
Kidde
Kokoon
FALLOUT SHELTER
CANNED WATER

During the Cold War, in the 1950s and '60s, the fear of nuclear war drove thousands of U.S. families to provide themselves with costly bomb shelters (also called fallout shelters), either converting their basements or installing prefabricated shelters several feet underground in their backyards. The shelters were stocked with essential supplies, and even some amenities, against the possibility of the families' having to shelter for many days or weeks. (Photo: Open Source)

RETHINKING THE UNTHINKABLE

The Cold War began in 1945 with the use of nuclear weapons to end World War II and officially ended in December 1989 with a joint declaration in Malta by Presidents George H. W. Bush and Mikhail Gorbachev. In retrospect, excepting the regional wars in places like Korea and Vietnam, this 44-year period was remarkably stable. While many factors contributed to this stability, the contribution of nuclear weapons is undeniable.

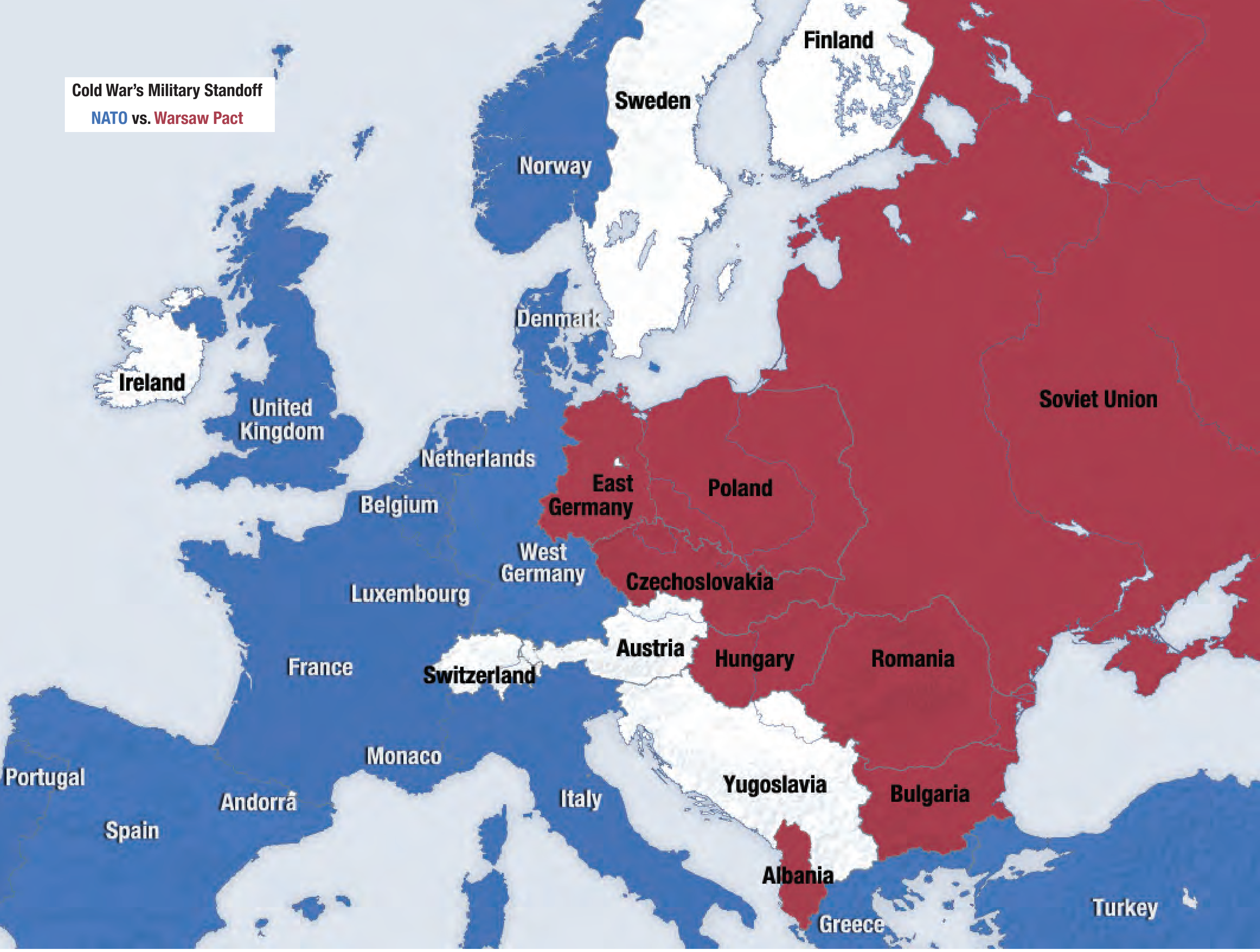
Nowhere is this stability more obvious than in Europe. During the 3.5 centuries before 1945, a major war had erupted in Europe every 11.9 years, and each lasted an average of 6.6 years. As the weapons for conventional war improved, each new war was more vicious and cost more in human lives than the previous one.

Yet for over 40 years following World War II, opposing U.S. and Soviet forces were poised for war in Europe but remained fixed in place. Why? Amassing adequate conventional forces in Western Europe to counter Soviet forces had been politically, economically, and geographically impossible. The peak size of the U.S. Army during the Cold War was 18 divisions. The Soviets had approximately 200 divisions. Western Europe could not have been protected from Soviet aggression without the balance of power brought by the omnipresent American nuclear weapons.

The prospect that any untoward movement to the east or to the west would precipitate the nuclear annihilation of nations, on both sides of the Iron Curtain, resulted in the stalemate created by nuclear weapons. The certainty of "mutually assured destruction" (MAD) reversed that centuries-old pattern of major European warfare and carnage. Europe has not had a major war for 69 years. So while a national security strategy based on MAD might not be Nirvana, history shows that as a deterrent, it worked.

How Deterrence Worked

During the Cold War, much was written on specific factors necessary to achieve deterrence. These requisite factors always included the following: (1) maintaining an acceptable degree of strategic parity between the states involved, (2) having confidence that weapons involved in deterrence would function as designed if called upon to do so, (3) avoiding significant surprises regarding advancements in the nuclear capabilities of foreign nations, and (4) ensuring that intelligence for the U.S. decision makers would be of the highest caliber possible. Prompt and accurate detection of foreign launch preparations and/or actual launches was an important aspect of this latter paradigm. Distinguishing Soviet exercises from actual preparations for a preemptive attack was equally important. Let us examine each of these in turn.



Nuclear weapons work without being detonated. They kept the Warsaw Pact's armies at bay for almost 50 years.

Maintaining Parity

Maintaining the evolving strategic parity with the Soviet Union resulted in the nuclear arms race. Ultimately, parity was arguably a non sequitur in that both the United States and the Soviet Union had more than sufficient numbers and varieties of nuclear warheads and delivery systems to destroy the other, even if a substantial fraction of these nuclear weapons had been destroyed in a preemptive attack.

Confidence That Your Weapons Will Work

Confidence on both sides that their respective nuclear weapons would function properly was achieved through well-funded nuclear weapons physics and engineering laboratories—staffed with scientists and engineers of the highest caliber—and through well-planned nuclear weapons testing programs. These tests were originally in the atmosphere and later underground. Ironically, radioactive debris from the atmospheric tests provided the other party with significant insights into the testing party's technology. This fact, and not concern over introducing radioisotopes into the environment, may well have constituted the most compelling impetus for underground testing.

In any case, when the 1963 Limited Test Ban Treaty moved all nuclear weapons testing underground, its ratification by the U.S. Senate was accompanied by robust safeguards that required the following: the maintenance of modern nuclear weapons laboratories and associated research; the establishment of the National Nuclear Test Readiness Program to enable a return to atmospheric testing if necessary for "supreme national interests;"[1] an active program to improve methods to detect, characterize, and monitor foreign nuclear

[1] A proviso of the 1963 Limited Test Ban Treaty authorized a resumption of U.S. atmospheric nuclear testing if the safety or reliability of the nuclear weapons stockpile could not be assured, with high confidence, without testing. The proviso grew out of the 1961 surprise Soviet withdrawal from the U.S.–Soviet mutual testing moratorium. From September through December, the Soviets conducted 56 tests, including the October test of the world's largest-ever (more than 50 megatons) nuclear weapon, "Tsar Bomba." They conducted more than 70 additional tests in 1962. The United States rushed to reestablish its own tests, but took until April 1962 to conduct its first one. The treaty's proviso is meant to ensure that the United States retains its nuclear testing capability even during test moratoriums like the current one.

detonations; and a robust nuclear weapons intelligence program. In the United States, similar safeguards were again appended to both the 1974 Threshold Test Ban Treaty and the 1996 Comprehensive Test Ban Treaty (CTBT). (The provisions of the CTBT are de facto in effect. The treaty was rejected by the U.S. Senate in 1999 by a vote of 51 to 48.)

No Big Surprises, Please!

During the Cold War, avoiding being surprised by some advancement in the nuclear capability of a foreign nation was considered essential, and this fact drove the development and use of many highly advanced technologies to gather information of the highest quality. This strategy gave rise to many critical innovations, including the Atomic Energy Detection System, which looked for nuclear weapon detonations; worldwide signal intelligence, including communications intelligence and electronic intelligence; reconnaissance systems, including the U-2 spy planes and Corona photographic satellites; and missile-launch detection systems. Of course, human-gathered intelligence was critical too, and much of what are viewed as "classical" espionage activities focused on gathering intelligence on nuclear capabilities.

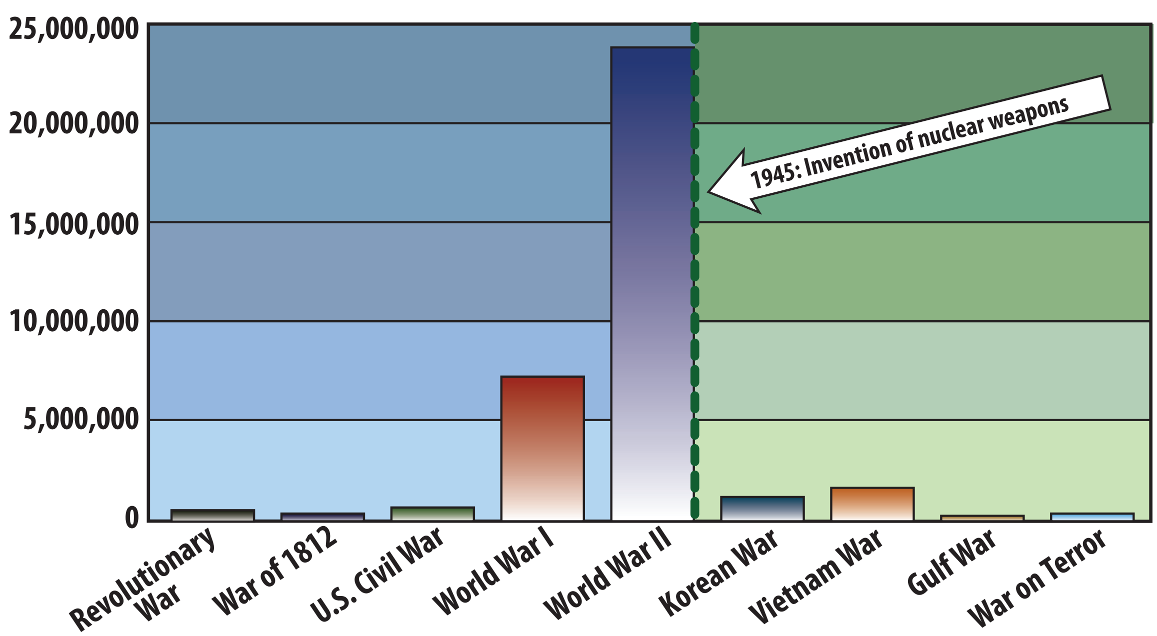
Intelligence Analyses for Making Decisions

Capabilities dedicated to analyzing this type of information for the government's decision makers were well-funded and diversified and included using nuclear scientists, particularly those at the nuclear weapons laboratories, as analysts. The value of using U.S. experts in nuclear weapons to review the data on foreign nuclear weapons activities is obvious.

The Central Intelligence Agency (CIA) established a Field Intelligence Element (FIE) at Lawrence Livermore National Laboratory, and the Defense Intelligence Agency formed FIEs at both Los Alamos and Sandia National Laboratories. In 1976 George H. W. Bush Sr., then the director of the CIA, exempted the Department of Energy's (DOE) FIEs from "contractor" status, an action that provided these civilian FIEs with exceptional access to intelligence information.

How Deterrence Is Working Today: Cold War Lessons Forgotten in a Hot, New World

With the end of the Cold War, the world political landscape has become much more convoluted and unpredictable and dangerous. Nowhere is this change more obvious than in the growing animus toward the United States as the world's chief superpower and its major cultural bully. A concomitant surge has also arisen in reemerging historical conflicts, regional "warlordism," lethal violence by nonstate actors, and international competition for resources, especially energy. Against this new backdrop, terrorists with the declared goal of acquiring nuclear weapons are being supported directly by nations actively pursuing such capabilities themselves in direct violation of international agreements, for example, Hezbollah receiving support from Iran. Other jihadist terrorists, some of them emboldened by "fatwas," are looking for opportunities to acquire nuclear weapon materials directly through theft or diversion.

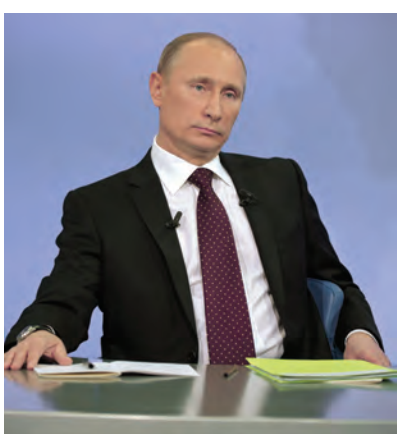


Estimated military deaths from wars before and after MAD. In addition, there were up to 55 million civilian deaths during World War II. Europe has not had a major war for 69 years.

There is a reemergence of confrontational strategies by Russia towards the United States. For example, during major strategic exercises in 2013, the Russians flew two Tu-160 Blackjack strategic bombers to Venezuela. In the Tu-160 shown here, Putin is the pilot launching the cruise missile. The Tu-160, which entered service in 1987, remains the largest supersonic aircraft in the world. The Tu-160 is designed to destroy strategic targets with nuclear or conventional weapons. Some of the Tu-160s are being modernized, but they will be replaced by a new-generation strategic bomber known as PAK-DA. *(Photos: Open Source)*

Tough Talk from the Bear . . .

Russia's recent actions to demonstrate its independence, military prowess, and new economic power are troubling. These actions include probes by Russian strategic bombers of U.S. naval operations and air defenses around Alaska, Canada, Greenland, and Great Britain; large joint exercises involving Russian and Chinese armed forces; Russia's continued support of Iran's nuclear ambitions; explicit nuclear threats against Poland for accepting a missile defense base on Polish territory; the military incursions into the Republic of Georgia; and more recently, the illegal seizure of Crimea from the Ukraine.



In March 2014, during the crisis in Crimea, Russian spokesman Dmitry Kiselyov starkly reminded the United States that, "Russia is the only country in the world that is realistically capable of turning the United States into radioactive ash." In December 2013 President Putin had named Kiselyov to head a new state news agency charged with portraying Russia in the "most positive light."

Russian Chief of Staff General Yuri Baluyevsky bluntly stated Russia's policy on the use of nuclear weapons: "We do not intend to attack anyone, but we consider it necessary for all our partners in the world community to clearly understand . . . that to defend the sovereignty and territorial integrity of Russia and its allies, military forces will be used preventively, *including the use of nuclear weapons.*"[2] [Emphasis added.]

> **"Russia is the only country in the world that is realistically capable of turning the United States into radioactive ash."**
>
> **~Russian spokesman**

Immediately, many Western policy analysts concluded that Baluyevsky's remarks did not really constitute a shift in Russian policy. However, even a casual observer must consider the policy in the context of the significant modernization now on-going in Russian tactical and strategic nuclear forces and the disturbing increases in Russian probing of Western defenses and resolve.

. . . While the Eagle Is Napping?

While the Russian military holds a positive view of nuclear weapons, these weapons have lost support within elements of U.S. armed forces assigned residual responsibility for them. For example, in August 2007, six nuclear weapons were accidentally loaded on a B-52 strategic bomber at Minot Air Force Base (AFB), North Dakota, and flown to Barksdale AFB, Louisiana, where they sat on the tarmac unnoticed

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[2]General Baluyevsky made this statement in January 2008 at a military conference that was broadcast on Russia's state-run cable Vest-24.

The Bear Comes Out of Hibernation

Nicknamed the "Bear," Russian Tu-95 nuclear capable bombers are again practicing attacks against the United States. (Photo: Open Source)

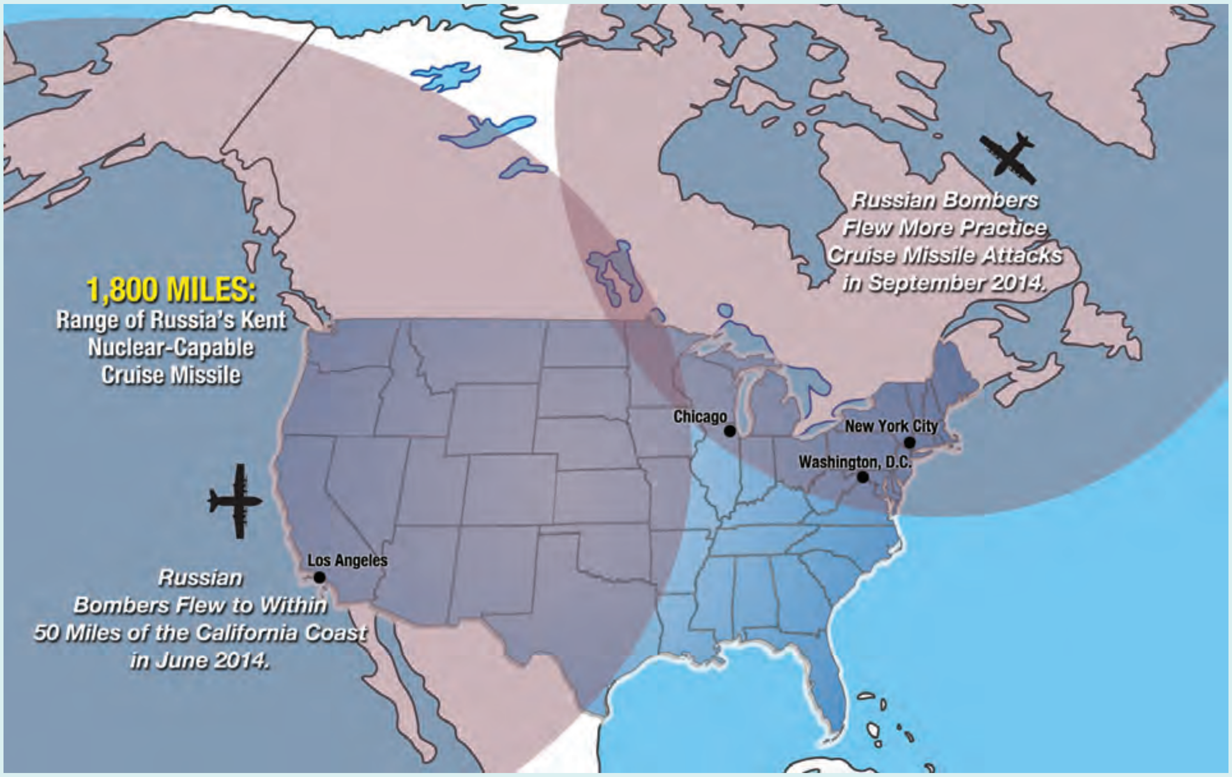
On August 17, 2007, Russian President Vladimir Putin announced that Russian heavy bombers were resuming regular air patrols outside Russian territory: "I have decided that flights of Russian strategic aircraft on a permanent basis should be resumed . . . ." Putin was reversing U.S.-Russia parallel and unilateral post–Cold War decisions to stop nuclear-capable bomber combat patrols into each other's air defense identification zones.

Since then there have been more than 50 instances of Russia's ignoring the post–Cold War practice. On June 13, 2014, Russian Tu-95 bombers, which can carry nuclear weapons such as the Russian AS-15 Kent cruise missile, with a range of 1,800 miles, flew to within only 50 miles of the California coast, close enough to threaten large U.S. cities in states as far east as Minnesota, Iowa, and Missouri. It was the closest a Russian aircraft had come to California since July 2012.

Then in September 2014, Russian bombers flew a similarly aggressive mission off the northeast coast of Canada. They came close enough that their cruise missiles could have reached Chicago, New York City, and Washington, D.C.

It is not known if the Tu-95s were armed with nuclear weapons on either of these occasions.

The Tu-95s can legally come inside the U.S. air defense identification zone, which extends 200 miles from the coastline and is part of international airspace. Foreign aircraft are required to identify themselves inside the zone. U.S. sovereign airspace, which foreign military aircraft may not enter without permission, extends 12 miles beyond the coast.



In 2009 Russian resumed its Cold War–era nuclear submarine patrols off U.S. coastlines. Pictured here is a Russian Delta IV nuclear missile submarine. The Delta-class submarines are being replaced with the modern Borei-class submarines, armed with newly designed ballistic missiles carrying new nuclear warheads. Russia has increased its military spending by 100 percent since 2004. (Photo: Open Source)

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for *36 hours*. The Defense Science Board, charged with investigating the incident, concluded that commingling nuclear forces with nonnuclear organizations has led to "markedly reduced levels of leadership whose daily focus is the nuclear enterprise and a general devaluation of the nuclear mission and those who perform the mission."

Obviously, the mishaps of a few should not be used to denigrate the commitment of whole commands. However, nuclear weapons, which were designed to prevent war, arguably have never been popular with the majority of military officers, whose careers are often defined by their execution of war and not their maintenance of peace. Clearly, sitting in a silo watching over a 30-something-year-old nuclear-tipped missile under an aged banner declaring "Peace Is Our Profession" is not as exciting and ribbon-garnering as flying a new F-22 Raptor air-superiority fighter into combat. On the positive side, General Norton Schwartz, at that time the U.S. Air Force Chief of Staff, declared the reinvigoration of the Air Force's nuclear enterprise his "number one priority."

Unfortunately, several recent widely publicized events, such as one at Malmstrom AFB in Montana, suggest that this "reinvigoration" has not been realized. In January of this year, more than 90 Malmstrom missileers, officers in charge of nuclear-armed ballistic missiles, were suspended for cheating or condoning cheating on monthly proficiency exams. The cheating was revealed during an investigation of illegal drug use and involved nearly half of the base's missile launch crew.

Are Smaller Stockpiles Really Better?

If Russian and U.S. deployed stockpiles are reduced below several thousand to several hundred weapons, the relative influence that other, smaller nuclear weapons arsenals could have on international security and stability would increase significantly. The possibility of producing enough weapons to reach parity would certainly be attractive to China and within its reach.

As with Russia, China has embarked on a major initiative to improve and modernize its nuclear weapons complex, beginning under Deng Xiaoping's 1978 economic reforms. More recently, this continuing initiative has greatly benefitted from the industrial modernization that is occurring in China, particularly from improvements in high-performance computing, precision manufacturing, and quality assurance.

> **Without very careful planning, disarmament would take us into an even more unstable and dangerous world.**

If the downsizing of Russian and/or American nuclear weapon inventories were to entice China to expand its nuclear weapons arsenal to parity with them, that expansion would not be constrained by a lack of technology or resources or by extant proscriptive treaties. Obviously, bringing China

Like Russia, China has embarked on a major push to improve and modernize its nuclear weapons complex and its military capabilities in general. China has increased its military spending by 170 percent since 2004. Shown here is the Chengdu J-20, a stealth, twin-engine fifth-generation fighter aircraft prototype. The J-20 is expected to be operational in 2017–2019. (Photo: Open Source)

into any nuclear arms reduction negotiations between Russia and the United States would become increasingly important.

As with Russia, China has a major initiative to improve and modernize its nuclear weapons complex.

Smaller U.S. and Russian stockpiles could even encourage the nuclear weapon ambitions of emerging nuclear weapon states such as Iran. The status of Iranian aspirations toward achieving a nuclear weapons capability is somewhat confusing. For example, in 2008 one National Intelligence Estimate (NIE) concluded that Iran had made the decision to stop its nuclear weapons program. Other experts disputed this estimate. Ironically, in another estimate, the NIE concluded with moderate confidence that the earliest possible data Iran would be technically capable of producing enough highly enriched uranium for a weapon was late 2009. Even Director of National Intelligence Admiral Michael McConnell seemed to reconsider the NIE's first estimate when he said, "I think I would change the way that we described [the Iranian] nuclear program."[3]

[3]Admiral McConnell's clarification came in testimony to the Senate Select Committee on Intelligence on February 5, 2008. He added, "We remain concerned about Iran's intentions and assess with moderate-to-high confidence that Tehran at a minimum is keeping open the option to develop nuclear weapons."

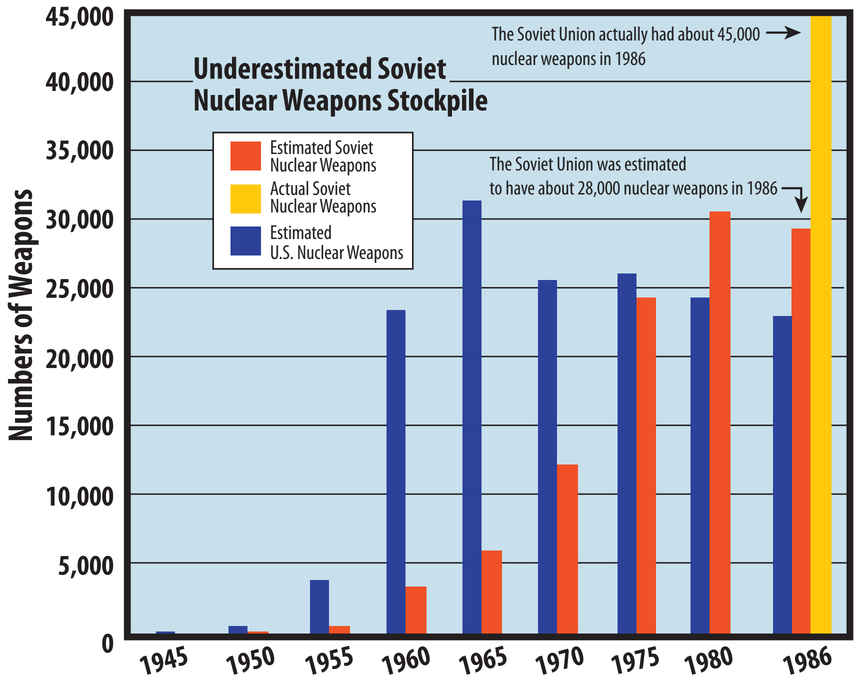
Whatever the actual status of Iranian nuclear weapon ambitions and capabilities, the rhetoric and ambitions expressed by Iran would lead one to conclude that nuclear weapons are an essential element in the reestablishment of Iran's historical dominance within the Fertile Crescent. In that case, negotiated reductions of Russian, American, and possibly Chinese arsenals must consider Iranian ambitions.

Of course, lower U.S. and Russian force levels also could precipitate a switch in their targeting strategies. Specifically, emphasis on "countervalue" targeting (the targeting of cities and civilian populations versus military assets) could supplant strategies based on "counterforce" targeting (military assets). While any strategies involving nuclear weapons would hold large populations at risk, at least indirectly, the change to smaller nuclear arsenals could result in the change to direct targeting of population and industrial centers, thereby giving each nuclear warhead a larger "deterrent value."

In the absence of very careful planning, the march toward disarmament would take us backwards into an even more unstable and dangerous world.

Seeking Balance in a New and Unstable World

In this unstable world, or possibly because of the instability, almost everyone would agree that the nuclear arsenals of the United States and Russia exceed numbers required for nuclear deterrence provided that a requisite balance is also achieved in the other defense elements that contribute to



In 1986 the United States underestimated the Soviets' nuclear arsenal by about 17,000 weapons.

deterrence. From the perspectives of both sides, those other defense elements include the respective confidence in their capabilities to maintain and certify the safety and reliability of their nuclear weapons, their extant abilities to rapidly reconstitute larger and/or different arsenals should these become necessary, and the survivability and reliability of their delivery systems.

For the United States, other essential defense elements include the possibility of resuming nuclear weapons tests under the "supreme national interest" clause of the CTBT. Such tests would be to ensure nuclear weapon readiness and effectiveness and to remediate any major defects that might be discovered via our Stockpile Stewardship Program and that are deemed a threat to U.S. security.

Often overlooked by proponents of disarmament who focus on the relative numbers in active or reserve stockpiles, these other defense elements are essential to the calculus of stability and must be maintained even as nuclear arsenals are reduced toward any bilateral goal of ultimate elimination. Then again, even if the United States and Russia agree to lower levels, what is the basis for establishing the new levels, and can these levels be verified—given our prior record of inaccurately estimating the size and composition of foreign nuclear arsenals?

Maintaining Parity: Problems with the Numbers

Since the end of the Cold War, maintaining parity with Russia has resulted in extensive negotiations to reduce strategic nuclear weapon stockpiles, eliminate specific weapons, enact specific limits or bans on nuclear weapon testing, and enact specific limits on antiballistic systems and capabilities. Thus, the most referenced comparisons between the U.S. and Russian nuclear arsenals are the relative numbers of strategic (but not tactical) weapons in their active and reserve stockpiles.

However, generating an estimate of those numbers of weapons and then verifying the estimates are problematic. Historically, the estimates have not always been accurate. For example, the *error* in the estimated size of the Soviet nuclear stockpile during the Cold War was larger than the *entire stockpile Russia is estimated to have today*. In 1993 the Russians revealed that the Soviet's nuclear stockpile peaked in 1986 at 45,000 weapons. This number was 17,000 warheads above estimates from the U.S. intelligence community (IC) at the time. Today, estimates are that Russia has about 4,500 strategic weapons in its inventory. But how accurate are these new estimates?

The error in the estimated size of the Soviets' Cold War nuclear stockpile was larger than Russia's entire estimated stockpile today.

The primary driver for why the Cold War assessment was so wrong was a persistent belief on the part of the IC that Soviet production of highly enriched uranium was achieved using gaseous-diffusion technology, which is considered to be a relatively inefficient enrichment technology. As such, the estimated quantities of uranium that could be produced, about 500 metric tons, were incapable of supporting any larger estimate of the Soviet nuclear weapons inventory. This view was defended in spite of contrary information that, by the mid-1980s, the Soviets had developed a large surplus in uranium enrichment capacity as evidenced by the fact they were strenuously trying to market excess enriched uranium to Western Europe. We now know that the Soviet Union had converted its entire enrichment process to the highly efficient gas-centrifuge technology and that the IC estimate of Russia's highly enriched uranium was low by at least 500 metric tons.[4] Therefore, our estimate was off by 100 percent.

[4] An intelligence assessment prepared for the Starbird Study (1980) correctly assessed that Russia had converted its uranium enrichment process to gas centrifuges and estimated Russia's nuclear weapon stockpile at 45,500. This assessment was harangued by arms control advocates as "wild speculation by war mongers" and by the U.S. intelligence community as "misinformed." ("Russian Says Soviet Atom Arsenal Was Larger Than West Estimated," William J. Broad, *The New York Times*, Sept. 26, 1993)

Obviously, stability is best achieved within a framework where estimates can be verified promptly and with an acceptable degree of certainty. Unfortunately, our history in formulating such estimates does not add to our confidence that such estimates will be valid.

Moreover, at lower numbers of strategic weapons, the calculus of stability requires that tactical nuclear weapons must also be taken into account. This imperative arises because such categorizations as "tactical" and "strategic" are policy-driven differences without any significant military distinction. Tactical nuclear weapons are defined as those used on a battlefield whereas strategic weapons are used against cities and a nation's military-industrial complex. But a nuclear warhead is a nuclear warhead, and the "how" and "why" it might be used are nuances of no import to the people targeted.

Thus, a disparity in the number of stockpiled tactical nuclear weapons is as significant as a disparity in strategic weapons. Their numbers should be combined when determining the calculus of stability.

At lower numbers of strategic weapons, the calculus of stability requires that tactical nuclear weapons must also be taken into account.

Without Testing: Confidence That the Weapons Will Work

Arms control agendas must consider the United States' capabilities to maintain and certify the aging weapons in its reduced nuclear arsenals. In the absence of nuclear weapon testing, maintaining and certifying nuclear weapons have defaulted to the Stockpile Stewardship Program, which is based on computer simulations, nonnuclear experiments, and scientific observation of nuclear weapons materials and components.

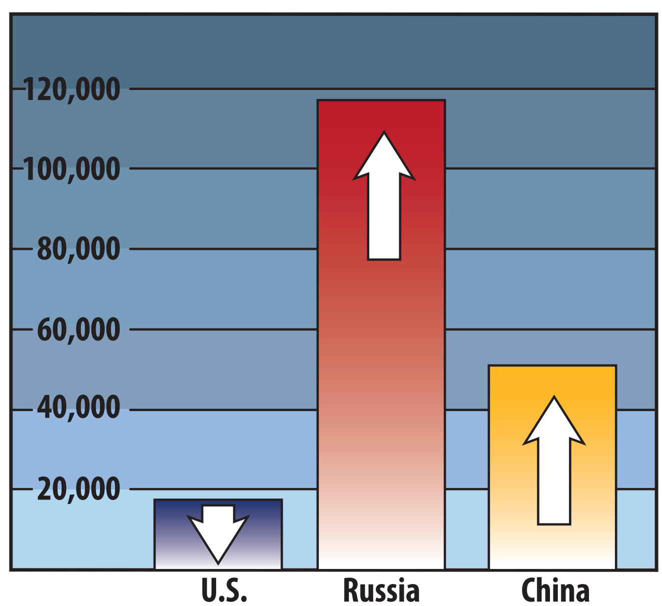
A second part of this program entails fabricating replacement warheads using extant procedures to replicate, as accurately as possible, the legacy warheads being replaced. Both parts of this program require the following: a significant reliance on legacy nuclear weapon designs and testing data; legacy manufacturing techniques that have fabrication problems, including a lack of detailed documentation regarding manufacturing designs and their acceptable tolerances; and access to materials that can adequately replace those no longer available, including some adhesives, lubricants, plastics, and materials (such as asbestos) that are now proscribed in the workplace.

Obviously, the most essential ingredient of any legacy-dependent program is the long-term retention of the requisite knowledge base and the special facilities upon which such a program must rely. But is this retention taking place?

The number of U.S. nuclear facilities that allow research on materials for nuclear weapons has been reduced significantly.

The U.S. nuclear weapons science laboratories were the last bastions within the DOE to be "transformed," that is, converted from nonprofit to for-profit organizations. Obviously, positive changes are always needed in any organization to preserve its vital capabilities. Such changes normally focus on cost savings, efficiencies, responsiveness, improvement in the work environment, and opportunities that will attract "the best and brightest" workforce.

It remains to be seen whether or not the recent transformations at both Los Alamos and Lawrence Livermore National Laboratories are successful. For example, have they retained benefits and hiring incentives sufficient to attract and retain a workforce with the requisite knowledge base capable of maintaining the extant U.S. nuclear weapon stockpile or of manufacturing replacement warheads? In fact, a number of the best mid-career contributors to whom the laboratories'



Estimated staffing of nuclear weapons complexes in 2014. The differences in the staffing are due primarily to the fact that Russia and China are maintaining and expanding their nuclear weapons production capabilities, while the United States has largely dismantled its capabilities.

After only 74 years of experience with the element, how well do we really understand plutonium? We still have problems predicting the stability of steel structures under stress, despite our over 2,000 years experience with steel. Here, cars rest on the collapsed portion of the I-35W Mississippi River bridge in Minneapolis, MN, after the bridge's August 1, 2007, collapse. (Photo: Open Source)

accumulated knowledge might have been transferred have already left or are planning to do so.[5]

For sure, in the absence of replacing these staff or providing other types of succession planning, workforce reductions at Los Alamos and Livermore have resulted in the loss of thousands of person-years of corporate memory covering the period of time in which U.S. nuclear weapons were designed, built, and actually tested. This is memory that is critically important to the national security mission of DOE's National Nuclear Security Administration (NNSA).

> **An essential ingredient of any legacy-dependent strategy is the retention of knowledgeable people and special facilities.**

In addition, the number of Category 1 nuclear facilities, the category that allows research on plutonium, uranium, and other materials for nuclear weapons, has been reduced significantly. For example, at Los Alamos, the number of such facilities has decreased from 12 in the late 1980s to 1 today. It is not obvious, given the situation, how the requisite materials research necessary for maintaining the residual U.S. stockpile and for performing technical assessments of foreign nuclear weapons capabilities will be sustained.

More important, the nonprofit university environment at Los Alamos and Livermore, initially provided by the University of California, no longer exists. Ironically, it was that environment, in which every idea and concept was challenged by the "clash of mind with mind,"[6] that gave the United States intrinsically reliable and yet intrinsically safe nuclear weapons.

Finally, although successful testing is the gold standard for having confidence our weapons will work as designed, the safeguards in the National Nuclear Test Readiness Program are now ignored or not maintained. Under those safeguards, the United States should maintain the capabilities needed to resume nuclear testing if needed in the future—but is this being done?

Nuclear Vigor: Russia and China

After the end of the Cold War, the Russian federal nuclear centers VNIIEF and VNIITF and other nuclear weapon research organizations were stabilized by an influx of U.S. support to, for example, prevent the migration of Russian nuclear weapons expertise. Today, in contrast to what is happening at their American counterparts, these Russian institutes are seeing their benefits, compensation,

[5] From the end of the Cold War until 1996, the DOE/NNSA contractor workforce dropped from about 59,000 to less than 30,000. Possibly because of the position taken by NNSA that "science-based stockpile stewardship" was essential to maintaining the stockpile without testing, the Los Alamos and Livermore laboratories were the last two organizations to be downsized and given new contractual configurations. This downsizing of their workforces continues; in 2012, for example, Los Alamos offered incentives to leave the Lab that reduced its staff of about 10,000 by about 800: an 8 percent reduction.

[6] "A university… is a place where inquiry is pushed forward, and discoveries verified and perfected, and rashness rendered innocuous, and error exposed, by the collision of mind with mind, and knowledge with knowledge." (John Henry Cardinal Newman, "The Idea of a University," 1852)

The Soviets discovered a surprisingly easy way to defeat our warheads. (Photo: Defense Nuclear Agency)

appreciation, working conditions, facilities, and meaningful research significantly improve. Rigorous research—including year-around experimentation at their Novaya Zemlya Test Site, which is leading to the development and deployment of new Russian nuclear weapons for newly designed delivery systems—continues to be their top priority.

The improvements in Russia's nuclear capabilities are leveraged off the increased profits garnered from Russian exports of oil on the one hand and driven by new confrontational trends in foreign policy on the other. The net result is that, at a time when U.S. nuclear weapon budgets are being cut and U.S. nuclear weapon experts are being offered early retirements or terminated, Russia's 2014–2016 defense program is planning a 50 percent spending increase in its nuclear program, designed to fund a significant upgrade in Russian strategic nuclear forces in conjunction with more Russian nuclear weapons research.

China's nuclear weapon program is enjoying a similar economic vigor and is directly benefiting from the rapid infusion of foreign advanced technologies appurtenant to China's economic modernization.

Russia's 2014–2016 defense program is planning a 50 percent spending increase in its nuclear program.

Surprising Ourselves

In the historical flow of science, nuclear weapons physics represents a relatively recent development. While nuclear weapons research has been rigorously pursued for over 70 years, it is naive to maintain that all possible technical discoveries that could lead to an advantage or all failure mechanisms that could lead to a disadvantage have been investigated and defined.

For example, our knowledge of plutonium metallurgy is only 74 years old whereas our knowledge of steel metallurgy exceeds 2,000 years. But as we learned from the collapse of the World Trade Center's Twin Towers in September 2001 and the I-35W bridge in Minneapolis in August 2007, we have problems predicting the stability of steel structures under stress despite our long history of working with steel.

Imagine then the challenges we face in understanding plutonium. Plutonium is much more complex and unstable than iron. Material scientists who work with plutonium know that predicting its behavior has always been a careful balance between empirical knowledge and informed guesswork. In an era when testing is banned, these plutonium ambiguities become even more problematic.

Staying on the right side of the fulcrum today requires rigorous, long-term experimental research programs in plutonium metallurgy, energetic materials, and weapons physics. These programs are supported by supercomputer modeling and simulation in lieu of the validation that testing would provide. Regardless of these efforts, because the properties of plutonium continue to change with age, what we think we know now about the plutonium triggers inside our nuclear weapons could change, and this could surprise us in some very unwelcome ways. The Stockpile Stewardship Program, in its present form, might work for now, but whether it will continue to be the best way to steward the nuclear stockpile should be questioned at some point in the future.

Just as we surprised our adversaries in WWII with our technological advances, our adversaries today can do the same to us.

Surprise! Undetected by the U.S. intelligence community, by the mid-1980s the Soviet Union had converted its gaseous-diffusion technology for making highly enriched uranium to the highly efficient gas-centrifuge technology. The centrifuges (shown here) had doubled Soviet production capacity. (Photo: Open Source)

Surprised by Our Adversaries

Just as we surprised our adversaries in World War II with technological advances such as the atomic bomb, our adversaries today can do the same to us. One important example of technological surprise from the Soviet nuclear weapons program occurred in the early 1960s. Soviet scientists had for years published numerous technical articles on the effects of x-rays on polymeric materials. Suddenly, they quit publishing. This aroused the interest of attentive U.S. IC experts.

Nuclear detonations produce intense x-rays. The polymeric heat shields used to protect the warheads of U.S. nuclear missiles were made of polymers that were reinforced by asbestos or glass fibers. Subsequently, we conducted underground nuclear tests at the Nevada Test Site and exposed these heat shields to the intense x-rays that the tests produced. Sure enough, the x-rays caused the protective heat shields to fail catastrophically.

This discovery was a real shocker. The Soviets had discovered that if they detonated one of their nuclear weapons in space anywhere near our incoming warheads, the intense x-rays would destroy the warheads' heat shields. Unbeknownst to us, all of our warheads were fatally flawed. This prompted the immediate development of new x-ray-resistant, graphite-reinforced heat shields for U.S. warheads, and these are still in use today.

> **The x-rays caused the warheads' heat shields to fail catastrophically. This discovery was a real shocker.**

Other examples of technological surprise from the Soviets include the rapid development of their first atomic bomb and their design and demonstration of the first thermonuclear bomb (a.k.a. hydrogen bomb). (Whereas the United States tested the first thermonuclear device, the Soviets were the first to make it a deliverable weapon.) They discovered that high-altitude electromagnetic pulses (EMPs) had catastrophically damaging effects on electronics, and they created special alloys for use in their nuclear weapons to counter those effects. The Soviets also were the first to deploy neutron bombs (enhanced-radiation weapons). Without going into details, each of these developments gave the Soviets military advantages. Only because we learned of their work were we able to evaluate and counter it with our own developments, strategies, and/or new technologies.

Given this prior record of important discoveries by our adversaries, any nuclear weapon reduction initiative must consider the possibility that other new-concept weapons or defenses could be developed that would provide strategic and/or tactical advantages.

Secretary of State Colin Powell's February 5, 2003, presentation slide to the United Nations Security Council showed an Iraqi-ordered aluminum tube allegedly meant for use in uranium enrichment.

As a result of a combination of systemic weaknesses, primarily in its nuclear weapons analytic capabilities, the U.S. intelligence community failed to accurately analyze and describe Iraq's nuclear capabilities in 2002. For example, it claimed that Iraq had made repeated attempts to acquire high-strength aluminum tubes for the purpose of enriching uranium to use in nuclear weapons. The intelligence community tested the tubes without inviting DOE experts—the intelligence community's nuclear experts—to participate. DOE, however, after doing its own analysis, concluded that "a [conventional] rocket production application is the more likely end-use for these [aluminum] tubes." DOE's conclusion was eventually accepted as the correct one.

President George W. Bush announces the beginning of Operation Iraqi Freedom from the Oval Office, March 19, 2003. "The people of the United States and our friends and allies will not live at the mercy of an outlaw regime that threatens the peace with weapons of mass murder."
(Photos: Open Source)

It is also possible that while foreign nuclear weapon programs could develop new weapons, these might not meet political definitions of "strategic" or even "nuclear" weapons. The problem then—for nuclear arms control and for deterrence—is that such novel weapons may not be considered as candidates for reduction under the terms of extant negotiated reduction agreements concerning strategic nuclear weapons.

Has Foiling Surprises Been Foiled?

Obviously, determining the existence of any such game-changing weapons or defenses would require the IC to have a robust and effective intelligence program. However, today, while remnants of technology-based intelligence collection systems remain in place, many have been reduced to the point that coverage is inadequate for today's potential threats.

In addition, capabilities dedicated to analyzing this type of information for use by the government's decision makers have also suffered. The most significant example is the unfortunate steady decline—to near extinction—of using nuclear scientists, particularly those at the DOE's national security science laboratories, as analysts.

With better nuclear intelligence, the "aluminum tube" issue certainly would not have been given weight in the debate leading up to the second war with Iraq.

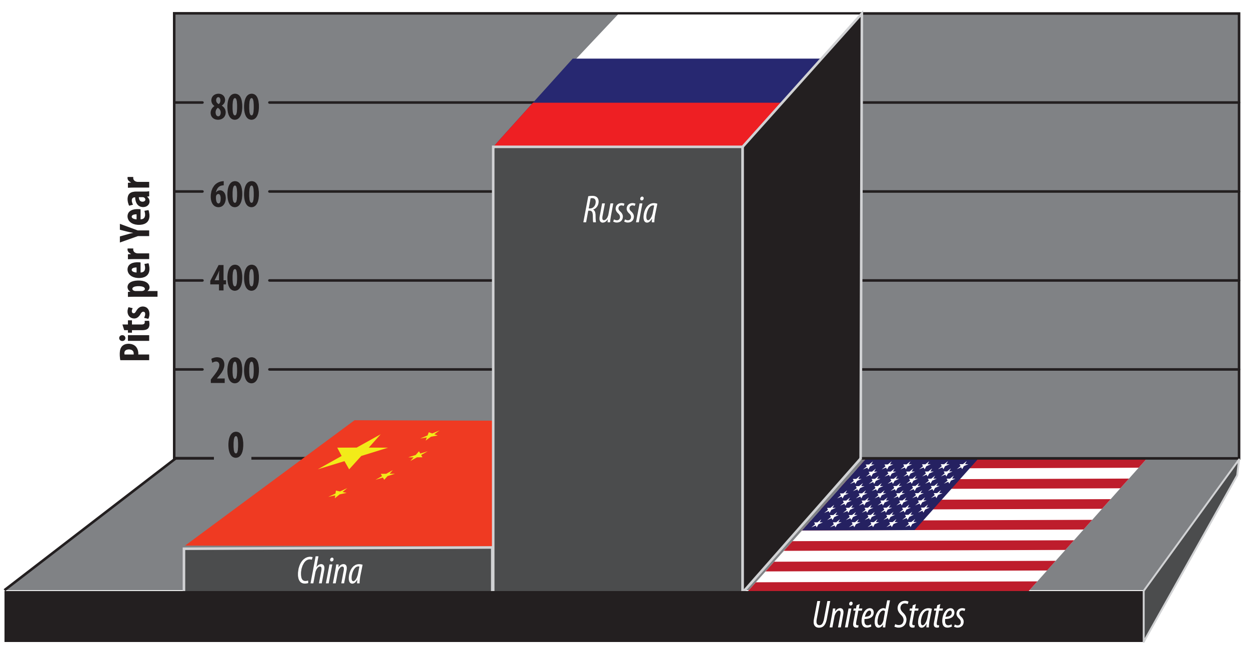
Unfortunately, one of the first causalities of the end of the Cold War was the IC's highly focused and well-funded nuclear intelligence program. For example, the nuclear intelligence divisions in both the CIA and the Defense Intelligence Agency were disestablished, and funding to the FIEs, charged with assessing foreign nuclear weapon developments, plummeted. Similarly, the Nuclear Intelligence Panel that consisted of senior nuclear weapons scientists and provided direct assessments to the director of the CIA was abolished.

Arguably, the intelligence failures evident in the First Gulf War (1991), in which the nuclear program of Iraq was *underestimated*, and the Second Gulf War (2003), in which the nuclear program of Iraq was *overestimated*, were directly related to the aforementioned reductions in the IC nuclear intelligence program. For example, if those reductions had not occurred, the widely publicized "aluminum tube" issue certainly would not have been given the weight it was given in the debate leading up to the second war with Iraq.[7]

Out of Balance: Rapidly Rebuilding Nuclear Stockpiles

As negotiated weapons levels are reduced, the calculus of deterrence becomes progressively more uncertain and

[7] Assessments that Iraq had acquired export-controlled, high-strength, high-specification aluminum tubes for use as centrifuge rotors were in error. They were procured to produce 81-mm rockets. (Aluminum Tube Investigation; Global Security Organization; http://www.globalsecurity.org/wmd/library/report/2004/isg-final-report/isg-final-report_vol2_nuclear-05.htm)



Plutonium pit production estimates for 2014. Russia has the ability today to produce at least 1,000 plutonium pits per year for use in building their new nuclear weapons. The United States, in contrast, has only one plutonium pit facility—an improvised one at Los Alamos—which has produced 29 certified pits since 1989.

By 2021 new nuclear missile systems, composed of new warheads and new delivery systems, will constitute 98 percent of Russia's intercontinental ballistic missile forces. This modernization includes the new RS-24 Yars (which NATO calls the SS-27 Mod 2), shown here, which is a new road-mobile system designed to carry up to six warheads and to counter U.S. antiballistic missile defense technology. *(Photo: Open Source)*

dangerous, particularly given the large stockpiles of plutonium and highly enriched uranium Russia has available for rapidly rebuilding its weapons inventories.

In robust, renovated nuclear weapons factories, Russia has the ability today to produce at least 1,000 plutonium pits per year for use in making new nuclear weapons. In an emergency, the production capacity could be much greater.[8]

The United States, in contrast, has only one plutonium pit facility—an improvised one at Los Alamos—which has produced 29 certified, "diamond-stamped"[9] pits since 1989 (when the Rocky Flats plutonium facility was closed).[10] The last diamond-stamped pit was produced in 2009.

While reconstituting new pit production was a significant accomplishment, the fact that the United States unilaterally disarmed itself with respect to being able to produce pits—and therefore produce new nuclear warheads or refurbish its aging warheads with new pits—arguably represents the largest nonnegotiated disarmament in history.

Arguably, this disarmament should have been a product of bilateral negotiations to reduce both U.S. and Russian stockpiles and the capacities and capabilities to reconstitute them, with adequate verification protocols appended to the agreement. If increased stability at lower force levels is the real goal, taking the production factor into consideration is an absolute necessity.

Any *balanced* arms control initiative to reduce nuclear weapons stockpiles must provide a balance in the comparable abilities of the negotiating parties to modernize and/or reconstitute larger stockpiles. In this regard, an imbalance between Russia and the United States probably already exists.

Ironically, if this capacity is not taken into consideration, bilaterally reducing the numbers of nuclear weapons could result in greatly increased dangers to the very world stability that arms control initiatives posit as their goal.

In addition to addressing production capacity, a particular interest of the United States should be to gain verification that closed or converted warhead-dismantlement plants in Russia are not being covertly used to produce new nuclear warheads. There are also obvious but difficult questions to be answered about how the refurbishment or remanufacture of extant weapons could be distinguished from the production of new warheads without classified information being revealed.

[8] During the peak of the Cold War, Russia produced plutonium and/or uranium parts for 2,500 to 4,000 warheads per year. Much of this production capacity has been mothballed but is still available to be put back into production.

[9] "Diamond stamped" signifies that a product has been manufactured to the highest standards required by the NNSA and the DoD. (*National Nuclear Security Administration Newsletter*, July 2007, Washington, D.C.)

[10] In 1989, due to safety and environmental concerns, DOE closed the Rocky Flats pit facility, which was the only facility in the country that could serially produce pits. A replacement pit facility has never been built.

Something Old, Something New

Absent the capability to replace its aging nuclear weapons, the United States will see the average age of its stockpiled weapons progressively increase. In 2005 our newest intercontinental ballistic missile (ICBM), the Peacekeeper, was decommissioned. In 2014 the average age of all nuclear weapons in the U.S. stockpile is about 34 years; the youngest U.S. warheads are about 23 years old. From public statements, it appears that the NNSA is preparing to accept weapons approaching twice that age.[11]

In contrast, Russian production capacity, if our estimates are accurate, will allow Russia to maintain a stockpile of nuclear weapons with a constant average age of approximately 5 years. (The average age of China's nuclear weapons is also about 5 years.) Moreover, with further negotiated reductions expected, the Russians could reduce the average age of their weapons by retiring older systems while maintaining production of new ones.

To a lesser extent, the age differential in favor of Russian warheads extends to their delivery systems. The most recent U.S. strategic missile to enter the active inventory was the U.S. Navy Trident II D-5, which was first deployed in 1990 and, under a proposed life-extension program, will remain in service until 2042. Much of the U.S. land-based strategic capability is based on the Minuteman III missiles, which entered service in 1970 and were produced until 1978. A refurbished Minuteman III could remain in service until 2040.

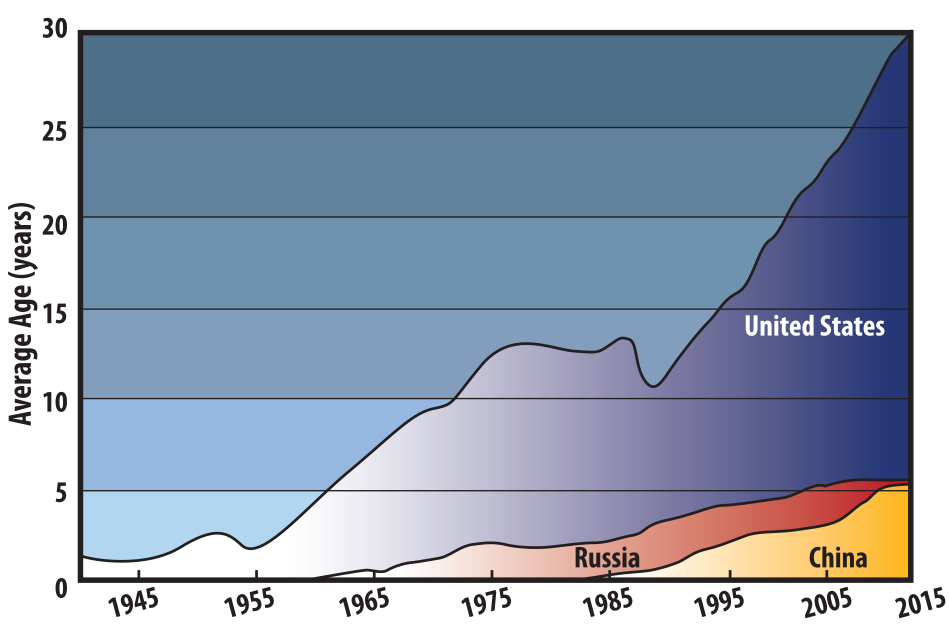
[11] "Right now, our best estimates [for the lifespan of plutonium pit-based weapons] are somewhere between 45 and 60 years, and that sounds like a long time, but remember, the last pit we made was made in the 1980s. After that, the properties [of plutonium pits] have changed to the point where you lack confidence that what you saw when you were testing is what you'd see now." (Linton Brooks, NNSA Administrator, *Global Security Newswire,* March 2, 2006)

The average age of nuclear weapons in the U.S. stockpile is about 34 years, and the youngest U.S. warheads are about 23 years old.

In contrast, Russia is making significant progress in modernizing its strategic and tactical nuclear weapons and their delivery systems. By early 2021 newly designed missile systems—the Topol-M ICBM, which NATO calls the SS-27 "Sickle"—will constitute 98 percent of Russian ICBMs. Russia is also deploying a newer road-mobile RS-24 Yars ballistic missile, probably a variant of the Topal, capable of carrying up to six warheads and designed to counter U.S. antiballistic missile technology. The Russians also have a new rail-mobile ICBM. By 2020 the Russian navy will have eight new Borei-class nuclear submarines. The Borei can carry 16 to 20 new solid-fuel Bulava R-30 submarine-launched ballistic missiles (SLBMs) with a range of over 6,000 miles. Each of these Bulava SLBMs will carry 6 to 10 individually targeted warheads for a total of up to 200 newly designed and newly manufactured warheads per submarine.

On October 31, 2014, the Russian news agency TASS reported that Putin announced, at a meeting with his top-ranking military officers, that 55 percent of Russia's strategic nuclear forces were now modernized. (He also announced Russia had modernized about 35 percent of their air force, over 50 percent of their navy, and close to 70 percent of their army's armored vehicles.)

The average age of U.S., Russian, and Chinese nuclear weapons. Unlike the United States, Russia and China continually replace their aging weapons with newly built weapons.



Rethinking the Unthinkable

The end of the Cold War brought many changes. These changes included the unification of Germany, the expansion of democracy into Eastern Europe, and the integration of Russia into the global economy. It also removed the worry about a nuclear war. "Thinking about the unthinkable," that is, seriously contemplating nuclear war, has all but vanished from the minds of most people.[12]

Another change that occurred was the substitution of informal "hand-shake" agreements for extensively negotiated treaties involving nuclear weapons. Verification protocols or safeguard provisions seldom accompanied these new informal agreements. Even as active stockpiles were reduced, agreements to reduce the capacity to manufacture nuclear weapons were never in vogue for a number of reasons, one of the most significant being mutual concerns over the secrecy inherent in such manufacturing processes.

> **Russia's warhead production capacity will allow it to maintain a stockpile of nuclear weapons with an average age of approximately 5 years.**

While this imbalance should have raised concerns in the United States, it has not. Even Russia's modernization of its strategic nuclear forces and its touting of these forces as the most important element of the Russian military have been little more than passing news items.

Similar apathy is being shown over the revival of incursions of Russian nuclear-capable aircraft to test the defenses and resolve of the United States and its allies. These probes, echoing the Cold War, are disturbing.

Significantly, these military incursions are being conducted at a time when Russian officials have continued to make substantial investments toward modernizing Russian nuclear weapon production and research capacities, while also supporting a robust testing program at Novaya Zemlya, in part to develop new nuclear weapons. (Within the limits of our detection capabilities, no evidence suggests that these tests are generating proscribed nuclear yields.)

> **Major imbalances have arisen between the nuclear weapon research and production capacities of Russia and the United States.**

[12] *Thinking about the Unthinkable* is the title of Herman Kahn's infamous and widely read 1962 book that explores the consequences resulting from a nuclear war. Kahn is one of the founders of the Hudson Institute.

President John F. Kennedy's address to the nation regarding the 1963 Limited Test Ban Treaty
~July 26, 1963~

"I ask you to stop and think for a moment what it would mean to have nuclear weapons in so many hands, in the hands of countries large and small, stable and unstable, responsible and irresponsible, scattered throughout the world. There would be no rest for anyone then, no stability, no real security, and no chance of effective disarmament. There would only be the increased chance of accidental war, and an increased necessity for the great powers to involve themselves in what otherwise would be local conflicts."

Since president Kennedy's speech in 1963, the number of declared nuclear weapons states has doubled to eight.

In stark contrast, the nuclear weapons research, testing, and production infrastructures of the United States have continued their rapid erosion through elimination and restructuring of organizations and reductions of workforces and budgets. This erosion has been accelerated by funds being diverted away from nuclear weapons research, surveillance, and manufacturing to address burgeoning environmental and security requirements. Ironically, the latter, spawned largely by those who inveigh against hypothetical security threats, are leaving the United States less secure internationally.

Former Los Alamos director Sig Hecker, now at Stanford University, argues that this problem is further exacerbated by "a risk-averse federal bureaucracy that has layered so many checks on the folks trying to do the actual nuclear weapons work at Los Alamos and elsewhere that a significant fraction of the work simply doesn't get done."[13]

> **The undeniable fact is that stability between the United States and Russia is now being maintained by Mutually "Assumed" Destruction.**

The author, Houston T. Hawkins, is shown here with a model of a nuclear warhead from an ICBM. The warhead is coated with a graphite-based x-ray–resistant heat shield he helped to develop. *(Photo: Los Alamos)*

Obviously, no one is advocating a return to the Cold War or an abrogation of environment or security regulations. However, the undeniable fact is that stability between the United States and Russia is now being maintained by Mutually "Assumed" Destruction. "Assured" no longer is the operative adjective, given the robustness of the Russian nuclear weapons program and the demise of similar emphasis, capacities, and capabilities in the United States. If the international stability everyone wants is to be maintained, this potentially destabilizing imbalance cannot be allowed to continue.

Our lack of capabilities for rapidly reconstituting large numbers of nuclear weapons and our virtual abandonment of vital nuclear programs must be evaluated in the calculus of defense and of arms reduction diplomacy.

An outcome of the extant situation is that major imbalances have arisen between the nuclear weapons research and production capacities of Russia and the United States.

Given these realities, it is easy to understand Russian President Putin's statement in his 2013 end-of-year address to the Russian Parliament: "In our efforts to upgrade our nuclear arsenal, we are reaching new milestones successfully and on schedule. Some of our partners will have to catch up."

~ Houston T. Hawkins
Hawkins is a retired USAF colonel and a senior fellow of Los Alamos National Laboratory

[13] http://www.nti.org/gsn/articleregulators-squelching-U.S.-nuke-reliability-tests-ex-los-alamos-chief/