2019

WINTER
VOLUME 5

STRATEGIC PRIMER: Nuclear Weapons Modernization

CURRENT CAPABILITIES AND EMERGING THREATS

NUCLEAR WEAPONS MODERNIZATION AND AMERICAN SECURITY

The American Foreign Policy Council (AFPC) is dedicated to advancing the prosperity and security of the United States. AFPC's Defense Technology Program launched the Strategic Primer initiative to educate Congressional staffers and the general public on technologies that affect U.S. national security. The Primers depict balanced representations of the potential benefits and limitations of a particular technology, its history and uses, and potential threats posed by adversarial use of the technology.

This work seeks to provide insights into the role U.S. nuclear weapons play in advancing America's security, and the rationale for modernizing U.S. nuclear weapons and their delivery platforms. The Primer provides a succinct and informative background on U.S. nuclear policy and strategy, current nuclear capabilities of the United States and its potential adversaries, plans and rationale for modernizing U.S. nuclear capabilities, and policy recommendations.

TABLE OF CONTENTS

Director: Richard M. Harrison
Editor: Ilan Berman
Principal Author: Mark A. Bucknam
Graphic Design: Ozzie Chung
Researchers: Jordan Hayley
William Thomas Mallard
Harrison Reiff

WHAT IS THE STATE OF THE U.S. NUCLEAR ARSENAL?

Since the end of the Cold War, the U.S. nuclear arsenal has been woefully underfunded.[1] The relatively benign appearance of the strategic environment facing America at the start of the 21st century's second decade led the Obama administration to make "preventing nuclear proliferation and nuclear terrorism" the top priority of the 2010 Nuclear Posture Review (NPR).[2] The 2010 NPR also made clear the president's policy of "reducing U.S. nuclear weapons and their role in U.S. national security."[3] Not surprisingly, then, for two-and-a-half decades—a quarter of a century—the U.S. nuclear deterrent mission, and the weapons that underpin it, became an afterthought for the Pentagon's policy-makers and acquisition officials. Additionally, little coordination took place between the DOE and DoD, the two organizations chiefly responsible for nuclear warheads and their delivery systems, leaving vital scientific and engineering experience to erode.[4]

ADDRESSING THE THREAT

While America has allowed all aspects of its nuclear deterrent to atrophy, Russia and China have been embarking on aggressive programs to modernize and build up their nuclear capabilities. In the decades ahead, additional nuclear threats, such as North Korea and Iran, are likely to emerge. It is time for the U.S. to respond.

OVERVIEW OF NUCLEAR WEAPONS IN U.S. POLICY

WHAT IS A NUCLEAR WEAPON?

Nuclear weapons take advantage of fission and/or fusion of atomic nuclei, which atom-for-atom produce more than a million times more energy than the most powerful conventional explosives. That is why the power of nuclear weapons are measured in thousands of tons (kilotons) or millions of tons (megatons) of TNT equivalent.

U.S. NUCLEAR WEAPONS POLICY

Since the advent of the atomic age, nuclear weapons have been integral to deterring and otherwise limiting conflicts between great powers. Although America's strategy for nuclear deterrence has changed over the course of seven decades, nuclear weapons remain essential for the U.S. today for deterrence, extended deterrence and assurance, and preventing nuclear proliferation. As the 2018 Nuclear Posture Review Report noted, with the return of great power competition and the "most diverse and advanced nuclear-threat environment" in America's history, U.S. nuclear capabilities "contribute uniquely to the deterrence of both nuclear and non-nuclear aggression."[5]

The United States has long maintained a policy of ***counterforce*** targeting, meaning that America primarily targets enemy nuclear forces, military-industrial capabilities, and related leadership and command facilities. However, as U.S. nuclear forces age and adversaries improve their ability to defend and harden key targets, U.S. nuclear forces become less capable of holding an adversary's forces at risk. In addition, reductions in the numbers of U.S. nuclear forces could well deprive the United States of the capacity to effectively perform counterforce targeting. A U.S. nuclear arsenal that has been allowed to atrophy or that has been significantly reduced from its current size will ultimately force U.S. planners to shift to ***countervalue*** targeting, which involves deliberately targeting the cities or civilian population centers of adversaries. America has long rejected a policy or strategy built primarily on countervalue targeting as militarily inappropriate, morally repugnant, and quite possibly lacking in credibility. A robust and modernized nuclear force will preclude the need to resort to countervalue targeting while maintaining a highly credible and effective deterrent.

DETERRENCE

The term "deterrence" comes from Latin, meaning "to frighten away from." While most people understand deterrence in terms of a threat to inflict unacceptable damage in order to prevent an adversary from taking a particular action—known as deterrence by "punishment"—there is another type of deterrence that operates by denying an adversary the benefits the adversary hopes to achieve by taking the action one wishes to deter, known as deterrence by "denial." U.S. nuclear weapons can be used to threaten overwhelming punishment against adversaries who cross Washington's redlines (deterrence by punishment), whereas missile defenses and passive defenses, such as nuclear and electromagnetic pulse (EMP) hardening, contribute to deterrence by denial.

EXTENDING DETERRENCE/ASSURANCE

Extended deterrence "refers to the U.S. threat to use nuclear weapons in response to attacks, from Russia or other adversaries, against allies in NATO and some allies in Asia."[6] Providing the security umbrella of extended deterrence is extremely important to maintaining a global level of stability, and provides a strong commitment to security alliances. "Assurance refers to the U.S. promise, made to those same allies, to come to their defense and assistance if they are threatened or attacked."[7] Assurance is also important for nonproliferation of nuclear weapons. In short, effective American deterrence not only deters attacks against the U.S. homeland and its forces, but it also deters attacks against certain allies and partners and relieves them of the need to acquire their own nuclear weapons. Assurance of U.S. allies and partners represents the flip-side of extended deterrence of potential adversaries.

PREVENTING PROLIFERATION

Since the advent of nuclear weapons, a fear of wide-ranging proliferation has motivated politicians, scientists, and concerned citizens to work to prevent their spread. It took the first two decades of the Cold War for the United States, the Soviet Union, and other international players to create the Treaty on the Non-Proliferation of Nuclear Weapons, better known as the Non-Proliferation Treaty or NPT. America's guarantees of extended deterrence proved essential in convincing U.S. allies such as Germany, Japan, and South Korea not to pursue their own nuclear weapons arsenals during the Cold War and instead to sign onto the NPT. Today, America's extended deterrence guarantees continue to assure U.S. allies and persuade them to forego acquiring their own nuclear arsenals even though those allies have the technical wherewithal to do so.

WHY SHOULD THE U.S. NUCLEAR ARSENAL BE MODERNIZED?

China and Russia, the two countries whose nuclear capabilities present the biggest threat to the United States, began modernizing their strategic forces years ago.[8] Moreover, these nations have expanded and improved so-called "non-strategic" capabilities in the form of intermediate range missiles and integrated air defenses that threaten to undermine the U.S. nuclear deterrent.[9] Since the end of the Cold War, new threats have emerged in the form of a nuclear-capable North Korea and an Iran with nuclear ambitions. Furthermore, a number of potential adversaries continue to stockpile chemical and biological weapons, and U.S. conventional military capabilities may not work as an effective deterrent against their use. America's nuclear arsenal is the foundation for deterring attacks against vital U.S. interests, especially attacks in which adversaries might contemplate employing nuclear, biological or chemical weapons against the United States, its forces overseas, or its allies and friends. If U.S. nuclear weapons are to continue deterring adversaries and assuring allies, however, the U.S. nuclear arsenal must be modernized.

The United States must maintain a deterrent not only because of existing threats, but to guard against technical surprise and other possible future dangers. At some point, an existing nuclear adversary may make an unexpected leap in nuclear capability, drastically increasing the quantity or quality of its nuclear forces, as Russian President Putin has threatened to do on several occasions.[10] Moreover, the U.S. nuclear arsenal exists not only to deter existing threats but to deter future adversaries from trying to match or exceed U.S. nuclear capabilities. Reducing these capabilities would invite current and potential future adversaries to consider how they might overcome America's nuclear deterrent, something that should not be allowed to happen.

Modernization will ensure the United States maintains nuclear capabilities that are flexible enough to deter any potential attacker now and well into the future. Some adversaries may be deterred by certain attributes of U.S. nuclear forces, but not by others. Therefore, preserving and modernizing the capabilities of the U.S. nuclear triad is key to providing the United States with an effective deterrent for the 21st Century.

> "Our nuclear deterrent plays a critical role in assuring U.S. national security, and it is DoD's highest priority mission. No other capability we have is more important. Our nuclear forces stand alone in being able to deter nuclear attack on the United States and our allies."[11]
>
> – U.S. Secretary of Defense Chuck Hagel, November 14, 2014

UNDERSTANDING NUCLEAR DELIVERY SYSTEMS

THE NUCLEAR TRIAD (STRATEGIC)

The nuclear triad consists of land-based **intercontinental ballistic missiles (ICBMs)**, s**ubmarine launched ballistic missile (SLBMs)**, and **strategic bomber aircraft**. Whereas the United States once fielded thousands of so-called "tactical" nuclear weapons for a wide range of missions, and the Russians continue to do so today, the non-strategic weapons in the U.S. nuclear arsenal now number just a few hundred B61 nuclear gravity bombs that can be delivered by aircraft. Each leg of the nuclear triad possesses unique strengths that collectively provide a well-balanced capability and greatly improve the security of the United States and that of its allies. Removing one leg of the triad would destabilize the effectiveness of the overall nuclear deterrence we currently enjoy.

INTERCONTINENTAL BALLISTIC MISSILE (ICBM) - ADVANTAGES

- Most responsive leg of the triad. A continual state of alert gives the President of the United States the option to launch an immediate large-scale, retaliatory strike anywhere in the northern hemisphere, creating a powerful deterrent against nuclear attack on the United States.
- 400 missiles widely distributed in hardened underground silos across several northern U.S. states present a nearly insurmountable targeting challenge for an adversary who might attempt a disarming first strike to eliminate U.S. nuclear weapons. Only Russia has the theoretical capability for such an attack; others adversaries have too few weapons.
- Without the ICBM force, a potential attacker could use a much smaller arsenal—fewer than 20 weapons—to destroy most of the U.S. bomber fleet and the submarine force that remains in port, which could be inviting enough to encourage a future adversary to attempt such a disarming first-strike.
- ICBMs give the United States a measure of escalation dominance, a guarantee that an adversary can never escalate a conflict beyond the U.S. ability to respond.

INTERCONTINENTAL BALLISTIC MISSILE (ICBM) - DISADVANTAGES

- Fixed location makes them easier to target.
- Inability to "recall" or abort a mission after launch.
- High-yield warheads might be unsuitable for some missions.

SUBMARINE LAUNCHED BALLISTIC MISSILE (SLBM) - ADVANTAGES

- Most survivable leg of the triad, due to mobility and stealth of submarines. The best guarantee of a U.S. secure second strike capability.
- Accounts for nearly 70 percent of the U.S. deployed strategic nuclear warheads.[12]

SUBMARINE LAUNCHED BALLISTIC MISSILE (SLBM) - DISADVANTAGES

- High cost of ballistic missile submarines.
- Inability to "recall" or abort a mission after launch.
- High-yield warheads might be unsuitable for some missions.

STRATEGIC BOMBER AIRCRAFT - ADVANTAGES

- Flexibility is provided by being able to deliver warheads of various yields.
- The most visible leg of the triad, making it useful for sending deterrence signals to potential adversaries.
- Forward deployment of nuclear bombers provides visible assurance of U.S. resolve to America's allies who may harbor doubts about Washington's willingness to employ ICBMs or SLBMs on their behalf.
- Capable of attacking mobile targets.
- Ability to recall an attack mid-flight if the need arises.

STRATEGIC BOMBER AIRCRAFT - DISADVANTAGES

- Potentially vulnerable to being intercepted by modern, sophisticated integrated air defenses.

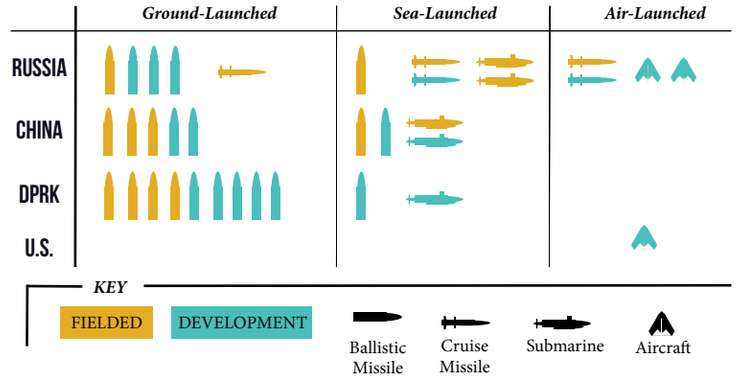
DUAL CAPABLE AIRCRAFT (TACTICAL)

In addition to the strategic nuclear triad, the U.S. nuclear arsenal also includes dual-capable aircraft (DCA) deployed by the United States in Europe in the form of the F-15E and F-16 fighters (to be replaced with F-35 Lightning II), and also deployed by several NATO allies in the form of F-16s and Tornado aircraft.[13] DCA are flexible in being able to perform conventional as well as nuclear missions. According to Ambassador Steven Pifer of the Brookings Institution, "the United States is believed to deploy some 200 B61 nuclear gravity bombs at six locations in five European countries. B61 bombs are reportedly maintained at Kleine Broegel Air Base in Belgium, Buechel Air Base in Germany, Ghedi Torre Air Base in Italy and Volkel Air Base in the Netherlands for potential use by the Belgian, German, Italian and Dutch air forces. B61 bombs are also said to be stored at Aviano Air Base in Italy and Incirlik Air Base in Turkey for potential use by American aircraft."[14] The B61 can be set before takeoff for a variety of yields, reportedly ranging from 0.3 kilotons (kT) up to 340 kT, and DCA could be used to attack mobile targets. However, today's DCA are vulnerable to interception by modern integrated air defense systems—a challenge that will be remedied when a DCA variant of the F-35 replaces today's F-15Es and F-16s.

NEW NUCLEAR DELIVERY SYSTEMS SINCE 2010

As this chart (adapted from the 2018 Nuclear Posture Review) illustrates, Russia, China, and even North Korea have fielded a variety of new nuclear capabilities since 2010, whereas the only new U.S. capability deployed has been the F-35 and that is unlikely to be certified for a nuclear role until 2024.[15]

(Data provided by the U.S.DoD)



STRATEGIC VS TACTICAL

It has been said that there is no such thing as a tactical or a non-strategic nuclear weapon because the use of such arms would have strategic consequences. Nonetheless, as Amy Woolf of the Congressional Research Service has noted, "most analysts consider nonstrategic weapons to be shorter-range delivery systems with lower-yield warheads that might be used…on the battlefield."[16] The United States "now has approximately 500 nonstrategic nuclear weapons, with around 200 deployed with aircraft in Europe and the remaining stored in the United States….[meanwhile] Russia still has between 1,000 and 6,000 warheads for nonstrategic nuclear weapons."[17]

RUSSIA

"Russia is in the second half of a decades-long modernization of its strategic and non-strategic nuclear forces…" So begins the 2018 report on Russian nuclear forces from the *Bulletin of the Atomic Scientists*.[18] As the 2018 U.S. Nuclear Posture Review outlines, Russia is engaged in "a comprehensive modernization of its nuclear arsenal. … These efforts include multiple upgrades for every leg of the Russian nuclear triad of strategic bombers, sea-based missiles, and land-based missiles. Russia is also developing at least two new intercontinental range systems, a hypersonic glide vehicle, and a new intercontinental, nuclear-armed, nuclear-powered, undersea autonomous torpedo."[19] Such developments complement and underpin Russia's broader military modernization efforts and its assertive foreign policy. Russia's nuclear modernization and newfound international assertiveness are of great consequence to the United States, because Moscow views the U.S. and its NATO allies as principal threats and impediments to its ambitions for regional hegemony and global influence. As if to highlight this point, President Putin and other high-level Russian officials have in recent years repeatedly rattled their nuclear sabers, rhetorically and through its military doctrine, weapons development and deployment, and military exercises.[20]

DOCTRINE

Russia's doctrine on the use of its nuclear weapons has evolved ostensibly since the end of the Cold War. While the Soviet Union dubiously proclaimed a doctrine of "no first-use" of nuclear weapons during the Cold War, since the early 2000s Moscow has dropped all pretense of abiding by "no first-use." With the 2014 publication of "The Military Doctrine of the Russian Federation," the Kremlin explicitly stated its willingness be the first to cross the nuclear threshold in the event of a conflict. According to the document, Russia reserves the right to use nuclear weapons in the event of a nuclear or weapon of mass destruction (WMD) attack against the Russian state or its allies, or in the event of a large-scale conventional strike that threatens the survivability of the state. Also, a combination of statements by President Putin and senior military officials dating from the early 2000s through 2018 emphasize Russia's reliance on nuclear weapons, especially nonstrategic nuclear weapons, in a variety of circumstances not specifically linked to the survival of the Russian state or in response to WMD attacks against Russia.[21] Russian doctrine emphasizes what many in the West view as the concept of "escalate-to-de-escalate," in which Moscow would make limited use of nuclear weapons to end an impending large-scale conventional attack against the Russian homeland. In sum, Russia's view of nuclear weapons as a foundation for its coercion and for securing national interests across a broad range of crises, coupled with its apparent willingness to use tactical nuclear weapons in a conflict, lowers Moscow's threshold for using nuclear weapons and poses a serious threat to the United States and its interests.

CAPABILITIES

Total Nuclear Weapons	6,850[29]
Deployed Strategic Nuclear Weapons	1,420[30]
Delivery Platforms	517[31]
Non-Strategic Nuclear Warheads	2,000[32]
Strategic Warheads in Storage	922[33]
Nuclear Warheads awaiting Dismantlement	2,500[34]
ICBMs	318 (1138 warheads)[35]
SSBNs	3 Delta-III; 6 Delta-IV; 3 Borei[36]
SRBMs	Unknown
MRBMs	Unknown
IRBMs	Unknown
Heavy Bombers:	60–70[37]

PROLIFERATION OR INTERNATIONAL AGREEMENT VIOLATION?

Russia has developed and fielded a new ground-launched cruise missile, the SSC-8, in direct violation of the 1987 Intermediate Range Nuclear Forces Treaty.[22] Russia is also in violation of the 2002 Open Skies Treaty and the 1991 Presidential Nuclear Initiative, along with multiple treaty regimes and conventions on chemical and biological weapons.[23] Russia has also proliferated missile technology and advanced nuclear fuel technology to a variety of states, including Syria and Iran.[24]

MODERNIZATION

Russia is modernizing all aspects of its nuclear arsenal and delivery platforms as part of a massive overhaul of its military forces. Russia has developed and is now deploying two new ICBM types (road-mobile and silo-based versions of the single-warhead SS-27 Mod 1 or Topol-M, and the multi-warhead SS-27 Mod 2 or Yars, capable of carrying up to four warheads), and will soon begin fielding the enormous Sarmat heavy-ICBM, capable of delivering ten or more warheads, to replace its aging SS-18s. Russia is also fielding the relatively new (2007) four-warhead Bulava SLBM on Russia's Delta-IV SSBNs, and upgraded, six-warhead versions of the Bulava SLBM on its new Borei-class SSBNs. Russia has deployed modernized versions of its Tu-160 and Tu-95MS heavy bombers, as well as a new type of cruise missile, and has announced plans to reopen the Tu-95 production line.[25]

Russia has announced plans for a new fifth-generation SSBN capable of fielding both cruise and ballistic missiles, a hypersonic delivery vehicle (Avangard), a nuclear-powered, multi-megaton, autonomous undersea vehicle (Canyon), and a next-generation strategic bomber (designated PAK-DA) with the future potential to field a recently tested nuclear-powered hypersonic cruise missile.[26]

These developments are in keeping with Russia's expansion of the number of warheads that each platform can field while remaining within the New START treaty limits.[27] In sum, "Russia envisages and prepares for aggression against neighbors to revise post-Cold War boundaries and spheres of influence while deterring any effective NATO response, including with nuclear first-use threats."[28]

CHINA

Since its first test of a nuclear weapon in 1964, China has pursued the creation of a nuclear weapons arsenal with much more hesitation than either the United States or Russia. China has only fielded a few hundred nuclear warheads, and has traditionally placed much more emphasis on advancing the capability of its conventional military forces. However, over the past decade, China has undertaken an extensive – and still ongoing – modernization of its nuclear arsenal. China is developing and testing new warheads as well as new technology for nuclear delivery platforms. As China's global footprint and international interests have grown, its military modernization program has become more focused on supporting missions beyond China's periphery and expanding its power projection capabilities.[38] Thus, while the United States has been drawing down its nuclear weapons, China has committed to increasing the size and capabilities of its own arsenal.

DOCTRINE

"China's 2015 defense white paper states that 'China has always pursued the policy of no first use of nuclear weapons and adhered to a…nuclear strategy that is defensive in nature.'"[39] Thus far, nuclear weapons have played a limited role in China's concept of deterrence; they have been viewed as necessary to deter nuclear attacks and nuclear coercion, but not aggression using conventional military forces:[40] "Chinese nuclear deterrence cannot be used to deter hostile nonnuclear military action, and its function in other non-nuclear military fields is not obvious."[41] However, recent events, including the deployment of new nuclear-armed cruise missiles, new ballistic missiles and new ballistic missile submarines, demonstrate that Beijing sees nuclear forces as more and more vital to its national security, and is placing greater emphasis on the strength of its nuclear deterrent.[42] Significantly, China does not distinguish between deterrence and compellence, thus leading Beijing to perceive all nuclear threats, including those intended to deter Chinese aggression, as coercive and potentially offensive in nature.[43] (Whereas deterrence is akin to defense and involves a threat to use force if an adversary takes an unwanted action that changes the status quo, compellence is akin to offense and involves a threat to use force to get an adversary to take some action that changes the immediate status quo – e.g., the U.S. threat to use force if the Soviets did not withdraw their nuclear missiles from Cuba during the Cuban Missile Crisis, or the U.S. threat to use force if Saddam Hussein did not withdraw his troops from Kuwait in 1991.)

CAPABILITIES

Total Nuclear War Heads	280[49]
Nuclear Capable Land Ballistic Missiles	121[50]
Silo-based ICBMs	20 (liquid fueled DF-5s; range 13,000km)[51]
Road Mobile ICBMs	50 (DF-31, DF-31A, or DF-31AG)[52]
ICMBs	75-100[53]
SSBNs	4(Type 094/Jin-class)[54]
SLBMs	48 (JL-2; range 7,000km)[55]
GLCMs (dual capable)	Unkown qty. (DH-10)
SRBMs (dual capable)	Unkown qty. (DF-15)
MRBMs (dual capable)	Unkown qty. (DF-21)
IRBMs (dual capable)	Unkown qty. (DF-26)
Bombers (dual capable)	20 (H-6)[56]

PROLIFERATION OR INTERNATIONAL AGREEMENT VIOLATION?

China became a member of the International Atomic Energy Agency (IAEA) in 1984 and joined the NPT in 1992 after the end of the Cold War. Like Washington, Beijing has signed but not ratified the Comprehensive Nuclear-Test-Ban Treaty (CTBT), and has not conducted an overt nuclear test since 1996. However, China has repeatedly been a proliferator of missile and nuclear technology to states such as Pakistan, Iran, North Korea, and Saudi Arabia, and has been sanctioned multiple times for violation of the Iran, North Korea, and Syria Nonproliferation Act.[44]

MODERNIZATION

China is increasing the size of its nuclear arsenal and the capabilities of its nuclear delivery systems. The Chinese military is enhancing its ICBMs, phasing out older, silo-based, liquid-fueled missiles, such as the DF-5, in favor of road-mobile, solid-fueled missiles, such as the DF-31 family of ICBMs. China is also completing development of and is expected to field the new road-mobile DF-41 ICBM, purportedly with advanced MIRV capabilities and an estimated range of 12,000-15,000 km, thus vastly increasing the number of nuclear weapons with which it could threaten all of the United States.[45] China's shift to road-mobile systems improves their survivability and the shift to solid-fueled missiles enables higher readiness, reduces maintenance, and shortens the time to launch. China is expanding its sea-based nuclear capability through the continued development of the Type 0-96 SSBN that will carry a new JL-3 SLBM and is expected to be fielded in the next decade.[46] According to DoD, China's People's Liberation Army (PLA) is "developing two new air-launched ballistic missiles, one of which may include a nuclear payload."[47] It is likewise testing a new hypersonic delivery vehicle, which could allow Chinese nuclear weapons to outmaneuver U.S. ballistic missile defense systems. China is expected to field a new stealth strategic bomber, designated the H-20, as well.[48]

NORTH KOREA

North Korea has conducted six nuclear tests: once in 2006, 2009, and 2013, twice in 2016, and once again in 2017. North Korea's history of belligerent threats and its arsenal of weapons of mass destruction, including chemical, biological, and nuclear weapons, pose a growing menace to the safety and security of the U.S. homeland and to American forces and allies in northeast Asia. A hiatus in nuclear and ballistic missile testing has followed a summer 2018 summit between President Trump and North Korean leader Kim Jung Un, but to date North Korea has not made meaningful steps toward the denuclearization of the Korean peninsula.

DOCTRINE

North Korea has stated repeatedly that it will use its nuclear weapons to strike Western targets, specifically the United States, if it is attacked or threatened. Given such statements and Pyongyang's emphasis on survivable, mobile, long-range ballistic missiles, the U.S. Defense Intelligence Agency assesses a "potential for usage [of nuclear weapons] at any stage of conflict when North Korea believes itself to be in regime-ending danger."[57] In the summer of 2017, the Congressionally established Commission to Assess the Threat to the United States from Electromagnetic Pulse (EMP) Attack (commonly known as the EMP Commission) warned that Pyongyang's preferred option for using its relatively small nuclear arsenal could well be to launch a crippling EMP attack against the United States.[58]

CAPABILITIES

As of the beginning of 2018, North Korea was thought to have enough fissile material for 30-60 nuclear weapons and to have assembled as many as 20 warheads.[59] North Korea deploys a wide variety of ballistic missile types, including Musudan IRBMs (range 3,000+ km) and an unknown quantity of Taepo Dong-2 ICBMs (range 12,000+ km).[60] On July 4 and 28, 2017, North Korea successfully tested a kind of ICBM missile called the Hwasong-14. The Hwasong-14 has a range of more than 10,000 km, which would put the western half of the United States within its range.[61] In November 2017, North Korea successfully tested the 13,000 km-range Hwasong-15, which is capable of striking anywhere in the United States.[62] The EMP Commission noted that North Korea could use satellites, like its polar-orbiting KMS-3 and KMS-4, which routinely pass over the United States, to deliver a nuclear EMP attack.[63]

PROLIFERATION

North Korea is one of the world's most prolific exporters of missile technology, nuclear weapons know-how, and ballistic missiles. In the past, North Korea is known to have exported missiles and missile technology to Iran, Libya, Yemen, Syria, and Iraq.

MODERNIZATION

In 2016, North Korea successfully tested a solid-fueled submarine-launched ballistic missile with a range of 1,200 km. In 2017, the North successfully conducted three ICBM tests and detonated a device with a yield reported to be in excess of 100 kilotons of TNT, which Pyongyang claimed was a hydrogen bomb.

IRAN

Iran has come under international sanctions repeatedly for its development of a covert nuclear program in violation of its obligations as a member of the NPT. In November 2011, the Director General of the IAEA issued a report highlighting evidence that Iran's work in this arena was designed to produce nuclear weapons.[64] In July 2015, Iran and the P-5+1 nations (the five permanent members of the UN Security Council, plus Germany) concluded the Joint Comprehensive Plan of Action, or JCPOA, in an effort to limit Iran's potential to develop nuclear weapons. This arrangement appears to have had at least a nominal effect; according to U.S. intelligence community, "Iran's implementation of the JCPOA has extended the amount of time Iran would need to produce enough fissile material for a nuclear weapon from a few months to about one year."[65] However, the revolutionary nature of the regime in Tehran, the prior existence of covert Iranian nuclear programs, evidence of Iran's work on a nuclear warhead, and Iran's continued development of ballistic and cruise missile technology, have all perpetuated the threat Iran poses to the security of its neighbors and to that of the United States.

DOCTRINE

Iran does not currently possess nuclear weapons, and therefore does not have an established doctrine for the use of such weapons. However, Iranian military writings highlight the potential for EMP attacks against the United States and other Western societies highly dependent on information technology.[66]

CAPABILITIES

Iran has the largest, most active, missile program in the Middle East, and continues to develop and field ever more capable and longer-range missiles. Moreover, Iran has a latent nuclear weapons program and possesses the technology to produce a bomb. Tehran's major impediment for obtaining a nuclear weapon has been its lack of weapons-grade fissile material.

PROLIFERATION

Iran was repeatedly caught with secret, undeclared nuclear facilities and openly flouted UNSCRs designed to curb its nuclear and missile programs. It has also engaged in illicit ballistic missile cooperation with North Korea,[67] and most recently has been caught shipping weapons to rebel groups in Yemen and Afghanistan in violation of United Nations Security Council resolutions.[68]

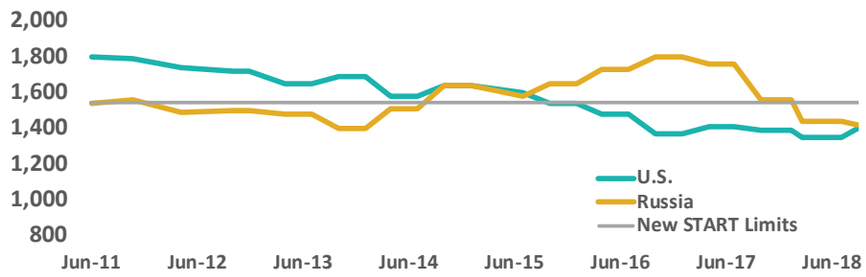
MODERNIZATION

The most worrisome near-term aspect of Iran's modernization is its missiles, many of which can carry nuclear warheads. Iran continues to test and develop new ballistic missile technology, including an apparently successful test on November 30, 2018 of its new two-stage, liquid-propellant Khorramshahr MRBM (2,000 km). The Khorramshahr is credited with being much more accurate than earlier Iranian MRBMs and is reported to be capable of carrying multiple warheads. The U.S. intelligence community has also expressed concerns over Iran's tests of new liquid-fueled space launch vehicles (SLVs)—the Safir and the Simorgh—whose technology could "shorten the pathway to an ICBM because space launch vehicles use similar technologies."[69]

WHY THE U.S. SHOULD MODERNIZE

Given today's complex threat environment, a return to Great Power competition in the international system, and the inherent unpredictability of the future, it is imperative that the United States modernize its nuclear arsenal and do so in a responsible fashion. The early optimism regarding Great Power peace and stability visible in the early years of the Obama administration has evaporated in recent years as a result of Russian and Chinese behavior. While the United States endeavored to lead by example in reducing the role and numbers of nuclear weapons in U.S. national security, other nuclear powers moved in the opposite direction, expanding their nuclear weapons capabilities and highlighting the importance of their nuclear weapons. These realities have progressively led the U.S. government to recognize the need to maintain an effective nuclear weapons force, retain all three legs of the triad, and modernize America's nuclear weapons capabilities. The nuclear command, control and communications systems (NC3) needed to operate America's deterrent forces were last updated under President Reagan and are likewise in desperate need of modernization.

NEW START WEAPON COMPARISON[70]



While both the United States and Russia are within New START treaty limits, the chart depicts how the United States has demonstrated its commitment to reducing the number of deployed warheads. The higher Russian numbers almost certainly reflect Russia's years of nuclear force modernization and continuing deployment of new systems, before a recent return to treaty limits.

THE DANGER OF A DECLINING NUCLEAR CAPABLE WORKFORCE

Since shortly after the end of the Cold War – that is, for more than two-and-a-half decades – there has been no new U.S. nuclear weapons development program, no nuclear weapons tests, and no new programs to develop weapons delivery systems for the strategic nuclear triad. As a result, real doubt now exists whether the nuclear weapons infrastructure and the skilled human capital needed to operate it are sufficient to remain effective.[71] Over a decade ago, the Defense Science Board warned that: "The skills that are being exercised today for nuclear-capable deterrent forces are almost exclusively related to the less demanding sustainment of the systems first deployed many years ago: Minuteman III, Trident D5, B-52, B-2, [and the] air-launched cruise missile (ALCM)..."[72] Since then, little if anything has been done to stop this decline in skills. The lack of significant, continuous experience regarding the ICBM leg of the triad is of particular concern, presenting a situation where design and system engineering skills could well disappear in the near future if critical expertise is not passed from the retiring generation to the next.

> "Today's nuclear weapons have aged well beyond their originally planned lifetime."[73]
>
> – 2010 Nuclear Posture Review

> "This capacity to prevent catastrophic conflict has been unprecedented throughout modern history, and highlights the stabilizing influence of America's nuclear arsenal. However, our ability to continue to provide strategic stability depends upon the modernization of our nuclear enterprise. Sustainment alone will not meet future adversarial threats. We simply must modernize."[74]
>
> —Admiral C. D. Haney, Commander of U.S. Strategic Command, July 14, 2016

U.S. NUCLEAR ARSENAL DEFICIENCIES

Without modernization, America's nuclear delivery systems (including its ICBMs, SSBNs, and bombers) become increasingly difficult to maintain and of dubious reliability, thereby undermining American deterrence.

WEAPONS AND INFRASTRUCTURE

- Maintaining a safe, reliable, and secure stockpile of weapons is crucial to U.S. deterrence credibility.
- "The last new, modern warhead development program (the W88) was completed by the early 1990s."[75]
- The W80 warhead carried by the current Air Launched Cruise Missile (ALCM) must be refurbished so that it can be placed on the forthcoming LRSO missile.
- The warheads carried by the current ICBM force must be refurbished so that they can be placed on the Ground Based Strategic Deterrent (GBSD) missile system.
- "Over half of NNSA's [National Nuclear Security Administration] infrastructure is over 40 years old, and a quarter dates back to the Manhattan Project era."[76]
- Due to the age of its facilities, the NNSA currently lacks the capacity to process nuclear material in quantities sufficient to ensure it can extend the life of the warheads needed for the various nuclear delivery systems.

2 INTER-CONTINENTAL BALLISTIC MISSILE SYSTEMS (ICBM)

- Current Minuteman III ICBMs have been in service for nearly 50 years.
- It is cheaper to provide a new alternative than attempt to extend further the life of U.S. ICBMs.
- Missile command modules are also in serious need of modernization.

3 STRATEGIC BOMBER AIRCRAFT

- The newest B-52s, which remain the backbone of the U.S. nuclear bomber fleet, were completed in 1962.
- New planes that can evade adversaries' modern air defenses and reach their targets are needed for conventional as well as nuclear missions.
- New long-range cruise missiles that can penetrate advanced air defenses are also needed to replace existing air-launched cruise missiles (ALCMs) that are 25 years beyond their design life.

4 BALLISTIC MISSILE SUBMARINE (SSBN)

- Current nuclear missile submarines are reaching the end of their lives after an extension from the originally planned 30-year life to one of 42 years.
- Any delay in replacements will lead to gaps in deterrent patrols by the most survivable leg of the triad.

5 NUCLEAR COMMAND, CONTROL, AND COMMUNICATION (NC3)

- "The NC3 architecture received its last major upgrade in the 1980s."[77]
- These "vintage" systems have become difficult to operate and maintain.[78]
- The legacy NC3 systems—which include floppy disks and vacuum tubes—cannot be expected to operate with modern computer and communication systems associated with the latest satellites, radar, command posts, and weapons delivery systems.

CURRENT MODERNIZATION PLAN

CURRENT SYSTEMS

- 14 Ohio class submarines – reach end of 42-year service life beginning in 2027 with last boat retiring in 2040.[79]
- Each boat contains 24 missile tubes, but under New START only 20 tubes contain missiles.[80]
- Each Trident II D5 missile can be armed with up to eight warheads (100 kiloton W76 (vast majority) or 455 kiloton W88), but under New START limits they are currently loaded on average with four to five warheads.[81]
- Funding for Trident II D5 missile life extension began in FY2010, and will extend the life of those missiles to 2042.
- Refurbishment of roughly 1,600 W76 warheads—designated the W76-1—for the Trident II (D5) SLBM was completed in early 2019.[82]

CURRENT SYSTEMS

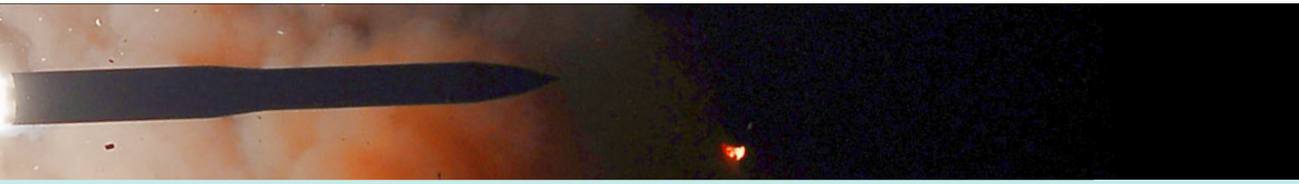
- 400 silo-based Minuteman III missiles, each capable of carrying up to three independently targetable W78 warheads or one W-87 warhead.[83] However, all have been limited to a single warhead.
- 450 hardened underground launch silos and command capsules are deployed across sparsely populated regions of Colorado, Wyoming, Nebraska, Montana, and North Dakota.
- In 2015, the Minuteman III missiles completed a $6-7 billion life extension program to keep them viable until 2030.[84]

BALLISTIC MISSILE SUBMARINES / SUBMARINE LAUNCHED BALLISTIC MISSILES

REPLACEMENT SYSTEMS

- A minimum of 12 Columbia class SSBNs with a program cost of $102.1 billion (in constant FY2018 dollars) over the next several decades.[85]
- Funding for the first Columbia class boat is scheduled for 2021, for the second in 2024, and roughly one per year thereafter, with the first boat expected to become operational in FY2027, second in FY2030, then roughly one per year from FY2032 thru FY2041.[86]
- The United Kingdom is fielding a new Dreadnought-class SSBNs that will use a common missile compartment that is being designed for the U.S. Columbia-class SSBNs; the British Navy will continue to carry U.S. built Trident II ballistic missiles armed with British nuclear warheads.
- The 2018 NPR called for fielding low-yield warheads on some Trident missiles as a near-term response to Russia's apparent perception of a gap in America's ability to respond to Russian low-yield weapons.
- The 2018 NPR also called for a longer-term response of a new nuclear sea-launched cruise missile.

INTERCONTINENTAL BALLISTIC MISSILE (ICBM)

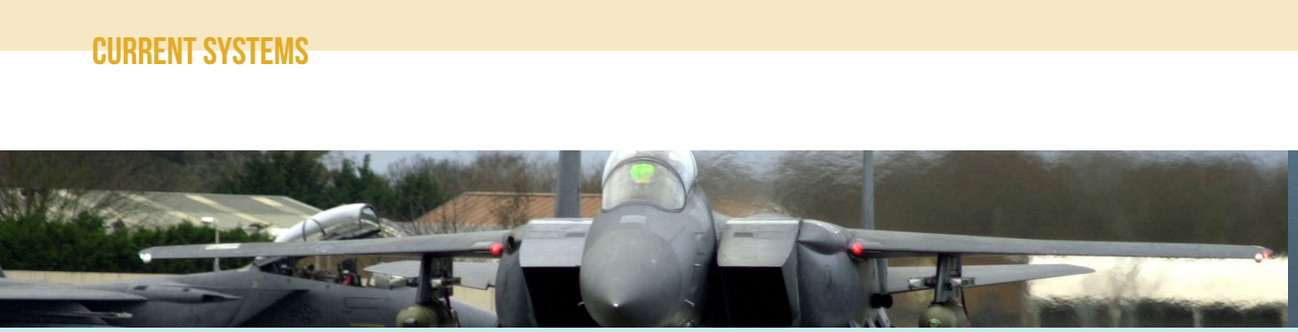


REPLACEMENT SYSTEMS

- As early as May 2010, the Obama administration—like every previous administration since that of JFK, and in keeping the recommendations of the Congressionally mandated, bipartisan Strategic Posture Commission of 2009—committed to retaining the strategic nuclear triad, including finding a replacement for the Minuteman ICBM.[87]
- Development of the next-generation ICBM, the Ground Based Strategic Deterrent (GBSD), has begun and the new missile is scheduled to replace the Minuteman III in 2029–2036.[88]
- In all, 642 missiles are expected to be purchased for a total cost of $85 billion.[89] Four hundred are slated for deployment, with the remaining 242 to be used as spares and for test flights.
- The anticipated lifespan for the new missile is 60 years, with 400 missiles deployed in 450 existing Minuteman silos with newly refurbished launch control facilities.[90]

CURRENT MODERNIZATION PLAN

- 66 nuclear capable B-52 Hs are based at Minot AFB, North Dakota and Barksdale AFB, Louisiana (approximately 40-46 are assigned to nuclear missions on any given day).[91]
- The B-52 is equipped with the Air Launched Cruise Missile (ALCM), which itself is increasingly vulnerable to modern air defenses and is slated for retirement in 2030.[92]
- 20 nuclear capable B-2s based at Whiteman AFB, Missouri, with perhaps 16 assigned to the nuclear mission day-to-day; the Air Force plans to retire the B-2 by 2040.[93]
- Under New START, the United States counts 60 heavy bombers (some combination of B-2s and B-52s) as deployed.
- There are approximately 450 B61-7, B-61-11, and B83 nuclear bombs for delivery by the B-2, which is **not** capable of carrying the ALCM.



- Certain F-15E and F-16C/D fighter aircraft are dual capable, meaning they are certified for delivery of nuclear weapons, specifically the B61-3, -4, and -11 gravity bombs, as well as conventional weapons.
- The *Bulletin of the Atomic Scientist* reports the yields of older B61s as being variable (selected on the ground before takeoff) between 0.3-45 kilotons (kT) for the B61-4, and 0.3-170 kT for the B61-3.
- Several of America's NATO allies, including Belgium, Germany, Italy, and the Netherlands maintain dual-capable aircraft (the Germans' and Italians' DCA aircraft is the PA200 Tornado, Belgium and the Netherlands fly the F-16) and can deliver the U.S. B61 nuclear gravity bomb.
- The United States reportedly maintains approximately 300 "tactical" variants of the B61, with "160-200 bombs [deployed] at six bases in Belgium, Germany, Italy, the Netherlands, and Turkey."[94]

CURRENT SYSTEMS

STRATEGIC BOMBERS

- The Air Force intends to buy at least 100 B-21 Raiders, formerly called the Long-Range Strike Bomber.[95]
- The first B-21s are expected to reach Initial Operating Capability (IOC) in the late 2020s, and nuclear certification should come two years after IOC. The last B-21s are expected to be fielded in the late 2030s.[96]
- The total program cost for 100 B-21s is approximately $80 billion (2015 estimate).[97]
- The B-21 will be equipped to carry the B61-12 and B83 nuclear gravity bombs and a new cruise missile, the Long-Range Stand Off (LRSO), which will replace the retiring ALCM.[98]
- The B61-12 gravity bomb is a more accurate, life-extended version of the B61 nuclear bomb, the oldest nuclear weapon in the U.S. inventory. The B61-12 overall program cost is $8.25 billion (reportedly for 480 bombs); the first B61-12 is scheduled for delivery in 2020 with program completion in FY2024.[99]
- The nuclear ALCM will be replaced by the LRSO cruise missile. The LRSO will be usable by the B-52H, B-2, and B-21. The Air Force plans to buy 1,000-1,100 missiles at a cost of $10.8 billion.[100]

REPLACEMENT SYSTEMS

DUAL CAPABLE AIRCRAFT (DCA)

- Some F-35s Block 4 aircraft will be certified to perform nuclear missions starting in FY2024, and will eventually replace the dual capable F-15Es and F-16C/Ds.[101]
- The F-35 will employ the B61-12 nuclear gravity bomb, which will replace the older B61-3, -4, -7, -10, and -11 variants of the bomb between FY2020 and FY2024. The B61-12 will reportedly have a variable yield with a maximum of 50kT; this lower maximum yield will be offset by the bomb's greater accuracy, allowing it to achieve the same or improved mission effectiveness.[102]
- America's NATO allies are also purchasing the F-35, and Belgium, Italy and the Netherlands are likely to use it to replace their F-16 dual-capable aircraft. Germany has yet to decide on a replacement for the Tornado, although the German Air Force is said to favor the F-35 as its new DCA platform.

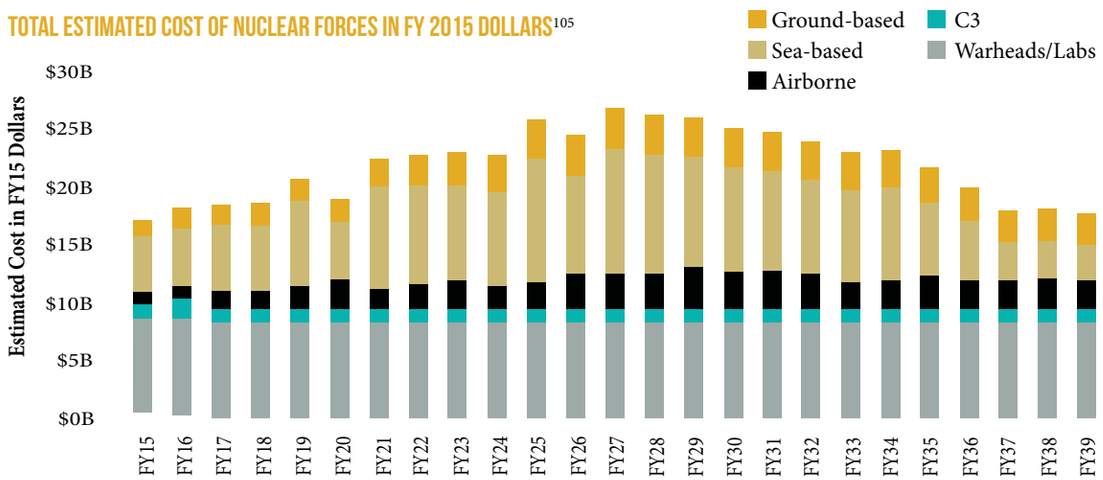
REPLACEMENT SYSTEMS

FUNDING U.S. NUCLEAR FORCE MODERNIZATION

Estimates of the cost to modernize the U.S. nuclear triad range from $300 billion to over $1 trillion. Some of these cost projections look 10 years into the future, while others look ahead three decades. Some estimates include the full cost of systems such as the B-21 Raider, even though the U.S. Air Force originally planned to build it as a new generation bomber for conventional missions.

The figure below shows a cost estimate from a 2015 report by the Center for Strategic and Budgetary Assessments (CSBA) that depicts categories of nuclear spending across a 25-year period. Here, spending can be seen to increase until around FY 2027, before gradually tapering off. While tens of billions of dollars is a lot of money in absolute terms, the spending depicted below peaks at 6.4 percent of the current DoD budget, approximately half of what DoD spends on healthcare each year and less than one percent of the current federal budget.[103] As the 2018 NPR stated, between two and three percent of the DoD budget today goes toward operating, maintaining, and sustaining existing nuclear forces, and the program of record to modernize nuclear forces will peak at around an additional four percent of the current DoD budget.[104] This is surprisingly affordable, given that nuclear deterrence is DoD's number-one priority mission and the fact that, after a decades long acquisition holiday, the United States must now replace all three legs of the nuclear triad simultaneously.

TOTAL ESTIMATED COST OF NUCLEAR FORCES IN FY 2015 DOLLARS[105]



Funding the nuclear modernization program of record established under President Obama and continued under President Trump is clearly a matter of prioritization, rather than affordability. As recommended in the same CSBA report cited above, a gradual increase of the overall defense budget by less than two percent above the BCA caps over the next decade, making cuts elsewhere in the budget, or some combination of the two would be enough to fund this effort.[106]

> "Maintaining an effective nuclear deterrent is much less expensive than fighting a war that we were unable to deter. Maintenance costs for today's nuclear deterrent are approximately three percent of the annual defense budget. Additional funding of another three to four percent, over more than a decade, will be required to replace these aging systems. This is a top priority of the Department of Defense."[107]
>
> — Secretary of Defense James N. Mattis, Nuclear Posture Review 2018

DEBATING U.S. NUCLEAR MODERNIZATION

COSTLY VS AFFORDABLE

- Defense budgets are already high and spending $1.2 trillion on nuclear modernization is simply unaffordable.

- U.S. nuclear weapons are the foundation of the rules-based international order the United States helped establish and has led since the end of the Second World War—to the enormous benefit of the the global community. At the height of planned spending on the existing nuclear modernization program of record, DoD's spending will increase from approximately three percent of the defense budget to a maximum of 6.4 percent, - still well below one percent of the federal budget.[108] In fact, eliminating all U.S. nuclear weapons would do next to nothing to reduce federal budget deficits. Given the importance of nuclear weapons in underpinning America's interests in the world, they are eminently affordable.

UNECESSARY AND REDUNDANT VS NECESSARY AND COMPLIMENTARY

- U.S. nuclear weapons are politically and militarily useless, especially in light of America's pronounced conventional military superiority. With U.S. SSBNs to ensure a survivable second-strike capability, there is no need to maintain a triad of nuclear delivery systems. Replacing the aging ALCM with the new LRSO is unnecessary given that the B-2 and future B-21 aircraft are sufficiently stealthy to penetrate sophisticated air defenses and deliver nuclear gravity bombs.[109]

- U.S. nuclear weapons are used every day to deter major power competitors from acting against U.S. national interests, and they are essential for deterring nuclear attacks against the United States and its allies. While America's formidable conventional military capabilities contribute to deterrence, the 2018 NPR correctly notes that U.S. nuclear weapons are "unique and essential to preventing adversary nuclear attacks, which is the highest priority of the United States." Furthermore, while "U.S. nuclear capabilities cannot prevent all conflict, and should not be expected to do so… they contribute uniquely to the deterrence of both nuclear and non-nuclear aggression."[110]

- Each leg of the U.S. nuclear triad plays a vital role in deterrence and in complicating an adversary's plans for nuclear aggression against the United States. Absent the ICBM leg of the triad, an adversary could eliminate the bulk of America's nuclear forces by hitting just three bomber bases and two SSBN bases. Although U.S. SSBNs at sea would survive, the U.S. president would likely be deterred from using the surviving 200-400 SLBMs to retaliate against an adversary with an equal or far greater number of nuclear weapons who could hold U.S. cities at risk. Several hundred ICBMs spread across the U.S. heartland in hardened launch sites force adversary planners to commit more than one warhead against each U.S. ICBM silo (a total of at least 900 warheads) in any attempt at a disarming first strike. Currently, only Russia is known to have a nuclear force large enough to attempt such a disarming nuclear first strike, and Russia appears intent on expanding that capability. U.S. ICBMs comprise the most responsive leg of the triad and could be launched in retaliation before inbound adversary weapons arrived on target. Because of the high state of readiness of U.S. ICBMs, their dispersed and hardened basing across the U.S. heartland, and their significant numbers, they make a disarming first strike all but impossible and a devastating retaliation inevitable, thereby serving as a powerful, stabilizing deterrent.

- Penetrating stealth bombers provide a U.S. president with valuable options in conventional as well as nuclear conflicts. But stealth bombers are neither invisible nor invulnerable. Indeed, once they open their bomb-bay doors to release a weapon, they reveal their presence, making sequential attacks against multiple targets extremely dangerous when operating against sophisticated enemy air defenses. Cruise missiles enable a single bomber to launch near simultaneous attacks against multiple targets deep inside enemy airspace. Moreover, the United States will continue to depend on the completely non-stealthy B-52H bomber as a workhorse of the airborne leg of its triad for decades to come—well beyond the viable lifespan of the ALCM.

DESTABILIZING VS STABILIZING

- (Arms Race) U.S. nuclear modernization will only provoke Russia and China to build more nuclear weapons, thereby triggering an expensive, destabilizing arms race. (Hair Trigger Alert) The new GBSD will only perpetuate a dangerous state of "hair-trigger" alert, and with it the threat of accidental or unauthorized launches that could initiate a massive nuclear exchange with Russia or China. (LRSO – Nuclear-Conventional Confusion) The LRSO is destabilizing because adversaries would not know until detonation whether they were under conventional or nuclear attack. Thus, they might respond to a conventional LRSO attack by launching their own nuclear weapons. (Low-Yield and Lower Threshold) Lower-yield weapons, such as the low-yield Trident and sea-launched cruise missile called for in the 2018 NPR, would cause less collateral damage, including fallout, and thus a U.S. president would be more likely to use them. Moreover a U.S. attack with low-yield Trident missiles could be mistaken for an attack with the higher-yield warheads and could elicit a devastating response.

- Former Secretary of Defense Ashton Carter noted that there may already be a nuclear arms race, but the United States is not in it, and in fact the buildup of nuclear arms by others occurred despite a 25-year hiatus in U.S. investment in nuclear arms.[111] For more than a decade, Russia and China have been modernizing and building up their nuclear forces, fielding new systems with new capabilities and highlighting the salience of nuclear weapons in their foreign and military policies. Meanwhile, the United States has been nursing along systems designed and deployed during the Cold War. Failing to modernize now will increasingly lead America's adversaries and allies, as well as U.S. political and military leaders themselves, to question U.S. nuclear deterrent capabilities.

That is, failing to modernize will be destabilizing, whereas modernizing will reestablish and reinforce stability.

- The term "hair trigger" is grossly misleading, and probably intentionally used to mislead. A hair trigger connotes a weapon that will fire at the slightest provocation, perhaps even unintentionally. It is difficult to imagine a less apt description of U.S. presidential control over the use of nuclear weapons. While U.S. nuclear weapons, especially ICBMs, can be held at a high state of readiness and can respond to launch orders within minutes, they are subject to strict and elaborate controls developed over decades that defy unauthorized use. Even if an ICBM could somehow be accidentally launched, a vanishingly small possibility, it would fly to an open-ocean region thanks to a 1994 U.S.-Russian de-targeting agreement.[112]

- Russia's nuclear weapons development, specifically its development of very-low-yield nuclear weapons, and its doctrine, deployments, and exercises, suggest that Russian leaders perceive a gap in U.S. nuclear deterrence capabilities that they could exploit by using low-yield nuclear weapons without eliciting a nuclear response from the United States. The 2018 NPR's call for additional low-yield capabilities (low-yield Trident SLBM warhead and a new sea-launched cruise missile) are an attempt to reestablish credible U.S. nuclear retaliatory capabilities – capabilities that dual-capable aircraft increasingly lack due to their questionable survivability in the face of Russia's sophisticated air defenses. Far from lowering the threshold for nuclear use, these new capabilities would significantly enhance the credibility of U.S. deterrent threats and thereby raise the threshold against Russia's use of low-yield weapons. U.S. nuclear retaliatory attacks would be designed to be distinguishable by Russia as limited, and there is no reason to expect that Russia would respond by committing nuclear suicide. In short, the new low-yield options proposed in the 2018 NPR are meant to address Russian developments and restore a stable deterrent situation in place of one where Russia perceives an opportunity to get away with nuclear first use.

VIOLATES NPT VS SUPPORTS NONPROLIFERATION

- Building new nuclear warheads and delivery systems violates the U.S. NPT commitment of nuclear disarmament and would reverse progress toward a world free of nuclear weapons.

- The 1968 Treaty on the Non-Proliferation of Nuclear Weapons, more commonly known as the Non-Proliferation Treaty, or NPT for short, is, as its name suggests, a treaty to prevent nuclear proliferation. Notwithstanding the treaty's aspirational Article VI, which says, "Each of the Parties to the Treaty undertakes to pursue negotiations in good faith on… nuclear disarmament" ("and on a treaty on general and complete disarmament under strict international control"), it is not an arrangement for nuclear disarmament, much less one of unilateral disarmament. The United States has gone a long way toward meeting its obligations under Article VI, by negotiating in good faith to end the arms race and by reducing U.S. nuclear forces by 85 percent since signing the NPT. However, further U.S. nuclear reductions and/or a failure to modernize U.S. nuclear forces, given the current strategic environment, would gravely undermine U.S. extended deterrence guarantees and thereby increase pressures on America's allies and friends to acquire their own nuclear arsenals. Thus, U.S. nuclear modernization actually supports nuclear nonproliferation.

"I am confident that we will continue to meet the challenges of the dynamic security environment. This includes ensuring the continued credibility of the U.S. nuclear deterrent, which backstops all U.S. military and diplomatic operations across the globe and helps ensure that tensions with Russia—no matter where or how they arise—do not escalate into large-scale war."[113]

– General Scaparrotti, the U.S. European Command Commander & Supreme Allied Commander Europe, March 5, 2019

RECOMMENDATIONS

ADDRESS ADVERSARY NUCLEAR WEAPON MODERNIZATION

The initial optimism that led President Obama to make non-proliferation and the prevention of nuclear terrorism the priorities of his administration's 2010 Nuclear Posture Review (NPR) has given way to a recognition of great power competition in which Russia and China seek to subvert the U.S.-led, rules-based international order. Russia's and China's revisionist actions, nuclear modernization, and nuclear saber rattling, combined with the continued nuclear ambitions of North Korea (and possibly those of Iran), has necessitated a reprioritization of U.S. nuclear policy toward deterrence of potential adversaries and assurance of allies and partners, as reflected in the 2018 NPR. Effective U.S. deterrence and assurance today, and especially in the years to come will, hinge on U.S. nuclear modernization.

REINFORCE THE NUCLEAR TRIAD

U.S. nuclear modernization should, first and foremost, continue to fund and execute the program of record to modernize all three legs of the nuclear triad, which was established with bipartisan support under the Obama administration and has continued under the Trump administration. That is, the administration and Congress should continue their support for the Columbia-class SSBN and associated Trident life extension programs, the Ground-Based Strategic Deterrent (GBSD) ICBM to replace the Minuteman III and refurbishment of 450 launch facilities, the B-21 Raider and the Long-Range Stand-Off (LRSO) cruise missile. In addition, the administration and Congress should continue their bipartisan support for existing NNSA warhead and infrastructure programs, DoD life extensions and nuclear command, control, and communications enhancements.

CLOSING THE CAPABILITY GAP

To bolster the credibility of U.S. deterrent threats and assurance guarantees, and to disabuse potential adversaries, especially Russia, of the notion that there is an exploitable gap in U.S. deterrent capabilities, the administration and Congress should support the two additional low-yield capabilities called for in the 2018 NPR. That is, Congress should specifically authorize DoD to modify some Trident warheads to give them a low-yield option, and should appropriate funds for a new sea-based cruise missile.

HOLD TREATY PARTICIPANTS ACCOUNTABLE

The Trump administration should change the way it talks about the end of the INF Treaty, and refrain from using the expression "U.S. withdrawal from the treaty." The INF Treaty has been rendered moot by longstanding Russian violations. The administration should describe the situation as one in which the INF is no longer in effect as a result of Russia's repeated and prolonged violations of the treaty.

KEEP OPEN THE OPTION TO FIELD INF-RANGE SYSTEMS

The administration and Congress should continue support for research and development of new INF-range systems capable of carrying both nuclear and conventional payloads, and prepare the ground for the rapid fielding of such systems should that become necessary or desirable. In addition to serving as a response to Russian violations of the INF treaty, new U.S. systems with ranges between 500-5,500 kilometers are likely to be valuable in the Indo-Pacific region; China, having never been a party to the INF treaty, has fielded nuclear and conventional missile systems barred to the United States and Russia under the INF, which new American capabilities would be able to counter.

PURSUE HYPERSONIC PLATFORMS

Finally, the United States should take note of Russia's and China's advances in hypersonic technology and actively develop its own offensive hypersonic systems, as well as defenses against emerging foreign hypersonic threats.

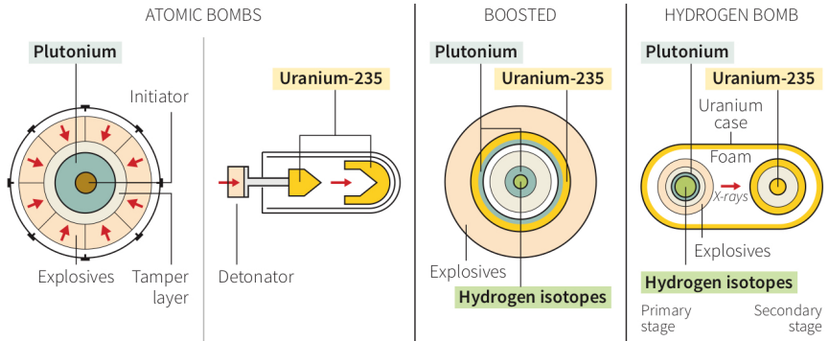
APPENDIX

WHAT IS A NUCLEAR WEAPON?

Generally speaking, there are two types of nuclear weapons: 1) fission devices, and 2) thermonuclear devices that employ a combination of fission and fusion. The fission detonation process consists of splitting atoms of heavy elements (uranium or plutonium) to release large amounts of energy, while the more complicated devices employing fusion cause two or more smaller atomic nuclei (from isotopes of hydrogen) to combine into a larger one (helium), thereby releasing even higher amounts of energy per instance of fusion than occurs with fission and significantly increasing the amount of bomb material that undergoes fission.

Fission chain reactions in nuclear weapons use one of two isotopes: uranium-235 or plutonium-239. Nuclear weapons explode with power measured in tons of TNT equivalent. Fission bombs, sometimes called atomic bombs or A-bombs, can produce yields measured in the tens of thousands of tons of TNT equivalent or kilotons (e.g., the plutonium bomb dropped on Nagasaki exploded with a yield equivalent to approximately 20 kilotons of TNT). Fusion weapons can produce yields in the megaton range, that is millions of tons of TNT. Fission bombs that use an implosion design can be made to explode with greater power by placing small amounts of isotopes of hydrogen (e.g., deuterium or tritium) at their core. The hydrogen isotope boosts the power of the fission bomb not so much by the fusion of the hydrogen isotopes but by the flood of highly energetic neutrons released by their fusion, which causes much more of the fissile bomb material to undergo fission.[114]

Two-stage thermonuclear bombs, sometimes called Hydrogen bombs or H-bombs because they employ isotopes of hydrogen, use the heat, pressure, and x-rays of boosted fission devices to implode fusion fuel (e.g., lithium-deuteride) encased in fissile material. In thermonuclear bombs, fusion contributes meaningfully to the explosive power of the bomb, and the high energy neutrons produced during fusion contribute greatly to fission in other bomb materials. In early 1954, the United States tested a bomb design that exploded with a yield of 15 megatons. Not to be outdone, in October 1961 the Soviet Union dropped a bomb in a test that produced a staggering 50 megaton explosion. By comparison, early fission weapons were much less efficient and destructive. The bombs detonated on Hiroshima and Nagasaki produced yields equivalent to 15 and 20 kilotons of TNT, respectively, and were considered inefficient, with the Little Boy uranium gun-design bomb dropped on Hiroshima reportedly consuming less than two percent of the bomb's U235 which was so painstakingly separated from natural uranium.[115]



INTERNATIONAL AGREEMENTS TIMELINE

October 10th, 1963

LIMITED TEST BAN TREATY (LTBT)[116]

Signed in Moscow, the LTBT prohibits nuclear testing in the atmosphere, space, or underwater but allows for nuclear testing underground, provided that all radioactive debris remains within the borders of the country conducting the tests. All nuclear powers, with the exception of the DPRK, have signed the treaty.

April 25th, 1969

TLATELOCO TREATY[118]

The treaty prohibits all nuclear activity, including testing, manufacture, possession, or storage of nuclear weapons, in Latin America, the Caribbean, and sectors of the Pacific and Atlantic Oceans.

May 18th, 1972

SEABED ARMS CONTROL TREATY[120]

In an effort to prevent weapon delivery via the ocean floor, the Seabed Arms Control Treaty prohibits any form of placement, testing, or storing of weapons of mass destruction, their launching mechanisms, or related facilities on the seabed beyond a 12-mile territorial zone.

June 17th, 1979

STRATEGIC ARMS LIMITATION TREATY II (SALT II)[122]

The U.S.-Soviet treaty, brokered by Gerald Ford and Leonid Brezhnev, imposed a 2,250 limit on strategic nuclear delivery vehicles for each side, a ban on new land-based ICBM launchers, a 1,320 limit on MIRV systems apiece, and limited deployment of new types of offensive arms. Due to disagreements on total numbers of allowable strategic bombers and warheads, coupled with growing skepticism among U.S. legislators, President Jimmy Carter withdrew the treaty from Senate ratification when the Soviet Union invaded Afghanistan in December 1979. The treaty never entered into force. Nevertheless, both countries agreed to abide by is terms until the draft agreement's stated expiration date on December 31, 1985.

October 10th, 1967

OUTER SPACE TREATY[117]

Deals in part with the potential use or placement of nuclear weapons in space: "States Parties to the Treaty undertake not to place in orbit around the Earth any objects ***carrying nuclear weapons or any other kinds of weapons of mass destruction***, install such weapons on celestial bodies, or station such weapons in outer space in any other manner."

March 5th, 1970

NUCLEAR NON-PROLIFERATION TREATY (NPT)[119]

The NPT prohibits nuclear-weapon states from giving nuclear weapons or related technology to non-nuclear-weapon states, while prohibiting non-nuclear-weapon states from pursuing or acquiring nuclear weapons. Three countries that possess nuclear weapons have never signed or been a party to the NPT: India, Israel, and Pakistan. While the DPRK was a signatory, it withdrew in 2003 and proceeded to acquire nuclear weapons.

May 26th, 1972

STRATEGIC ARMS LIMITATION TREATY I (SALT I)[121]

In response to the Soviet buildup of offensive missile systems and anti-ballistic missile capabilities, President Lyndon B. Johnson called for talks in order to curb offensive and defensive technology development. Under Johnson's successor, President Nixon, both the USSR and the US agreed to limit strategic offensive and defensive systems in separate treaties: SALT I and the Anti-Ballistic Missile (ABM) Treaty.

June 1st, 1988

INTERMEDIATE -RANGE NUCLEAR FORCES (INF) TREATY[123]

The treaty required the destruction of all land-based missiles with ranges of 500-5,500 km as well as their launchers and other associated equipment. The agreement was initially between the United States and the Soviet Union, but it is still upheld by the United States, Russia, Belarus, Kazakhstan, and Ukraine. While Turkmenistan and Uzbekistan both possess inspectable INF facilities, neither have participated in the agreement since the fall of the Soviet Union.

December 5th, 1994

STRATEGIC ARMS REDUCTION TREATY (START I)[125]

START I limited the US and the USSR (now Russia) to a maximum of 1,600 delivery vehicles and 6,000 nuclear warheads each. The treaty further established categorical limits for individual types of vehicles and warheads. While the treaty bans the development of new types of ICBMs and SLBMs, it allows for modernization programs.

June 1, 2003

STRATEGIC OFFENSIVE REDUCTIONS TREATY (SORT)[127]

SORT overlapped, rather than replaced, the START I Treaty, and it required both Russia and the U.S. to reduce their arsenals to between 1,700-2,200 strategic nuclear warheads by December 31, 2012. Despite the limitations imposed by SORT, it explicitly allowed each country to determine the composition and structure of its own offensive arms within the limitations of the treaty.

September 27th, 1991

PRESIDENTIAL NUCLEAR INITIATIVE (PNI)[124]

The PNI, a unilateral arms control initiative by President George H. W. Bush, returned overseas ground-launched short-range weapons to the U.S. for destruction. The United States declared it would no longer deploy nuclear weapons on ships, submarines, or Navy aircraft. On October 5, 1991, Mikhail Gorbachev reciprocated with his own pledged reduction measures. *However, Russia has failed to follow through with its PNI pledges, and continues to field systems that the U.S. long ago dismantled.*

STRATEGIC ARMS REDUCTION TREATY II (START II)[126]

Negotiated by the United States and Russia between June 1992 and January 1993, START II would have banned heavy ICBMs and the use of multiple independently targetable reentry vehicles (MIRVs) on ICBMs, but it never entered into force. The U.S. Senate voted overwhelmingly to ratify START II in 1996, but the Russian Duma delayed ratification until the year 2000 and made that ratification contingent on terms unacceptable to the United States. In 2002, Russia withdrew its contingent ratification, citing U.S. withdrawal from the Anti-Ballistic Missile (ABM) Treaty. Still, to improve strategic stability, the United States eliminated its Peacekeeper ICBMs (capable of carrying 10 MIRVs) and downloaded all of its Minuteman ICBMs to a single warhead configuration.

February 5th, 2011

NEW START[128]

New START further limits U.S. and Russian nuclear arsenals while providing for transparency and inspection of one another's facilities. The treaty allows no more than 700 deployed ICBMs, SLBMs, and nuclear-equipped heavy bombers; 1,550 nuclear warheads on deployed ICBMs, SLBMs, and heavy bombers; and 800 deployed and non-deployed ICBM launchers, SLBM launchers, and heavy bombers equipped for nuclear armaments. Both the United States and Russia met the February 5, 2018 deadline for achieving these numbers. Similar to SORT, New START allows each signatory to decide the composition of its strategic arsenal within the treaty's numerical limits. It does not constrain testing, development, or deployment of missile defense programs or long-range conventional strike capabilities. Additionally, the treaty provides for 18 on-site inspections annually. The New START Treaty will expire in 2021 unless both parties agree to extend it until 2026.

COMMON NUCLEAR TERMS

Common nuclear terms are defined by the Office of the Deputy Assistant Secretary of Defense for *Nuclear Matters in the 2016 Nuclear Matters Handbook.*[129] *Terms with an asterisk are defined by Strategic Primer authors.

atomic bomb - Term sometimes applied to a nuclear weapon utilizing fission energy only.
critical mass - The minimum amount of fissionable material capable of supporting a chain reaction under precisely specified conditions.
first strike* - An all-out attack on an adversary's offensive nuclear weapons with the intent of disarming that adversary.
first use* - Going first in crossing the threshold from using conventional weapons to using nuclear weapons in a conflict. Unlike a first strike, which is intended to be massive and disarming, an instance of first use could be quite limited in its employment of nuclear weapons.
fission - Process whereby the nucleus of a particular heavy element splits into (generally) two nuclei of lighter elements, with the release of substantial amounts of energy.
fusion - The process whereby the nuclei of light elements, especially those of the isotopes of hydrogen, namely, deuterium and tritium, combine to form the nucleus of a heavier element with the release of substantial amounts of energy and a high-energy neutron.
hydrogen bomb - Term sometimes applied to nuclear weapons in which part of the explosive energy is obtained from nuclear fusion (or thermonuclear) reactions.
launch on warning/launch under attack* - The act or readiness posture of being able to launch one's own nuclear weapons in response to compelling evidence that one's adversary's nuclear weapons are en route to attack, but before the adversary's weapons have arrived at their targets.
mutual assured destruction - A U.S. doctrine of reciprocal deterrence resting on the United States and the Soviet Union being able to inflict unacceptable damage on the other in retaliation for a nuclear attack.
no first use* - A declaratory policy in which an actor armed with nuclear weapons pledges not to go first in crossing the threshold from using conventional weapons to using nuclear weapons in a conflict, meaning that actor would only use its nuclear weapons in retaliation for a nuclear attack against it.
nuclear weapon - Complete major assembly (i.e., implosion, gun, or thermonuclear), in its intended ultimate configuration, or in a disassembled configuration for a temporary period of time, which, upon completion of the prescribed arming, fuzing, and firing sequence, is capable of producing the intended nuclear reaction and release of energy.
nuclear yields - Energy released in the detonation of a nuclear weapon, measured in terms of the kilotons or megatons of TNT required to produce the same energy release. Yields are categorized as follows: 1) very low: less than 1 kiloton; 2) low: 1 kiloton to 10 kilotons; 3) medium: over 10 kilotons to 50 kilotons; 4) high: over 50 kilotons to 500 kilotons; and 5) very high: over 500 kilotons.
nucleus - Small, central, positively charged region of an atom, which carries essentially all the mass. Except for the nucleus of ordinary (light) hydrogen, which is a single proton, all atomic nuclei contain both protons and neutrons.
ride-out* - The act or policy of waiting for detected in-bound nuclear weapons to detonate before deciding whether and how to respond.
second strike* - An overwhelmingly devastating retaliatory attack against one's adversary after that adversary has attempted a disarming first strike. Possessing a survivable second-strike capability should act as a powerful deterrent against an adversary's attempt at a first strike and should be a stabilizing factor day-to-day and during nuclear crises.
stockpile sustainment - Encompasses the refurbishment of existing warheads and the reuse or replacement of nuclear and non-nuclear components in order to maintain the security, safety, reliability, and effectiveness of the nuclear weapon stockpile.
thermonuclear - Refers to the process (or processes) in which very high temperatures are used to bring about the fusion of light nuclei such as those of hydrogen isotopes (e.g., deuterium and tritium) with the accompanying release of energy and high-energy neutrons.
warhead - That part of a missile, projectile, torpedo, rocket, or other munitions that contains either the nuclear or thermonuclear system, high explosive system, chemical or biological agents, or inert materials intended to inflict damage.

REFERENCES

1. Jim Garamone, "Carter: DoD Will Rebuild, Sustain its Nuclear Deterrence Enterprise," U.S. Department of Defense News Release, September 26, 2016. https://www.defense.gov/News/Article/Article/956050/carter-dod-will-rebuild-sustain-its-nuclear-deterrence-enterprise
2. U.S. Department of Defense, *Nuclear Posture Review Report* (Washington: April 2010), iii, 1, https://dod.defense.gov/Portals/1/features/defenseReviews/NPR/2010_Nuclear_Posture_Review_Report.pdf
3. Ibid.
4. Miriam John, Michael Anastasio, and William LaPlante, statement before the House Armed Services Committee Subcommittee on Strategic Forces, March 9, 2017, http://docs.house.gov/meetings/AS/AS29/20170309/105641/HHRG-115-AS29-Wstate-JohnM-20170309.pdf
5. U.S. Department of Defense, *Nuclear Posture Review Report* (Washington: February 2018), VI.
6. Amy Woolf, "Nonstrategic Nuclear Weapons," Congressional Research Service Report RL32572, January 17, 2019, 18. https://crsreports.congress.gov/product/pdf/RL/RL32572
7. Ibid.
8. John, Anastasio, and LaPlante, statement before the House Armed Services Committee Subcommittee on Strategic Forces.
9. Ibid.
10. Caroline Dorminey, "What the U.S. Should Do about Putin's Nuclear Threats," CATO Institute, March 1, 2018, https://www.cato.org/publications/commentary/what-us-should-do-about-putins-nuclear-threats; Vladimir Isachenkov, "Putin issues ominous warning on rising nuclear war threat." Associated Press, December 20, 2018, https://www.apnews.com/deaa45c70d3c4da98410d5a3ec309510; Neil MacFarquhar, "Threatening U.S., Putin Promises Russians Both Missiles and Butter," *New York Times*, February 20, 2019, https://www.nytimes.com/2019/02/20/world/europe/russia-missile-threat.html
11. Secretary of Defense Chuck Hagel, "A Message to the Force on Our Nuclear Enterprise," Washington, DC, November 14, 2014. http://www.stratcom.mil/Media/News/News-Article-View/Article/983768/a-message-to-the-force-on-our-nuclear-enterprise/
12. Amy F. Woolf, "New START Treaty: Central Limits and Key Provisions." Congressional Research Services Report RL41219, September 27, 2018, 21, https://crsreports.congress.gov/product/pdf/R/R41219.
13. Office of the Deputy Assistant Secretary of Defense for Nuclear Matters, *Nuclear Matters Handbook*¸ Office of the Secretary of Defense, Washington, DC, 2016, 31-32, http://www.acq.osd.mil/ncbdp/nm/NMHB/docs/NMHB2016_Ch3_web.pdf
14. Steven Pifer, "NATO, Nuclear Weapons and Arms Control," Brookings Institution Arms Control Series Paper 7, July 2007, 13, https://www.brookings.edu/wp-content/uploads/2016/06/0719_arms_control_pifer.pdf.
15. U.S. Department of Defense, *Nuclear Posture Review Report 2018*, 8.
16. Woolf, "Nonstrategic Nuclear Weapons," summary page.
17. Ibid.
18. Hans M. Kristensen and Robert S. Norris, "Russian nuclear forces, 2018," *Bulletin of the Atomic Scientists* 74, no. 3 (2018), 185, https://www.tandfonline.com/doi/pdf/10.1080/00963402.2018.1462912?needAccess=true
19. U.S. Department of Defense, *Nuclear Posture Review Report*, 9.
20. Ibid., 6-10, 30-31.
21. National Institute for Public Policy, Foreign Nuclear Developments: A Gathering Storm (Fairfax, VA: National Institute Press, 2015), 3, http://www.nipp.org/wp-content/uploads/2015/07/Foreign-Nuclear-Developments-7.15.pdf; Woolf, "Nonstrategic Nuclear Weapons," 24-25; Vladimir Putin, "Presidential Address to the Federal Assembly," Moscow, Russia, March 1, 2018. http://en.kremlin.ru/events/president/news/56957
22. U.S. Department of Defense, Nuclear Posture Review Report, 6-10.
23. Ibid; Keith Payne, ed., *Russian Strategy: Expansion, Crisis, and Conflict* (Fairfax, VA: National Institute of Public Policy Press, 2016), http://www.nipp.org/wp-content/uploads/2016/01/FINAL-FOR-WEB-1.12.16.pdf.
24. Arms Control Association, "Arms Control and Proliferation Profile: Russia," October 2018, https://www.armscontrol.org/factsheets/russiaprofile.

25. U.S. Department of Defense, *Nuclear Posture Review Report*, 6-10; U.S. Defense Intelligence Agency, "Global Nuclear Landscape," February 2018, 8-14, https://dod.defense.gov/portals/1/features/2018/0218_NPR/img/Global_Nuclear_Landscape_2018_Final.pdf; U.S. National Air and Space Intelligence Center (NASIC)/Defense Intelligence Ballistic Missile Analysis Committee (DIBMAC), "2017 Ballistic and Cruise Missile Threat," June 2017, 26-37, https://www.nasic.af.mil/About-Us/Fact-Sheets/Article/1235024/2017-ballistic-and-cruise-missile-threat-report/
26. U.S. Department of Defense, *Nuclear Posture Review Report*, 8-9; U.S. Defense Intelligence Agency, "Global Nuclear Landscape," 14; Kristensen and Norris, "Russian nuclear forces, 2018," 189-190; Vladimir Putin, "Presidential Address to the Federal Assembly."
27. U.S. Department of Defense, *Nuclear Posture Review Report*, 8-10; Kristensen and Norris, "Russian nuclear forces, 2018," 185-192. https://www.tandfonline.com/doi/pdf/10.1080/00963402.2018.1462912?needAccess=true; Arms Control Association, "Arms Control and Proliferation Profile: Russia."
28. Payne, ed., *Russian Strategy: Expansion, Crisis, and Conflict*, 105.
29. Kristensen and Norris, "Russian nuclear forces, 2018," 189-190.
30. U.S. Department of State, Bureau of Arms Control, Verification and Compliance, "New START Treaty Aggregate Numbers of Strategic Offensive Arms," September 1, 2018, https://www.state.gov/t/avc/newstart/286466.htm
31. Ibid.
32. Woolf, "Nonstrategic Nuclear Weapons," 27.
33. Kristensen and Norris, "Russian nuclear forces, 2018," 186.
34. Ibid., 185.
35. Ibidem, 187.
36. Ibidem, 189.
37. Ibidem, 190.
38. U.S. Department of Defense, Office of the Secretary of Defense, "Annual Report to Congress: Military and Security Developments Involving the People's Republic of China 2018," May 16, 2018, https://media.defense.gov/2018/Aug/16/2001955282/-1/-1/1/2018-CHINA-MILITARY-POWER-REPORT.PDF
39. State Council Information Office, *China's 2013 White Paper*, as cited in Eric Heginbotham, et. al., *China's Evolving Nuclear Deterrent: Major Drivers and Issues for the United States* (Santa Monica: RAND, 2017), 18. https://www.rand.org/content/dam/rand/pubs/research_reports/RR1600/RR1628/RAND_RR1628.pdf.
40. Heginbotham et. al., *China's Evolving Nuclear Deterrent: Major Drivers and Issues for the United States*, 16.
41. 寿晓松 [Shou Xiaosong], «战略学» [*Science of Military Strategy 2013*], as cited in Heginbotham, et. al., *China's Evolving Nuclear Deterrent: Major Drivers and Issues for the United States*, 17.
42. Heginbotham, et. al., *China's Evolving Nuclear Deterrent: Major Drivers and Issues for the United States*, 16.
43. Ibid., 24.
44. Arms Control Association, "Arms Control and Proliferation Profile: China," July 6, 2017, https://www.armscontrol.org/factsheets/chinaprofile.
45. Center for Strategic and International Studies (CSIS), "Dong Feng 41 (DF-41 / CSS-X-20)," Center for Strategic and International Studies (CSIS) *Missile Defense Project*, June 15, 2018. https://missilethreat.csis.org/missile/df-41/
46. U.S. Department of Defense, "Annual Report to Congress: Military and Security Developments Involving the People's Republic of China 2018," 76-77; U.S. Defense Intelligence Agency, "Global Nuclear Landscape," 16-19; Hans M. Kristensen and Robert S. Norris, "Chinese nuclear forces, 2018," *Bulletin of the Atomic Scientists* 74, no. 4 (2018), 289-295, https://www.tandfonline.com/doi/pdf/10.1080/00963402.2018.1486620?needAccess=true
47. U.S. Department of Defense, "Annual Report to Congress: Military and Security Developments Involving the People's Republic of China 2018," 76-77.
48. Sebastien Roblin, "China's H-20 Strategic Stealth Bomber (Everything We Know Right Now)," *The National Interest*, December 16, 2018, https://nationalinterest.org/blog/buzz/chinas-h-20-strategic-stealth-bomber-everything-we-know-right-now-38922.
49. Kristensen and Norris, "Chinese nuclear forces, 2018," 289-295.
50. Ibid.
51. Ibidem.
52. U.S. Department of Defense, "Annual Report to Congress: Military and Security Developments Involving the People's Republic of China 2018," 36-37, 75-77; U.S. Defense Intelligence Agency, "Global Nuclear Landscape," 16-19; Kristensen and Norris, "Chinese nuclear forces, 2018," 289-295.

53. U.S. Department of Defense, "Annual Report to Congress: Military and Security Developments Involving the People's Republic of China 2018," 36; U.S. Defense Intelligence Agency, "Global Nuclear Landscape," 16-19; Kristensen and Norris, "Chinese nuclear forces, 2018," 289-295.
54. Ibid.
55. Ibidem.
56. Kristensen and Norris, "Chinese nuclear forces, 2018," 290.
57. U.S. Defense Intelligence Agency, "Global Nuclear Landscape," 21.
58. U.S. Commission to Assess the Threat to the United States from Electromagnetic Pulse (EMP) Attack, "Report of the Commission to Assess the Threat to the United States from Electromagnetic Pulse (EMP) Attack: Volume 1 Executive Report," July 2017, vii, 1, 5, http://www.firstempcommission.org/uploads/1/1/9/5/119571849/executive_report_on_assessing_the_threat_from_emp_-_final_april2018.pdf; William R. Graham, "Chairman's Report," Report to the Commission to Assess the Threat to the United States from Electromagnetic Pulse (EMP) Attack, July 2017, 23-25, http://www.firstempcommission.org/uploads/1/1/9/5/119571849/report_final_amended_emp_commission_chairmans_report_08222018.pdf
59. Hans M. Kristensen and Robert S. Norris, "North Korean nuclear capabilities, 2018," *Bulletin of the Atomic Scientists* 74, no. 1 (2018), 41.
60. U.S. National Air and Space Intelligence Center (NASIC)/Defense Intelligence Ballistic Missile Analysis Committee (DIBMAC), "2017 Ballistic and Cruise Missile Threat," 27-29; Nuclear Threat Initiative, "North Korea," June 2018, https://www.nti.org/learn/countries/north-korea/; Nuclear Threat Initiative, "Missile: North Korea," July 2017, https://www.nti.org/learn/countries/north-korea/delivery-systems/; "Missiles of North Korea," Center for Strategic and International Studies (CSIS) *Missile Defense Project*, June 15, 2018, https://missilethreat.csis.org/country/dprk/.
61. U.S. Defense Intelligence Agency, "Global Nuclear Landscape," 22; "Missiles of North Korea."
62. Ibid.
63. William R. Graham, "Chairman's Report," 23-25.
64. Director General of the International Atomic Energy Agency, "Implementation of the NPT Safeguards Agreement and relevant provisions of Security Council resolutions in the Islamic Republic of Iran," IAEA, GOV/2011/65, November 8, 2011, 7-8, "Appendix: Possible Military Dimensions to Iran's Nuclear Program," Annex Page 1 – Annex Page 12, Attachments 1 and 2, https://www.iaea.org/sites/default/files/gov2011-65.pdf
65. Daniel R. Coats, "Worldwide Threat Assessment of the US Intelligence Community," Statement for the Record before the Senate Armed Services Committee February 13, 2018, 7, https://www.dni.gov/files/documents/Newsroom/Testimonies/2018-ATA---Unclassified-SSCI.pdf.
66. William R. Graham, "Chairman's Report," 21-23.
67. Paul K. Kerr, Steven A. Hildreth, and Mary Beth D. Nikitin, "Iran-North Korea-Syria Ballistic Missile and Nuclear Cooperation," Congressional Research Service *Report* R43480, February 26, 2016, 4, https://crsreports.congress.gov/product/pdf/R/R43480.
68. Arms Control Association, "Arms Control and Proliferation Profile: Iran," May 2018, https://www.armscontrol.org/factsheets/iranprofile.
69. Coats, "Worldwide Threat Assessment of the US Intelligence Community," 8.
70. U.S. Department of State, "New START Treaty Aggregate Numbers of Strategic Offensive Arms."
71. Defense Science Board Task Force, "Nuclear Deterrence Skills," September 2008, 17, http://www.acq.osd.mil/dsb/reports/2000s/ADA487983.pdf
72. Ibid.
73. U.S. Department of Defense, *Nuclear Posture Review 2010*, 37.
74. Admiral C. D. Haney, Statement before the House Committee on Armed Services Subcommittee on Strategic Forces, July 14, 2016, 9, http://docs.house.gov/meetings/AS/AS29/20160714/105199/HHRG-114-AS29-Wstate-HaneyC-20160714.pdf
75. U.S. Department of Defense, *Nuclear Posture Review 2018*, 61.
76. Ibid., XIV, 61.
77. Lt Gen David A. Deptula, USAF (Ret.), and Dr. William A. LaPlante, with Robert Haddick, *Modernizing U.S. Nuclear Command, Control, and Communications* (Washington, DC: Air Force Association, February 2019), 4, http://www.mitchellaerospacepower.org/nc3.
78. Ibid., 5.

79. Ronald O'Rourke, "Navy Columbia (SSBN-826) Class Ballistic Missile Submarine (SSBN[X]) Program: Background and Issues for Congress," Congressional Research Service Report R41129, October 23, 2018, 4, https://crsreports.congress.gov/product/pdf/R/R41129.
80. Ibid., 3.
81. Congressional Research Service, "U.S. Strategic Nuclear Forces: Background, Developments, and Issues," Congressional Research Service *Report* RL33640, November 21, 2018, 9, 25-27, https://crsreports.congress.gov/product/pdf/RL/RL33640.
82. Ibid.; Hans Kristensen and Robert Norris, "U.S. Nuclear Forces, 2018," *Bulletin of the Atomic Scientists* 74, no. 2 (2018), 126.
83. Congressional Research Service, "U.S. Strategic Nuclear Forces: Background, Developments, and Issues," 9.
84. Ibid., 14; Kristensen and Norris, "U.S. Nuclear Forces, 2018," 124.
85. Government Accountability Office, "Weapon Systems Annual Assessment[:] Knowledge Gaps Pose Risks to Sustaining Recent Positive Trends, GAO-18-360SP," April 2018, as cited in O'Rourke, "Navy Columbia (SSBN-826) Class Ballistic Missile Submarine Program: Background and Issues for Congress," 11.
86. Ibid., 6.
87. "November 2010 Update to the National Defense Authorization Act of 2010 Section 1251 Report: New START Treaty Framework and Nuclear Force Structure Plans," 10-11, http://www.lasg.org/budget/Sect1251_update_17Nov2010.pdf; *America's Strategic Posture: The Final Report of the Congressional Commission on the Strategic Posture of the United States* (Washington, DC: U.S. Institute for Peace, 2009), xvii, 25-26, 100.
88. Congressional Research Service, "U.S. Strategic Nuclear Forces: Background, Developments, and Issues," 21.
89. Ibid.; Kristensen and Norris, "U.S. Nuclear Forces, 2018," 125. Note: Kristensen and Norris claim the Air Force intends to buy 666 missiles at a cost of $100 billion rather than 642 missiles costing $85 billion as reported by CRS in November 2018.
90. Congressional Research Service, "U.S. Strategic Nuclear Forces: Background, Developments, and Issues," 21.
91. Various official documents give different numbers of B-52s assigned to the nuclear mission: 41, 44, and 46. Amy F. Woolf, "The New START Treaty: Central Limits and Key Provisions," Congressional Research Service *Report* RL41219, September 21, 2018, 21 (Woolf reports 41 B-52s deployed); Congressional Research Service, "U.S. Strategic Nuclear Forces: Background, Developments, and Issues," 35 (cites "44 [B-52Hs] assigned to nuclear missions on a day-to-day basis."); U.S. Department of Defense, *Nuclear Posture Review 2018*, 46 (the 2018 NPR says "The air leg consists of 46 nuclear capable B-52H…strategic bombers…")
92. U.S. Department of Defense, *Nuclear Posture Review 2018*, 47; Congressional Research Service, "U.S. Strategic Nuclear Forces: Background, Developments, and Issues," 37.
93. Congressional Research Service, "U.S. Strategic Nuclear Forces: Background, Developments, and Issues," 32; Jeremiah Gertler, "Air Force B-21 Raider Long-Range Strike Bomber," Congressional Research Service *Report* RL41219, October 12, 2018, 9, https://crsreports.congress.gov/product/pdf/R/R44463.
94. Woolf, "Nonstrategic Nuclear Weapons," 21-22; Congressional Research Service, "U.S. Strategic Nuclear Forces: Background, Developments, and Issues," 32.
95. Gertler, "Air Force B-21 Raider Long-Range Strike Bomber," 9.
96. Ibid., 4, 8-10.
97. Congressional Research Service, "U.S. Strategic Nuclear Forces: Background, Developments, and Issues," 42.
98. U.S. Department of Defense, *Nuclear Posture Review 2018*, 50, 61.
99. Note: In April 2017, the GAO warned that the B61-12 could be delayed until 2022 and cost $10 billion, but subsequent statements from DoD and NNSA continue to project a 2020 delivery and the lower cost of $8.25 billion. United States Government Accountability Office, "National Nuclear Security Administration: Action Needed to Address Affordability of Nuclear Modernization Programs," GAO 17-341, April 2017, https://www.gao.gov/assets/690/684310.pdf; U.S. Department of Energy, National Nuclear Security Administration, *Fiscal Year 2019 Stockpile Stewardship and Management Plan Report to Congress*, October 2018, 2-11; U.S. Department of Defense, Nuclear Posture Review 2018, X, 47, 61; Congressional Research Service, "U.S. Strategic Nuclear Forces: Background, Developments, and Issues," 32-33; Kristensen and Norris, "United States Nuclear Forces, 2018," 127.
100. U.S. Department of Energy, National Nuclear Security Administration, *Fiscal Year 2019 Stockpile Stewardship and Management Plan Report to Congress*, vii, viii, 1-9, 4-41, 5-2; U.S. Department of Defense, *Nuclear Posture Review 2018*, 50, 61; Congressional Research Service, "U.S. Strategic Nuclear Forces: Background, Developments, and Issues," 37-39.
101. U.S. Department of Defense, *Nuclear Posture Review 2018*, 50, 54; Gertler, "F-35 Joint Strike Fighter (JSF) Program," 19, 30.
102. Congressional Research Service, "U.S. Strategic Nuclear Forces: Background, Developments, and Issues," 32-33; Kristensen and Norris, "United States Nuclear Forces, 2018," 129.
103. U.S. Department of Defense, *Nuclear Posture Review 2018*, 51. The comparison to DoD spending on healthcare is not contained in the 2018 NPR, but comes instead from comparing the $48.4 billion requested for DoD healthcare in the FY17 budget to peak spending a decade later, which is projected by CSBA to reach a little over $25 billion in FY15 dollars.
104. U.S. Department of Defense, *Nuclear Posture Review 2018*, 51.
105. Todd Harrison and Evan Braden Montgomery, *Are U.S. Nuclear Forces Unaffordable* (Washington, DC: Center for Strategic and Budgetary Assessments, June 23, 2015), 2, http://csbaonline.org/uploads/documents/Cost-of-Nuclear-Forces-WEB.pdf
106. Ibid.
107. U.S. Department of Defense, *Nuclear Posture Review 2018*, III.
108. Ibid., III, 51.
109. William J. Perry and Andy Weber, "Mr. President, kill the new cruise missile," *Washington Post*, October 15, 2015, https://www.washingtonpost.com/opinions/mr-president-kill-the-new-cruise-missile/2015/10/15/e3e2807c-6ecd-11e5-9bfe-e59f5e244f92_story.html?utm_term=.35684b4e408a
110. U.S. Department of Defense, *Nuclear Posture Review 2018*, VI, 16.
111. Tim Johnson, "Will boosting spending on nuclear weapons deter U.S. enemies?" McClatchy, November 3, 2016, https://www.mcclatchydc.com/news/nation-world/national/national-security/article112265397.html
112. "Text of Moscow Declaration by President Clinton and Russian President Yeltsin," Moscow, Russia, January 14, 1994, paragraph 3, https://fas.org/nuke/control/detarget/docs/940114-321186.htm
113. General Curtis M. Scaparrotti, testimony before the Senate Committee on Armed Services, Washington DC, March 5, 2019, https://www.armed-services.senate.gov/imo/media/doc/Scaparrotti_03-05-19.pdf
114. U.S. Department of Defense, Office of the Deputy Assistant Secretary of Defense for Nuclear Matters, *Nuclear Matters Handbook 2016*, n.d., http://www.acq.osd.mil/ncbdp/nm/NMHB/chapters/Appendix_C.htm
115. Based on calculations using information from Samuel Glasstone and Philip J. Dolan, *The Effects of Nuclear Weapons*, Third Edition, Department of Defense and Department of Energy (Washington: GPO, 1977), 5.
116. U.S. Department of State, "Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and Under Water," n.d., http://www.state.gov/t/isn/4797.htm
117. U.S. Department of State, "Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies," n.d., https://www.state.gov/t/isn/5181.htm
118. Nuclear Threat Initiative, "Treaty for the Prohibition of Nuclear Weapons in Latin America and the Caribbean (LANWFZ) (Tlatelolco Treaty)," September 22, 2016, http://www.nti.org/learn/treaties-and-regimes/treaty-prohibition-nuclear-weapons-latin-america-and-caribbean-lanwfz-tlatelolco-treaty/
119. U.S. Department of State, "Nuclear Nonproliferation Treaty," n.d., http://www.state.gov/t/isn/npt/
120. Nuclear Threat Initiative, "Treaty on the Prohibition of the Emplacement of Nuclear Weapons and Other Weapons of Mass Destruction on the Seabed and Ocean Floor and in the Subsoil Thereof (Seabed Treaty)," October 26, 2011, http://www.nti.org/learn/treaties-and-regimes/treaty-prohibition-emplacement-nuclear-weapons-and-other-weapons-mass-destruction-seabed-and-ocean-floor-and-subsoil-thereof-seabed-treaty/
121. U.S. Department of State, Office of the Historian, "Strategic Arms Limitations Talk/Treaty (SALT) I and II," n.d., https://history.state.gov/milestones/1969-1976/salt
122. Ibid.
123. U.S. Department of State, "Treaty Between The United States Of America And The Union Of Soviet Socialist Republics On The Elimination Of Their Intermediate-Range And Shorter-Range Missiles (INF Treaty)," n.d., https://www.state.gov/t/avc/trty/102360.htm#narrative
124. Arms Control Association, "The Presidential Nuclear Initiatives (PNIs) on Tactical Nuclear Weapons at a Glance," August 2012, https://www.armscontrol.org/factsheets/pniglance
125. Nuclear Threat Initiative, "Treaty Between the United States of America and the Union of Soviet Socialist Republics on the Strategic Offensive Reductions (START I)", October 26, 2011, http://www.nti.org/learn/treaties-and-re-

gimes/treaties-between-united-states-america-and-union-soviet-socialist-republics-strategic-offensive-reductions-start-i-start-ii/
126. U.S. Department of State, "Article by Article Legal Analysis of the START II Treaty and its Associated Documents," https://www.state.gov/t/avc/trty/104150.htm
127. U.S. Department of State, "Treaty Between the United States of America and the Russian Federation On Strategic Offensive Reductions (The Moscow Treaty)," n.d., http://www.state.gov/t/isn/10527.htm
128. U.S. Department of State, "New START," n.d., http://www.state.gov/t/avc/newstart/index.htm
129. U.S. Department of Defense, Office of the Deputy Assistant Secretary of Defense for Nuclear Matters, *Nuclear Matters Handbook 2016*, 263-272, https://www.acq.osd.mil/ncbdp/nm/nmhb/index.htm.

Photo/Image Credit:

Cover Image | B-2 Spirit, https://www.af.mil/News/Photos/igphoto/2001622211/
2 | B-52 H Stratofortress bomber, https://www.af.mil/News/Photos/igphoto/2001950487/
6 | Russian Submarine, https://www.shutterstock.com/image-photo/submarine-launch-ballistic-missile-isolated-war-1068616685
8-9 | Chinese Submarine, https://en.wikipedia.org/wiki/Jin-class_submarine
10-11 | North Korean missile, https://en.wikipedia.org/wiki/2017_in_North_Korea#/media/File:North_Korea%27s_ballistic_missile_-_North_Korea_Victory_Day-2013_01.jpg
14 | Ohio Class Submarine, https://commons.wikimedia.org/wiki/File:US_Navy_060411-N-1810F-001_The_Ohio-class_guided_missile_submarine_USS_Florida_(SSGN_728)_makes_her_way_through_Cumberland_Sound_to_Naval_Submarine_Base_Kings_Bay.jpg
15 |Columbia Class Submarine, https://commons.wikimedia.org/wiki/File:Artist_rendering_of_a_Columbia-class_ballistic_missile_submarine,_2019_(190306-N-N0101-125).jpg
14-15 | Vandenberg officials launch Minuteman III missile, https://www.af.mil/News/Photos/igphoto/2000665214/
16 | B-52 Stratofortress, https://nara.getarchive.net/media/a-b-52-stratofortress-aircraft-lands-on-base-during-the-strategic-air-commands-e2d35f
16 | F-15E, https://picryl.com/media/an-f-15e-strike-eagle-494th-fighter-squadron-fs-taxis-from-the-runway-at-royal-703e89
17 | B-2 Spirit, https://www.af.mil/About-Us/Fact-Sheets/Display/Article/104482/b-2-spirit/
17 | F-35, https://upload.wikimedia.org/wikipedia/commons/2/2a/An_F-35_Lightning_II_completes_a_flyover_of_USS_Zumwalt_%28DDG_1000%29._%2829774535153%29.jpg
23 | Reuters, "Routes to a nuclear weapon EPS C," https://pictures.reuters.com/CS.aspx?VP3=SearchResult&VBID=2C0BXZSHDOPO_2&SMLS=1&RW=1324&RH=689#/

AFPC INFORMATION

For close to four decades, the American Foreign Policy Council (AFPC) has played an essential role in the U.S. foreign policy debate. Founded in 1982, AFPC is a 501(c)(3) non-profit organization dedicated to bringing information to those who make or influence the foreign policy of the United States and to assisting world leaders with building democracies and market economies. AFPC is widely recognized as a source of timely, insightful analysis on issues of foreign policy, and works closely with members of Congress, the Executive Branch and the policymaking community. It is staffed by noted specialists in foreign and defense policy, and serves as a valuable resource to officials in the highest levels of government.

About The Defense Technology Program A revolution is taking place in the nature of warfare. The proliferation of ballistic missiles and weapons of mass destruction has given rogue states and terrorist groups unprecedented access to potentially devastating capabilities, while space and cyberspace have emerged as distinct new arenas of strategic competition. The American Foreign Policy Council's work in these areas is aimed at helping U.S. officials understand and respond to this new, and increasingly complex, threat environment.

For more information about the program, please contact Richard M. Harrison, Vice President of Operations and Director of Defense Technology Programs, at Harrison@afpc.org.

509 C Street NE | Washington, D.C. 20002 | 202.543.1006
www.afpc.org