Nuclear security: The enduring challenge of nuclear weapons

by Todd S. Sechser

In July 2015, the United States, Iran, and five other world powers reached a landmark deal intended to prevent Iran from acquiring nuclear weapons. The product of years of diplomacy, this agreement offered Iran the promise of relief from crippling economic sanctions in exchange for constraining its ability to produce the raw material necessary for a nuclear weapon. The deal provoked impassioned reactions from both supporters and critics. U.S. Secretary of State John Kerry argued that the agreement represented “a hugely positive step” that would “make our citizens and our allies safer.” By contrast, President-elect Donald Trump called the agreement “a disastrous deal,” declaring that dismantling it would be his “number one priority” as President.

While the Iran deal continues to be a subject of intense debate, there is widespread agreement that nuclear proliferation poses a grave challenge to international security. In 1963, President John F. Kennedy called the spread of nuclear weapons “one of the greatest hazards which man faces.” Since Kennedy’s declaration, every U.S. president has made nuclear nonproliferation a chief foreign policy objective of their administration.

More than half a century later, nuclear nonproliferation continues to rank as one of the top foreign policy challenges faced by the United States. Questions persist about the nuclear deal with Iran, and North Korea continues to pursue a larger and more sophisticated nuclear arsenal. Moreover, the United States will face critical choices about its own nuclear arsenal in the coming administration.

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SIGNATURE NONPROLIFERATION AND ARMS CONTROL ACHIEVEMENTS OF EACH U.S. PRESIDENT SINCE 1960

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Building and stopping the bomb

Nuclear weapons harness the energy of atomic fission to achieve their destructive power. At an atomic level, a nuclear explosion involves splitting the nucleus of one atom, which releases energy along with several other neutrons that, in turn, split neighboring atoms. Given enough fissionable material, this process triggers a chain reaction that releases a tremendous amount of energy—in the form of a nuclear explosion—in just one millionth of a second.

The power of nuclear explosives is so immense that they are measured by how many thousands—or millions—of tons of TNT would be required to create an equivalent explosion. For instance, the atomic bomb dropped on Hiroshima, Japan, in 1945 exploded with an energy equivalent to about 15 kilotons—that is, 15,000 tons—of TNT. But the United States and Soviet Union soon developed weapons that were vastly more powerful. During the Cold War, the most powerful nuclear weapon deployed by the United States carried an explosive yield of 25 million tons (megatons) of TNT. Soviet weapons were even more powerful. The largest thermonuclear weapon ever tested, a Soviet weapon known in the United States as “Tsar Bomba,” created an explosion equivalent to 50 million tons of TNT—nearly 4,000 times more powerful than the atomic bomb that destroyed Hiroshima.

Today, the most powerful nuclear weapon in the U.S. arsenal, the B83 bomb, carries a maximum yield of 1.2 megatons.

All nuclear weapons rely on atomic fission. While the atomic weapons dropped on Japan in 1945 utilized strictly fission devices, however, modern thermonuclear weapons utilize fission as merely the first of two stages. In these weapons, a “primary” fission explosion triggers a much more powerful “secondary” device that relies on atomic fusion rather than fission. Because this process releases energy by fusing together hydrogen isotopes, thermonuclear weapons are often called “hydrogen bombs.” These weapons can generate explosive power far more efficiently than pure fission weapons.

The most difficult step in building a nuclear weapon is not, however, constructing the bomb itself. The basics of nuclear weapons design are widely known, and easily available in unclassified literature. In fact, this has been the case for decades: more than 40 years ago, a former director of Lawrence Livermore Laboratory wrote that “the only difficult thing about making a fission bomb of some sort is the preparation of a supply of fissile material of adequate purity; the design of the bomb itself is relatively easy.”

Rather, the most important hurdle for a government or organization with nuclear ambitions is obtaining the material necessary for a fission reaction. Paul Kerr, a nonproliferation analyst at the Congressional Research Service, notes that “obtaining fissile material is widely regarded as the most difficult task in building nuclear weapons.” There are two such “fissile” materials: plutonium-239 (Pu-239) and uranium-235 (U-235). Both materials, in sufficient quantity, can sustain the chain reaction that characterizes nuclear fission. But both are difficult to obtain. Plutonium-239 does not exist in nature, and can only be obtained by extracting it out of spent uranium fuel from nuclear reactors. Uranium-235 is naturally occurring, but comprises less than 1% of natural uranium. To
obtain it in sufficiently pure quantities for a nuclear weapon, it must be separated from other uranium isotopes in a painstakingly process known as “enrichment.”

The most effective way to prevent the spread of nuclear weapons therefore is to stop countries from acquiring the materials necessary to build them. Indeed, this is the basic organizing principle of the international nonproliferation regime. For example, the International Atomic Energy Agency (IAEA), which monitors compliance with nonproliferation agreements, does not actually inspect civilian nuclear facilities. Instead, it inspects nuclear facilities to ensure that nuclear material is not diverted from civilian use to military programs. In other words, accounting for nuclear materials takes precedence over monitoring their military application.

Preventing countries from acquiring the materials to build a nuclear weapon is challenging because those materials—or the ability to create them—are natural byproducts of civilian energy programs. Commercial nuclear reactors produce Pu-239 as part of the natural process of “burning” uranium fuel rods. The fuel rods themselves, however, cannot be used in a nuclear weapon; the plutonium must be extracted through a complex chemical separation procedure known as reprocessing.

Uranium-235 is also inextricably connected to civilian energy programs because it is the primary fuel source for commercial nuclear reactors. In order to be usable in most nuclear reactors, uranium mined from the ground must be enriched so that it contains between 3% and 5% U-235. The process of enrichment removes some of the more prevalent isotope U-238, leaving a higher proportion of fissionable U-235. There are several techniques for enriching uranium, but the most common method involves transforming the uranium into a gas and feeding it into high-speed centrifuges. The spinning motion of the centrifuges—around 1,500 revolutions per second—separates the heavier isotopes from the lighter ones, allowing U-235 to be extracted in gradually higher concentrations. While the enrichment level required for a nuclear weapon is much higher than the level for a reactor—more than 90% U-235—this level of purity can be achieved using the very same facilities used to enrich nuclear fuel. The difference lies in the number of times the uranium is fed through the centrifuges, not the equipment used. In short, a country that has the ability to enrich fuel for a nuclear reactor also has the ability to obtain highly-enriched uranium for a nuclear bomb.

Just eight countries operate plutonium reprocessing facilities, only one of which (Japan) does not already possess nuclear weapons. Uranium enrichment capabilities are somewhat more common. Fourteen states operate such facilities, including six non-nuclear states: Argentina, Brazil, Iran, Japan, Germany and the Netherlands. The IAEA conducts regular monitoring and inspections of these facilities, ensuring that all nuclear material is accounted for and not diverted for other purposes.

The inherent tension between civilian nuclear energy and nuclear weapons has plagued nonproliferation efforts since the beginning of the nuclear age. The Treaty on the Nonproliferation of Nuclear Weapons (NPT), the backbone of the international nonproliferation regime, grants member states an “alienable right” of access to “research, production and use of nuclear energy for peaceful purposes.” Accordingly, a core mission of the IAEA is to facilitate the dissemination of nuclear technology to NPT members for civilian purposes, even though this technology could in principle be used to support a military weapons program. Yet this reflects the bargain at the heart of the
treaty: in exchange for forsaking nuclear weapons, the world’s nonnuclear states receive an assurance of access to civilian nuclear energy.

Yet the spread of nuclear weapons is by no means inevitable. President John F. Kennedy worried in 1963 that by 1970, there might be “ten nuclear powers instead of four, and by 1975, fifteen or twenty.” His dire predictions have not come to pass: more than half a century after the Cuban missile crisis, just nine states possess nuclear weapons. Four states have given them up (South Africa, Kazakhstan, Belarus and Ukraine), and several others terminated their programs before crossing the nuclear threshold, including Argentina, Brazil and Libya. Still more countries—perhaps numbering in the dozens—possess the scientific expertise and industrial wherewithal to produce a nuclear weapon if they wished, but have thus far declined to do so.

Still, the nonproliferation regime’s record remains imperfect. Of greatest concern are the four countries that remain outside the NPT: India, Israel, Pakistan and North Korea. All four have acquired nuclear weapons, the most recent of which—North Korea—conducted its first successful nuclear test just a decade ago. And Iran appeared to be on the cusp of acquiring enough nuclear material for a nuclear weapon when it signed the 2015 nonproliferation deal with the United States. Both countries will present the next U.S. president with difficult choices.

Contrasting paths in nonproliferation

Iran

Iran’s nuclear program dates back to the 1950s, when it signed its first nuclear cooperation agreement with the United States. Iran’s first nuclear reactor, a small research reactor, was supplied by the United States in 1967. During the next decade, Iran launched an ambitious nuclear energy program, planning to build between ten and twenty nuclear reactors that would supply more than 20,000 megawatts of energy—enough to power New York City. Iran signed contracts to build nuclear reactors with several European companies, but these agreements were scuttled after the 1979 Iranian revolution.

Iran’s nuclear ambitions, however, worried U.S. leaders even before the revolution. In the 1970s, as the United States was negotiating a provisional agreement for Iran to buy two nuclear reactors, a State Department official warned that these reactors could create a proliferation risk. He wrote that an “aggressive successor to the Shah might consider nuclear weapons the final item needed to establish Iran’s complete military dominance of the region.” In 1974, a U.S. National Intelligence Estimate argued that “there is no doubt... of the Shah’s ambition to make Iran a power to be reckoned with. If he is alive in the mid-1980s,” the report went on, “and if other countries have proceeded with weapons development, we have no doubt that Iran will follow suit.”

Since Iran’s revolution, officials in the West have routinely offered dire projections about the inevitability of an Iranian nuclear bomb. In 1984, a West German intelligence report warned that Iran’s nuclear weapons initiative was “entering its final stages” and would yield a bomb within two years. That same year, U.S. Senator Alan Cranston (D-CA) warned that Iran was seven years away from making a nuclear weapon. A decade later, in 1995, The New York Times quoted “senior American and Israeli officials” as saying that Iran might be “less than five years away from having an atomic bomb.” U.S. General Anthony Zinni repeated the five-year forecast in 1998, and Israel’s Defense Minister predicted in 2001 that an Iranian bomb was four years away. In 2013, Israeli Prime Minister Benjamin Netanyahu issued perhaps the most impassioned warning yet about Iran’s nuclear ambitions, declaring that Iran was completing work on facilities that would put it merely weeks away from a nuclear weapons capability. After more than 30 years of these warnings, however, Iran has yet to obtain a nuclear weapon.

At the same time, Iran has made steady progress developing the ability to enrich uranium. In April 2006, Iranian President Mahmoud Ahmadinejad announced that his country had, for the first time, successfully enriched uranium. At that time, Iran had installed roughly 300 centrifuges at its pilot uranium enrichment plant at Natanz, a facility 125 miles south of Tehran. By early 2009, that number had increased almost twentyfold, to nearly 6,000. And by 2015, the number of installed centrifuges had grown to more than 19,000—including 1,000 second-generation centrifuges that are five times more efficient than their predecessors.

The number of centrifuges is important because it dictates the speed at which Iran could enrich enough uranium for a nuclear weapon. According to the IAEA, a nuclear weapon requires roughly 27 kilograms of highly enriched uranium. In order to obtain this amount from natural uranium in a year’s time, Iran would need about 5,000 of its first-generation centrifuges. With 18,000 first-generation centrifuges, it could produce the necessary amount in about three months. Adding an additional 1,000 advanced centrifuges would cut the timeframe for one nuclear weapon to about 11 weeks—or more than four nuclear weapons per year.

Iran maintains that it has a right to enrich uranium under the NPT—a claim the United States disputes—and Iranian
leaders have always insisted that its enrichment capabilities are for peaceful purposes only. Indeed, Supreme Leader Ayatollah Khamenei apparently issued a religious edict that “the production, stockpiling, and use of nuclear weapons are forbidden under Islam and that the Islamic Republic of Iran shall never acquire these weapons.” But following the revelation of secret Iranian nuclear facilities in 2002 and 2009, the United States, United Nations (UN) Security Council, and European Union imposed several rounds of harsh economic sanctions that targeted Iran’s banks, petroleum exports, foreign assets, and ability to do business internationally.

The 2015 nuclear deal negotiated by the Obama administration offered Iran a way out from under these crippling sanctions. The Joint Comprehensive Plan of Action (JCPOA), as the deal is known, was signed by seven countries plus the European Union: Iran, the United States, Russia, France, China, Britain and Germany. Under the deal, Iran made five key commitments in exchange for the promise of partial relief from international sanctions. These commitments were structured to ensure that Iran remained at least one year away from enriching enough uranium to build a nuclear weapon, if it ever decided to do so.

- **Limits on centrifuges.** Iran agreed to reduce its number of operating centrifuges to about 5,000 (from the current level of 19,000) for a period of ten years. Those 5,000 centrifuges may only be first-generation machines, and may only be operated at a single enrichment facility at Natanz.

- **Limits on enrichment levels.** Iran is prohibited from enriching uranium beyond a maximum purity level of 3.67% — the level required for use in nuclear power plants — for a period of 15 years.

- **Limits on uranium stockpile.** At the time of the agreement, Iran possessed nearly 10,000 kilograms of low-enriched uranium — enough to make eight to ten nuclear weapons, according to the White House. While low-enriched uranium cannot directly be used in a nuclear weapon, enriching it to a weapons-grade level would take much less time than starting from natural uranium. The agreement limits this stockpile to 300 kilograms.

- **Constraints on plutonium production.** Iran has been building a “heavy-water” nuclear reactor near the town of Arak, which could produce plutonium. The JCPOA commits Iran to redesigning the reactor so that it cannot produce weapons-grade plutonium, and prohibits Iran from conducting any plutonium reprocessing.

- **Inspections and monitoring.** To ensure Iran’s compliance with these limitations, the agreement specifies a variety of monitoring and inspection provisions to be overseen by the IAEA. These provisions include IAEA monitoring of Iran’s uranium mills, enrichment facilities, centrifuge manufacturing infrastructure, and other facilities.

In January 2016, the IAEA certified that Iran had met its key obligations under the JCPOA, including: shipping 98% of its low-enriched uranium to Russia, dismantling more than 12,000 centrifuges, and disabling the Arak reactor by pouring cement into its core. As stipulated by the agreement, the United States and European Union then lifted a variety of oil and financial sanctions on Iran. However, several U.S. sanctions that were not part of the agreement, including the U.S. trade embargo, remain in place.

Despite this apparent nonproliferation success story, President-elect Trump and many Congressional Republicans have been critical of the deal. During the recent presidential campaign, Mr. Trump maintained that the deal amounted to appeasement of a hostile foreign regime, and that Iran would ultimately renege. “They are going to have nuclear weapons,” he argued after the deal was struck. “They are going to take over parts of the world that you wouldn’t believe. And I think it’s going to lead to nuclear holocaust.” Mr. Trump’s comments echoed those of Israeli Prime Minister Benjamin Netanyahu, who called the deal a “stunning, historic mistake.”

Critics of the agreement cite several concerns. One concern is that Iran could construct — or may already possess — secret nuclear facilities that are not encompassed by the deal. Indeed, in both 2002 and 2009, Iran was revealed to be constructing secret facilities for uranium enrichment and plutonium.
production. A second objection centers around the deal’s timeframe: instead of committing Iran to permanent limits on its ability to enrich uranium, many of the agreement’s key provisions expire after 15 years. Third, critics worry that the removal of economic sanctions and the return of $100 billion in assets under the agreement will strengthen Iran’s economy and provide it with the resources to augment its nuclear program in the future. And most broadly, some have argued that the deal sends a signal of weakness to Iran, suggesting that the United States is not resolved to prevent it from acquiring nuclear weapons. John Bolton, who served as U.S. Ambassador to the UN under President George W. Bush, called the agreement “the worst act of appeasement in American history.”

President-elect Trump has not specified exactly how he will approach the Iran deal. Some of Mr. Trump’s key advisers are fierce critics of the deal, including Rep. Mike Pompeo (R-KS), his selection for director of the Central Intelligence Agency, who tweeted that “I look forward to rolling back this disastrous deal with the world’s largest state sponsor of terrorism.” In an op-ed in USA Today, Mr. Trump himself promised to renegotiate the agreement, though he did not say which provisions he would seek to change. He will have the ability to unilaterally restore U.S. sanctions on Iran, which Iranian leaders have said they would treat as a breach of the agreement. If Iran withdraws from the deal, the United States could lose the ability to monitor its program through IAEA inspections. Moreover, the other parties to the agreement—including Russia and key European Union countries—have expressed little enthusiasm for returning to the negotiating table. Whether to risk alienating America’s allies in Europe in exchange for a second bite at the apple is one of the first foreign policy decisions Mr. Trump will have to make.

North Korea

While Iran appears to have taken meaningful steps away from a nuclear weapon, the Democratic People’s Republic of Korea—or North Korea—has moved decisively in the opposite direction under the leadership of “supreme leader” Kim Jong Un. After testing its first nuclear device in 2006, North Korea has repeatedly over the last two decades. In 1994, the Clinton administration reached a deal with North Korea known as the Agreed Framework, which called for North Korea to freeze its nuclear program in exchange for new nuclear reactors, fuel oil for heating and electricity, and a gradual normalization of relations with the United States. While North Korea complied with part of the agreement by halting plutonium production, it simultaneously launched a covert uranium enrichment program. When this program was discovered in 2002, the United States responded by terminating shipments of fuel oil, and North Korea announced its withdrawal from the NPT—the only country ever to do so.

Following North Korea’s first nuclear test in 2006, the UN Security Council adopted a series of increasingly severe economic sanctions on North Korea, including arms and technology embargoes, luxury good bans, trade and financial restrictions and travel bans for key North Korean personnel. A number of other countries, including the United States and the European Union, have imposed their own sanctions over the last decade as well. Yet while these sanctions have damaged the North Korean economy, they have not stopped its nuclear program. Indeed, Jae Ku, director of the U.S.-Korea Institute at Johns Hopkins School of Advanced International Studies, argues that “no amount of sanctions will stop North Korea. Nuclear weapons are their sole survival strategy.”

One reason economic sanctions have failed is that key countries—especially China—do not enforce them as vigorously as the United States would prefer. China is North Korea’s most important ally and its largest trading partner, accounting for more than 70% of its trade volume. In 2014, trade between the two countries reached almost $7 billion. China recently opened a new
high-speed rail line to North Korea, and established new shipping routes to boost its imports of North Korean coal. A key reason for China’s reluctance to push Pyongyang harder is that it does not want to destabilize the North Korean regime. A collapse of the North Korean government could send hundreds of thousands of refugees across the border into China, an event that Chinese leaders desperately want to avoid. The effectiveness of economic sanctions therefore has been limited, as China attempts to balance its opposition to North Korea’s nuclear program with its desire to preserve a stable North Korean regime.

For the incoming Trump administration, North Korea’s nuclear program poses a variety of challenges. First, the new administration will have to decide what level of North Korean nuclear development—if any—is unacceptable. The North Korean government asserts that it has successfully tested a hydrogen bomb and that it can mount nuclear warheads on ballistic missiles. While experts are skeptical of those claims—and North Korea has provided no hard evidence to corroborate them—it seems clear that North Korea harbors ambitions to achieve these goals, and it has made significant progress developing long-range ballistic missiles over the last several years. The Trump administration will need to decide which technological milestones it is unwilling to let North Korea reach.

Once the new administration decides on its red lines, the next question is how to enforce them. Military force is one option. During the 1994 crisis, the United States considered—and rejected—an attack against North Korea’s nuclear facilities. Presidents George W. Bush and Barack Obama likewise declined to use military force to stop North Korea’s nuclear progress. One key reason is that a war against North Korea’s 1.2 million-man army would be calamitous for South Korea, which would suffer devastating artillery—and possibly nuclear—attacks. East Asia experts Victor Cha and David Kang estimated that North Korea could fire 500,000 rounds of artillery in the first hour of a conflict. Hundreds of thousands, and perhaps millions, could be killed. Moreover, China might elect to enter a war on the side of North Korea to prevent the country’s collapse, as it did in 1950 during the Korean War.

But it is also possible that North Korea might back down in the face of a U.S. preemptive strike, especially if China or Russia were willing to come to its aid. Without outside assistance, the North Korean army would almost certainly be defeated by the smaller but more-sophisticated forces of the United States and South Korea. Anticipating this outcome, Kim Jong Un might call for Russia or China to help negotiate a face-saving resolution to the crisis rather than initiate a war that would almost certainly end in the collapse of his own regime. But North Korea’s erratic behavior and bellicose rhetoric make it difficult to tell how it might react if attacked. A coercive strike would certainly be a tremendous gamble for the United States— with potentially catastrophic consequences if North Korea did not respond as planned.

If history is any guide, the next president is likely to have no more success ending North Korea’s nuclear program than its predecessors. One alternative, then, is to simply accept North Korea’s nuclear status and rely on deterrence to contain the threat. Indeed, President Obama’s Director of National Intelligence, James Clapper, argued in 2016 that convincing North Korea to give up its nuclear weapons peacefully is “probably a lost cause.” If the next administration agrees that coercive diplomacy is unlikely to work, it could focus instead on reinforcing U.S. commitments to defend its allies in Northeast Asia.

During the presidential campaign, however, President-elect Trump appeared to lean in the opposite direction, suggesting that the United States might withdraw its military forces from South Korea and Japan and leave the two countries to develop their own nuclear weapons. “They have to protect themselves or they are going to have to pay us,” he argued, prompting furious reactions from Japanese and South Korean leaders.

The challenge for the next administration therefore is how to contain the North Korean threat without provoking it, while simultaneously reassuring America’s allies in Northeast Asia. The United States has now lived with a North Korean nuclear weapon for more than a decade. Whether it can continue to do so will be up to Mr. Trump.
Nuclear weapons at home and abroad: U.S. options

Nuclear modernization debate

For decades, the United States has deployed its strategic nuclear weapons on three basic platforms: land-based intercontinental ballistic missiles (ICBMs), strategic bombers, and submarine-launched ballistic missiles (SLBMs). This collection of platforms is often called the “nuclear triad.” Today, the United States deploys roughly 1,750 strategic weapons on these vehicles. By maintaining diversity in its nuclear arsenal, American leaders hope to minimize the possibility that an enemy could destroy the entire U.S. arsenal in a single attack. This principle is the cornerstone of nuclear deterrence.

But the U.S. nuclear triad is aging. For example, the country’s 76 nuclear-capable B-52H bombers were produced in the early 1960s and are now decades older than the crews flying them. Its 450 Minuteman III ICBMs were last produced in 1977—40 years ago. The nuclear warheads themselves are beginning to gray as well: the United States has not produced a new nuclear warhead since the early 1990s, making the average age of a U.S. nuclear warhead nearly 30 years old, well past its intended lifespan of 20 to 25 years. Moreover, because of a voluntary national moratorium on nuclear testing, existing weapons cannot be tested to assess their reliability.

Beginning in 1993, the United States established the Stockpile Stewardship Program, a program intended to maintain the reliability and safety of U.S. nuclear warheads in the absence of nuclear testing. Under this initiative, the national laboratories conduct experiments, materials testing, and computer simulations to evaluate potential problems as the arsenals age. They also implement Life Extension Programs designed to repair and replace thousands of high-precision components contained in nuclear warheads before they deteriorate. These programs have extended the life of existing nuclear warheads by up to thirty years beyond their original lifespan.

In response to concerns about the age and reliability of the U.S. nuclear triad, in 2014 the Obama administration embarked on a long-term effort to modernize the U.S. nuclear arsenal. These plans call for upgrading the U.S. warhead stockpile and either modernizing or replacing each leg of the triad.

But this modernization plan has its critics. One objection is to its cost: independent estimates put the cost of nuclear arsenals modernization at more than $1 trillion over the next 30 years. These costs include replacing the nation’s ballistic missile submarines, building a new fleet of strategic bombers, buying new ICBMs, developing a new air-launched nuclear cruise missile, and refurbishing existing nuclear warheads. Sen. John McCain (R-AZ), chairman of the Senate Armed Services Committee, remarked dryly: “it’s very, very, very expensive.”

Other critics have observed that the Obama administration’s modernization plans conflict with his commitment to pursue nuclear arms reductions. In 2009, shortly after taking office, President Obama delivered a widely publicized speech in Prague declaring that he intended to “reduce the role of nuclear weapons in our national security strategy.” His vision appeared to take shape the following year, when the United States reached a nuclear arms reduction agreement with Russia known as “New START.” Yet the modernization initiative suggests that deteriorating relations with Russia since 2010 have convinced the Obama administration to maintain a high priority on nuclear weapons.

U.S. nuclear modernization plans may also be in tension with international nonproliferation objectives. Article VI of the NPT stipulates that nuclear nations must “pursue negotiations in good faith on effective measures relating to cessation of the nuclear arms race at an early date and to nuclear disarmament.” While the treaty provides no deadline for this obligation, some international observers have complained that the modernization program conveys the impression that the United States has no intention of meeting this commitment.

In light of these concerns, several questions face the incoming Trump administration. The new president will first have to decide whether to continue the nuclear modernization program launched by President Obama. Early indications suggest that he plans to do so: Mr. Trump complained during the 2016 presidential campaign that “our nuclear program has fallen way behind,” and promised to “ensure our strategic nuclear triad is modernized to ensure it continues to be an effective deterrent.”

Modernization plans, however, may confront budgetary realities. Jeffrey Lewis, a nuclear expert at the Monterey Institute of International Studies, argued that “there isn’t enough money” to fund the entire modernization effort. If Congress indeed balks at the price tag, the Department of Defense will face difficult choices about which aspects of the plan to retain.

Budgetary concerns have prompted some analysts to suggest that the United States reconsider the need to maintain a complete nuclear triad. For example, nuclear experts from the Federation of American Scientists and the Natural Resources Defense Council argued that the United States should eliminate the sea-based leg of the triad, basing nuclear weapons solely on less-expensive ICBMs and bombers. In their view, this approach would maintain deterrence at an acceptable cost while also simplifying the nuclear command and control system. Others have suggested maintaining only the submarine leg of the triad, reasoning that submarines are more difficult to locate and destroy, and therefore more credible as a deterrent force. The Obama administration
in 2013 reaffirmed its commitment to maintaining all three legs of the triad, but a new administration staring at a trillion-dollar modernization bill might reevaluate this position.

**Nuclear weapons abroad**

During the Cold War, the United States deployed nuclear weapons to at least 14 other countries. At the peak of these deployments during the 1970s, the number of U.S. nuclear weapons stationed abroad exceeded 7,000.

The primary purpose of deploying nuclear weapons abroad was to deter Soviet aggression. Beginning in the 1950s, U.S. leaders believed that the powerful Soviet military could be deterred only by a credible nuclear threat. The United States deployed nuclear weapons throughout Europe and the Mediterranean, beginning with nuclear gravity bombs delivered to French Morocco and Britain in 1954. These “non-strategic” nuclear weapons were thought to deter the Soviet Union because they created a credible risk that a conventional war in Europe would turn nuclear—even if inadvertently.

Today, the Soviet Union is long gone, but the United States maintains perhaps 200 nuclear gravity bombs in five NATO countries: Belgium, Germany, Italy, the Netherlands and Turkey. And official NATO policy continues to affirm the role of these weapons as a deterrent against potential aggressors.

Yet U.S. nuclear deployments in Europe recently have come under scrutiny. The failed July 2016 coup d’état in Turkey—where the United States stores its largest cache of nuclear weapons—refocused attention on the risks of stationing nuclear weapons beyond U.S. borders. Incirlik Air Base, where these weapons are stored, was closed for 24 hours during the coup attempt, and electricity was cut off. The Turkish commander of the base was later arrested for collaborating with the coup plotters. Fortunately, the base witnessed no clashes between coup supporters and opponents, but the incident revived decades-old concerns about the security of U.S. nuclear weapons abroad.

Indeed, this was not the first time a security breach occurred at a foreign installation storing U.S. nuclear weapons. In 2010, for example, peace activists made their way through two perimeter fences at a Belgian air base, entered a bunker containing nuclear weapons vaults, and wandered around for an hour before finally being apprehended by an unarmed guard. Incidents such as these have led former U.S. Sen. Sam Nunn (D-GA) to conclude that U.S. nuclear weapons abroad are “more of a security risk than asset to NATO.”

In addition to citing security concerns, critics of these deployments argue that U.S. nuclear weapons in Europe no longer serve any military purpose. The Soviet threat to Western Europe disappeared a quarter-century ago, leaving the United States as the world’s dominant conventional military power. The United States therefore no longer needs these nuclear weapons to compensate for conventional weakness. U.S. nuclear weapons in Turkey cannot even be used, since neither the United States nor Turkey has any aircraft at the Incirlik base capable of delivering them. According to former State Department official Richard Sokolsky and scholar Gordon Adams, “the military rationale for maintaining U.S. nuclear weapons in Europe has all but disappeared.”

Even the historical deterrent value of U.S. nuclear deployments abroad has been disputed. A 2014 study conducted by Matthew Fuhrmann and Todd S. Sechser investigated nuclear deployments to 23 countries between 1950 and 2000, concluding that foreign-based nuclear weapons did not strengthen the deterrent effect of NATO and other alliances during this period. “While having a nuclear ally carries important security benefits,” they write, “those benefits do not appear to be enhanced by hosting the ally’s nuclear weapons.”

The cost of maintaining nuclear weapons abroad has also become more salient in light of current debates about modernizing the U.S. arsenal. Former Defense Department officials Barry Blechman and Russell Rumbaugh have observed that the 200 or so weapons in Europe will add at least $8 billion to the cost of modernization: not only are the warheads themselves slated to be redesigned, but new aircraft will also need to be configured in order to carry them.

Yet the case for removing U.S. nuclear weapons from Europe is not entirely straightforward. Advocates of the weapons argue that they are important symbols of reassurance to NATO allies. Three former high-ranking national security officials—including two former national security advisers—argued that U.S. nuclear weapons in Europe are “fundamentally, political weapons.” Their primary purpose, in this view, is not military, but symbolic: they serve as a visible reminder to both allies and adversaries of the U.S. commitment to defend NATO allies with every available tool. Withdrawing them could send an ominous message that this commitment has weakened, and perhaps create pressures for U.S. allies to obtain their own nuclear weapons.