing, testing, and fielding systems for their own nuclear deterrents for over a decade. Russia is modernizing across its nuclear arsenal as well as its other non-nuclear strategic systems. This includes new road-mobile and silo-based intercontinental ballistic missiles (ICBMs), ballistic missile submarines (SSBNs) and missiles, bomber aircraft, and cruise missiles. Russia is also actively testing never-before-seen nuclear capabilities such as hypersonic glide vehicles, nuclear-powered and nuclear-armed cruise missiles, and nuclear-powered unmanned underwater vehicles.

China is also modernizing and expanding its already considerable nuclear forces, marking the return to Great Power competition. China is developing, testing, and fielding new generations of land-based ballistic missiles, increasing the range of its submarine-launched ballistic missiles, and pursuing a new bomber. China is investing significant resources on advanced nuclear-capable systems and hypersonic vehicles. See Figure 1.1 for an overview of the nuclear environment in which the United States is to field a modern deterrent for the 21st Century.

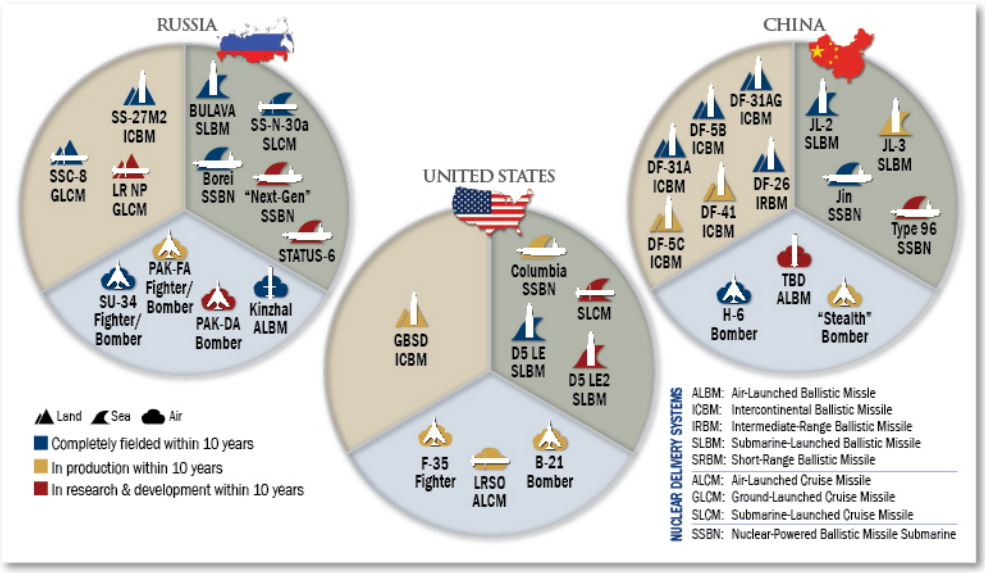

Figure 1.1 Nuclear Delivery System Programs of the United States, Russia, and China

BRIEF HISTORY OF NUCLEAR WEAPONS

1945 TO 1992

Nuclear weapons came into being as a result of a bold attempt to invent a practical way to use an untested technology. The Manhattan Project produced the world's first atomic bombs in 1945. On July 16, 1945, the United States detonated "the gadget," the Nation's first nuclear explosive device at the Trinity Site in New Mexico. Twenty-one days later, on August 6, 1945, President Harry S. Truman authorized a specially equipped B-29 bomber named the *Enola Gay* (Figure 1.2) to drop a nuclear bomb, dubbed *Little Boy* (Figure 1.3), on Hiroshima, Japan. A second B-29 bomber, *Bockscar* (Figure 1.4), dropped a second U.S. atomic weapon, *Fat Man* (Figure 1.5), on Nagasaki, Japan, on August 9, 1945. The atomic bombs dropped on Hiroshima and Nagasaki remain the only nuclear weapons ever used in combat.

Figure 1.2 Enola Gay

Figure 1.3 Little Boy

Figure 1.4 Bockscar

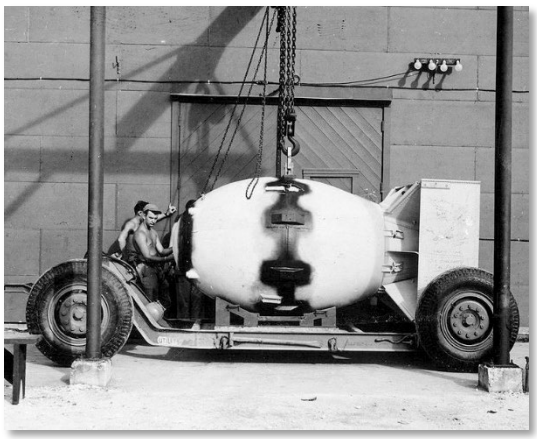

Figure 1.5 Fat Man

The United States did not remain the world's sole nuclear power for long. The Soviet Union tested its first nuclear device in August 1949. The United Kingdom became the third nuclear weapons state with its first test in October 1952.

The creation of nuclear weapons helped define the era. The two nuclear superpowers, the United States and the Soviet Union competed to advance new weapon designs and conduct nuclear explosive testing to support continuous innovations in nuclear weapons technology.

At the beginning of the nuclear era, the U.S. nuclear weapons program focused on producing sufficient nuclear material to build enough weapons for a second-strike capability, or the ability to attack after absorbing an all-out first strike. The United States also focused on fielding weapons on almost every type of military delivery system available. By 1967, the United States had over 30,000 nuclear weapons in its arsenal. Many of these were "tactical"—shorter range, lower yield, non-strategic—nuclear weapons. The United States relied on these nuclear weapons as a means available to counter the dominance of Soviet conventional forces, particularly in Europe.

After 1967, U.S. priorities shifted in the face of economic pressures. Because warheads were less expensive than missiles, U.S. strategy emphasized nuclear weapons with high yield-to-weight ratios and the ability to field Multiple Independently Targetable Reentry Vehicles (MIRVs), allowing several warheads to be mounted on a single missile. U.S. weapons systems featured improved operations and logistics for the military operator; modernized safety, security, and control features; and enhanced military performance characteristics (e.g., selectable yields and greater accuracy). The United States also drastically reduced its stockpile of tactical nuclear weapons. These changes were made possible by a better understanding of nuclear physics and weapon designs provided by nuclear explosive testing.

1992 TO 2018

At the end of the Cold War, with the dissolution of the Soviet Union, there was reduced focus on nuclear weapons without a nuclear superpower rival. With the near simultaneous end of both nuclear weapons production in 1991 and nuclear testing in 1992, the new challenge facing the nuclear enterprise was to maintain and sustain the legacy deterrent without new production or testing, and to extend the operational lives of both weapons and delivery systems indefinitely.

In 1991, the United States shuttered its plutonium pit production facility. The same year, in an effort to realize the "peace dividend" from the end of the Cold War, President George H.W. Bush ordered the withdrawal and destruction of ground-launched short-range missiles that had carried nuclear weapons, and the removal of all tactical nuclear weapons from surface ships, attack submarines, and naval aircraft. In 1992, in anticipation of a potential comprehensive test ban treaty, the United States voluntarily suspended underground nuclear testing.

The termination of both new nuclear weapons production and explosive testing halted the continuous cycle of modernization programs that included building and subsequently replacing the weapons in the stockpile with newer, more modern designs. A key part of this process was the use of nuclear testing to refine new designs in the development process, to test the yields of weapons after they were fielded, and to define and repair certain types of technical problems. Without an ability to produce new weapons or to test, the United States was faced with the unexpected challenge of sustaining the deterrent in a new and unknown way.

The *National Defense Authorization Act for Fiscal Year 1994* directed the Department of Energy (DOE) to establish a Stockpile Stewardship Program (SSP) using science-based methods and advanced computing to guarantee that the stockpile remained safe, secure, and effective without the need to conduct nuclear explosive tests.

Since 1994, DOE, and subsequently the National Nuclear Security Administration (NNSA), has successfully maintained and sustained the safety, security, and effectiveness of the stockpile without nuclear explosive testing.

Through the development of new scientific, computational, and technical tools and methodologies, the Secretaries of Defense and Energy have been able to certify the continued viability of the U.S. nuclear deterrent without nuclear explosive testing every year since 1995.

The United States has not fielded a newly designed nuclear weapon (with new nuclear components) since 1991. During this time, the United States also significantly reduced its stockpile quantities. In 1991, the U.S. nuclear stockpile had 19,000 nuclear weapons; by 2003, there were approximately 10,000; by 2009, there were

roughly 5,000. In 2017, the last time the United States published unclassified stockpile numbers, there was a total of about 3,800 weapons. Figure 1.6 shows the size of the U.S. nuclear stockpile from 1945 to 2017.[1]

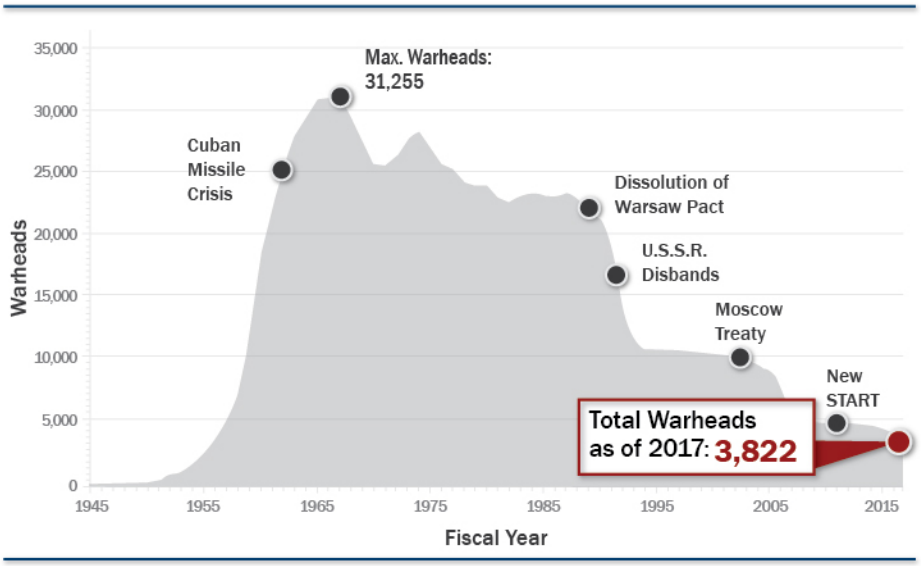

Figure 1.6 U.S. Nuclear Stockpile, 1945–2017

Because the United States has produced no new nuclear weapons, it has instead extended the lives of the weapons in the legacy stockpile. Life extension programs (LEPs) have underpinned the ability of the United States to sustain its weapons beyond their original design lives.

The U.S. nuclear stockpile has continued to decrease in quantity in accordance with arms control treaties with Russia and internal U.S. decisions concerning the appropriate size of the U.S. nuclear deterrent. For more information on arms control treaties see *Chapter 12, Nuclear Treaties and Agreements*.

2018 AND BEYOND

The global security environment has become more dangerous than the United States had hoped after the Cold War. Nuclear competition among Great Powers has not gone away. While the NNSA SSP has succeeded in keeping the legacy stockpile safe, secure, and effective, and the nuclear platforms and systems are continually maintained for operational readiness, modernization can no longer be delayed.

Figure 1.7 illustrates the evolution of the nuclear deterrent from 1955 to the present.

[1] The number of warheads depicted in Figure 1.6 include both active and inactive warheads. Several thousand additional nuclear warheads are retired and awaiting dismantlement.

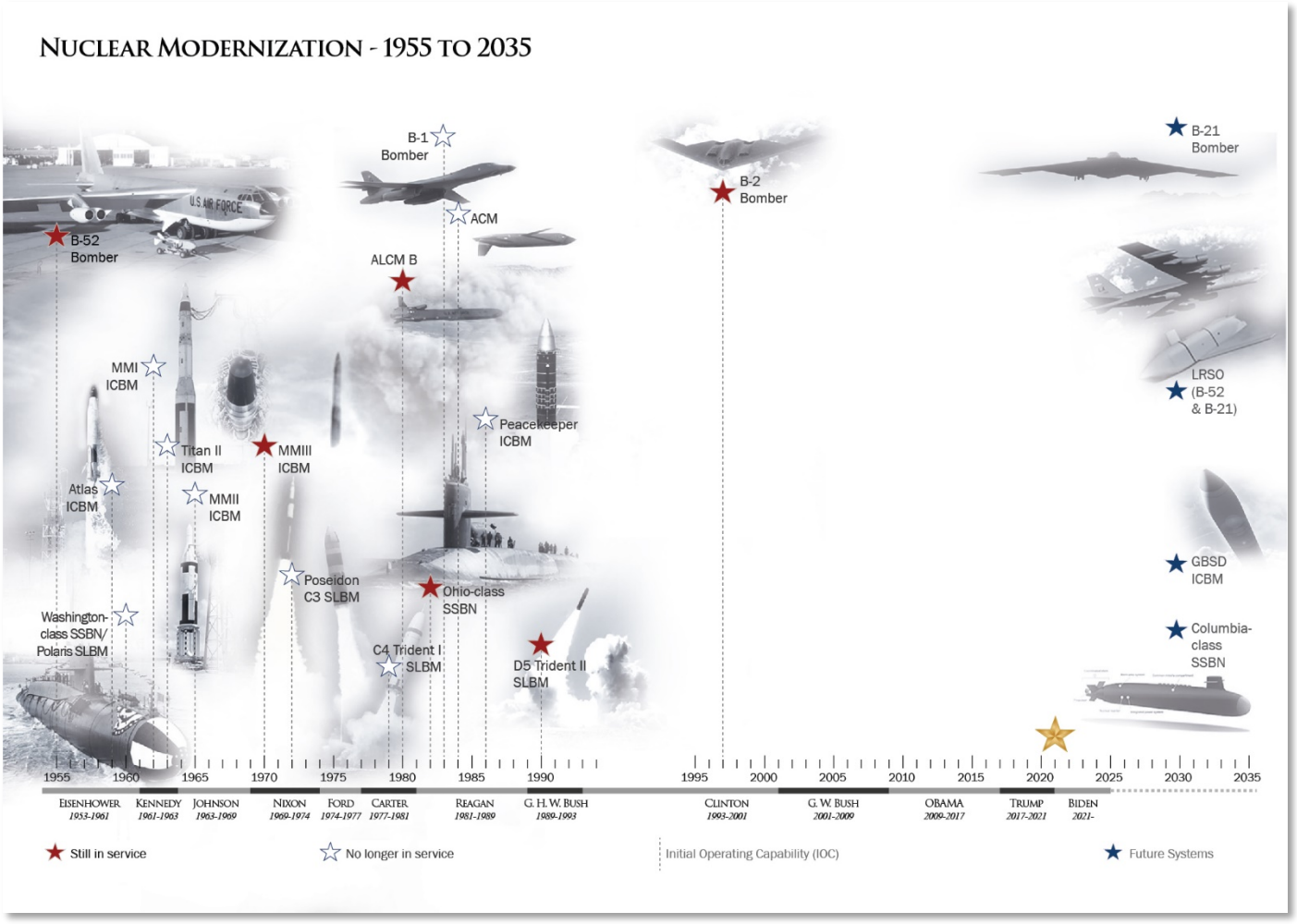

Figure 1.7 Evolution of the U.S. Nuclear Deterrent, 1955–Present

The average age of U.S. nuclear weapons is 40 years old at life extension or planned retirement—more than twice the original design lives.

All life-extended weapons in the stockpile will reach the end of their planned lifetimes by mid-century, which in some cases is more than three times as long as they were designed to operate. Some components of those life-extended weapons (e.g., plutonium pits) have been reused as-is, meaning that those components have been in the stockpile for many decades beyond their originally projected lifespans, and will remain in the stockpile until they can be replaced.

Similarly, U.S. nuclear delivery systems have all been sustained beyond their design lives. By 2035, 100% of U.S. nuclear delivery systems will have exceeded their design lives by an average of 30 years. By the early 2040s, 100% of U.S. nuclear delivery vehicles will have reached end of life. At retirement, both the air-launched cruise missile (ALCM) and the Minuteman III ICBM will be over 50 years into their 10-year design life. The Ohio-class SSBN is already beyond its projected lifetime, and the B-2A bomber and the F-15E dual-capable aircraft will both be approaching 40 years old before they are retired. The B-52 bomber will be about 100 years old when it is finally scheduled to retire in the mid-2050s.

All current U.S. ballistic missile warheads were designed and built in the 1970s and 1980s, and their designs addressed specific Cold War problems from the 1960s. In the time of high stockpile numbers, U.S. nuclear tactics emphasized overwhelming adversary defenses using many weapons to defeat a single target and using as much yield as possible given space and weight constraints.

For deterrence purposes, the current composition of the stockpile must contain the attributes required to maintain sufficient diversity and flexibility, to include:

- *Survivable* – the force and NC3 resilience needed to survive any potential adversary attack and endure throughout crises and conflict;
- *Forward Deployable* – the mobility and range needed to temporarily or permanently relocate some U.S. nuclear capabilities to allied or partner territory for needed political or military effect;
- *Diverse and Graduated Options* – the availability of forces with the spectrum of yield options, weapon types, and delivery options necessary to support the most effective tailoring of strategies across a range of adversaries and contingencies;
- *Accurate Delivery* – the precision needed to hold adversary assets at risk while minimizing unintended effects;
- *Penetrating* – the capacity to counter active and passive defenses, including hardened and buried facilities, to pose credible deterrent threats, and achieve military objectives with high confidence;
- *Responsive* – the capacity to deploy and employ forces as promptly as is necessary to pose credible threats;
- *Diversity of Ranges* – the availability of forces with a spectrum of range options necessary to support the most effective tailoring of strategies;
- *Diversity of Trajectories* – the capacity to locate forces at multiple geographical locations and with multiple flight profiles to complicate adversary active and passive defense planning;
- *Visible* – the capacity to display national will and capabilities as desired for signaling purposes throughout crisis and conflict; and
- *Weapon Reallocation* – the capacity to change target information quickly to enable adaptive planning and effective employment.[2]

FUTURE OF THE NUCLEAR DETERRENT

The U.S. military has operated the nuclear force so that the deterrent has done its job, as evidenced by the fact that no nuclear weapons have been employed in combat since 1945. In addition, U.S. scientists, engineers,

[2] U.S. Department of Defense, "Nuclear Posture Review," (Arlington, VA: U.S. Department of Defense, February 2018), 43–44, https://media.defense.gov/2018/Feb/02/2001872886/-1/-1/1/2018-NUCLEAR- POSTURE-REVIEW-FINAL-REPORT.PDF.

designers, and production workers have maintained the stockpile and successfully extended the lives of U.S. weapons without the need to resume nuclear explosive testing.

However, Cold War legacy delivery systems and their associated weapons cannot be sustained indefinitely. It is necessary to modernize the nuclear deterrent to avoid "rusting to zero" (performance degradation due to weapons aging). A modern U.S. deterrent must also be threat responsive, and able to take advantage of technological advances, as adversary technologies also advance. Replacement programs are underway to ensure there are no capability gaps when these legacy systems age out, or become obsolete due to advances in adversary capabilities.

Nuclear deterrence will continue to be vital to U.S. national security strategy and be underpinned by nuclear forces and effective nuclear command, control, and communications. The nuclear deterrent will provide survivable and responsive capabilities to ensure adversaries do not attempt a disarming first strike; demonstrate resolve through the positioning of forces, messaging, and flexible response options; ensure the United States can respond to a broad range of contingencies with tailored options; and mitigate the risk of a technological failure or adversary breakthrough, while providing adaptability to changes in the security environment.