Participants in Iran nuclear negotiations in Vienna on day deal was signed (Flickr/Dragan Tatic)

Time to Come in from the Cold (War)

Nuclear Force Structure for an Uncertain World

By Wallace R. Turnbull III

The U.S. nuclear deterrent is at a turning point. Seven decades have passed since a nuclear weapon was used, and many noted leaders have called for the abolition of nuclear weapons altogether—a "Global Zero."[1] At the same time, the legs of the U.S. nuclear deterrent triad are overdue for modernization at a projected cost of $1 trillion over the next 30 years.[2] This modernized triad—consisting of a new long-range bomber and cruise missile, a replacement intercontinental ballistic missile, and a new ballistic missile submarine, as well as refurbished nuclear warheads—will be fielded in the 2030s and, based on historical recapitalization rates, will operate well into the 2060s.

This article considers the strategic environment of 2040 and beyond to assess whether the planned nuclear force structure is sufficient to provide deterrence in the uncertain world of the future. Keir Lieber and Daryl Press observed that the only way to do this "is to work through the grim logic of deterrence: to consider what actions will need to be deterred, what threats will need to be issued, and what capabilities will be needed to back up those threats."[3] This article assesses the U.S. nuclear deterrent using the framework recommended by Lieber and Press to show that the nuclear capabilities provided by the current and planned force are insufficient to provide credible deterrence in the 21st century. It argues for the addition of low-yield, high-accuracy nuclear weapons and electromagnetic pulse weapons to the air leg of the triad to bolster deterrence against limited nuclear war.

The reality that nuclear weapons did not disappear with the end of the Cold War has been acknowledged by a number of scholars, including Keith Payne, Paul Bracken, and Thérèse Delpech, as the so-called second nuclear age.[4] Defined by Bracken as "the spread of the bomb for reasons that have nothing to do with the Cold War," this second nuclear age is characterized by a multipolar world that contains a variety of nuclear actors who wield a range of nuclear weapons and whose interests have nothing to do with U.S.-Soviet dynamics.[5] New nuclear actors such as Pakistan, India, North Korea, and Iran have all decided that these weapons are useful, and established nuclear powers such as Russia have rediscovered the value of such weapons. Russian President Vladimir Putin declared, for example, that "only nuclear weapons allowed Russia to maintain its independence in the troubled 1990s" and that "developing and deploying an entirely new generation of nuclear weapons and delivery systems" will be a main point of Russia's defense modernization activities.[6] This should not be surprising because, as Bracken notes, the United States once "found the bomb a most useful weapon."[7] The stark reality of the second nuclear age is that many actors find nuclear weapons useful and are pursuing their development and acquisition. Some may even use them.

Lieutenant Colonel Wallace R. Turnbull III, USAF, wrote this essay while a student at the Air War College. It won the 2015 Secretary of Defense National Security Essay Competition.

Emerging Strategic Environment

To understand which actions will need to be deterred by U.S. nuclear forces, we must first consider the strategic environment in which deterrence is expected to function. Former Secretary of Defense Robert Gates observed that divining the strategic environment of the future is fraught with uncertainty: "When it comes to predicting the nature and location of our next military engagements, since Vietnam . . . we have never once gotten it right."[8] Rather than making firm predictions, we can only form some broad characterizations that appear likely given the current strategic environment.

According to Bracken, the most significant feature of the second nuclear age is that it is a multiplayer game.[9] Unlike the bipolar Cold War world, the emerging strategic environment is characterized by the existence of many independent nuclear actors. Today, there are many states with nuclear weapons, and the tumultuous history of proliferation suggests this number may grow in the future.[10] A consequence of the multiplayer game is that most nuclear actors now face security threats from more than one nuclear-armed opponent. India, for example, is concerned about deterring both China and Pakistan. This security trilemma, as it has been called by Linton Brooks and Mira Rapp-Hooper, means "actions taken by one state to defend against another state have the effect of making a third state feel insecure."[11] Overlapping security trilemmas suggest crisis stability dynamics are geometrically more complicated in the second nuclear age. Thérèse Delpech noted that one has only to look at the last three centuries of multipolar European history to conclude that the strategic environment of the future is "just as likely to be one of confrontation as of stability" and may indeed be less stable than the bipolar Cold War world.[12]

In the Nuclear Futures Project, Duncan Brown and Thomas Mahnken observed that another feature of the second nuclear age is the "imbalance in political stakes between the United States and potential adversaries."[13] Unlike the Cold War, where the Soviet Union represented an existential threat to U.S. security, the Nation today "has limited stakes in many potential conflicts," while many potential adversaries are likely to view conflict with the United States as an existential threat.[14] This imbalance poses the danger that adversaries may be motivated not only to pursue nuclear weapons but also to use those weapons to avoid defeat by superior conventional power.[15] The key lesson for adversaries in the second nuclear age, as demonstrated by the swift defeat of the regimes of Muammar Qadhafi and Saddam Hussein, is that in a conventional fight with the United States, America's enemies may be "fighting for their lives."[16] Deterring escalation during a conventional conflict when the adversary believes the regime, and even its existence, is at stake may make Cold War deterrence look relatively easy by comparison.[17]

A third feature of the emerging strategic environment is the potential for catalytic instability and escalation from terrorism or a nuclear accident. Terrorism, according to Bracken, provides a catalyst that "was not present in the first nuclear age."[18] For example, a terrorist attack could greatly increase the risk of nuclear escalation if it occurred in the midst of an ongoing Indian-Pakistani crisis. Likewise, catalytic escalation could be caused by terrorists who managed to acquire nuclear material in the form of fuel or radioactive waste from a nuclear powerplant and built a radiological dirty bomb.[19] In addition to terrorism, a nuclear accident would be a powerful catalyst. Though fortunately none resulted in a nuclear explosion, there were at least 32 documented accidents involving U.S. nuclear weapons between 1950 and 1980.[20] The U.S. nuclear stockpile is, on average, more than 20 years old, and many weapons lack modern safety features.[21] The same concerns likely apply to Russia's arsenal. More alarming, however, are newer members of the nuclear club such as Pakistan, which lacks decades of experiential nuclear learning and whose stockpiles of nuclear weapons lack sophisticated safety features.[22] A nuclear accident in this environment is not unthinkable.

Limited Nuclear War in the Second Nuclear Age

Due to the potent combination of multiplayer dynamics with overlapping security trilemmas, imbalanced political interests, and an increasing risk of catalytic escalation, the second nuclear age is likely to be a dangerous one. Jeffrey Larsen argues that these factors and others result in an increasing risk of *limited nuclear war*, defined as "a conflict in which nuclear weapons are used in small numbers and in a constrained manner in pursuit of limited objectives . . . or in the face of conventional defeat."[23] During the Cold War, Herman Kahn suggested that there were "very large and very clear 'firebreaks' between nuclear and conventional war."[24] In Kahn's firebreak model, there were strong incentives for the United States and Soviet Union to maintain the firebreak and avoid nuclear war. Barry Watts, however, observed that the strategic environment suggests the nuclear-conventional firebreak is shrinking and that "the taboo against nuclear use is being threatened" by the prospect of limited nuclear war.[25] The current U.S. nuclear force was built to deter the Soviet Union from waging total nuclear war against the United States. In the uncertain world of the second nuclear age, the United States must also be prepared to deter a wide range of nuclear opponents across a variety of circumstances.

Thomas Mahnken evaluated a number of plausible limited nuclear conflict scenarios such as demonstration attacks or nuclear use to prevent conventional defeat.[26] These scenarios are useful for considering what actions the United States might need to deter in the future. Mahnken's key insight is that in each scenario, an adversary uses a relatively small amount of nuclear force in a limited manner to accomplish limited objectives. The plausibility of these scenarios lies in the perception of the adversary, who believes nuclear weapons are useful and that the United States lacks a credible deterrent against limited use due to the structure of the current arsenal, which emphasizes high-yield weapons delivered via ballistic

President Ford and Soviet General Secretary Leonid Brezhnev sign Joint Communiqué following talks on limitation of strategic offensive arms in Vladivostok, November 24, 1974 (Gerald R. Ford Library/David Hume Kennerly)

missiles. Bruce Bennett, analyzing possible U.S. nuclear responses to limited-use scenarios, observed that the United States would seek to minimize civilian casualties and thus use only a few weapons, noting that the current nuclear force does not provide the limited options a U.S. President might want and "thereby may be inadequate to deter adversary nuclear weapon threats."[27]

In recent years, numerous studies and reports have examined the optimal shape of the nuclear triad.[28] By and large, these have focused on the structure of the triad—the specific mix of bomber aircraft, submarine-launched ballistic missiles (SLBMs), and land-based intercontinental ballistic missiles (ICBMs)—or on the quantity of weapons required for deterrence. The contribution of a triad of delivery systems to strategic stability is not being disputed.[29] However, perhaps more important to deterrence in the second nuclear age than the means used to deliver a nuclear weapon is the type of weapon being delivered and the effects that weapon will produce.

The United States maintains nuclear weapons "to create the conditions in which they are never used."[30] To create such conditions, the United States must be able to brandish a credible threat such that an adversary concludes the cost of limited nuclear use outweighs any possible benefit. The prospect of limited nuclear war highlights the need to be able to threaten a flexible, limited counterforce nuclear response that minimizes civilian casualties and avoids third-party escalation, such as overflying Russia on the way to a target.[31] This is not a new revelation. The 2009 Congressional Commission on the Strategic Posture of the United States, for example, emphasized the need for a spectrum of flexible force employment options, as did the 2011 Nuclear Futures Project, which concluded that the United States needed the ability to rapidly deliver nuclear weapons with a range of yield options to "achieve military effects and political objectives without causing extensive collateral damage."[32] Likewise, Lieber and Press concluded in 2009 that the United States needed high-accuracy, low-yield nuclear weapons to give "leaders options they can stomach employing in these high-risk crises."[33]

Required Capabilities

In view of the types of limited nuclear scenarios that seem likely in the second nuclear age, the most significant gap in the current U.S. nuclear force structure is a lack of nuclear capabilities useful for controlling escalation while minimizing collateral damage. A number of authors have concluded that low-yield nuclear weapons and electromagnetic pulse (EMP) weapons are particularly useful in many potential limited nuclear scenarios.[34] It is worth noting that

these capabilities have, in the past, been included in the U.S. nuclear force.

In his 1957 work on limited nuclear war, Robert Osgood argued that deterrence credibility "requires that the means of deterrence be proportional to the objectives at stake."[35] Unfortunately, the bulk of the currently deployed U.S. nuclear deterrent consists of ballistic-missile weapons with yields in the hundreds of kilotons.[36] In a limited nuclear war, these weapons lack proportionality and thus are not useful in most scenarios, calling into question U.S. deterrence credibility. In a limited nuclear war, the lack of U.S. means proportional to the limited objectives at stake means the President will be faced with only two options, both unacceptable: either acquiesce or escalate to general nuclear war, in effect committing mass murder by inducing significant collateral damage. The lack of credible escalatory options short of general nuclear war means nuclear opponents may calculate that the United States is unlikely to respond, thus increasing the adversary's perceived value of nuclear escalation. In addition to continuing to modernize the existing triad of delivery systems, the United States must preserve credibility for the second nuclear age by investing in new low-yield and EMP nuclear capabilities and the means to accurately deliver these capabilities.

Conventional Weapons as Substitute?

Those in favor of eliminating the U.S. nuclear deterrent often argue that its conventional weapons are able to provide a sufficient deterrent against nuclear attack on the United States. The Global Zero Nuclear Policy Commission report, for example, stated that "strong conventional forces and missile defenses may offer a far superior option for deterring and defeating a regional aggressor" and "precision-guided conventional munitions hold at risk nearly the entire spectrum of potential targets, and they are useable."[37] When evaluated against the stark realities of the strategic environment, however, these arguments do not stand up. As illustrated earlier, a number of nuclear powers see utility in acquiring nuclear weapons precisely to counter the conventional superiority of countries such as the United States. In a limited regional nuclear scenario, it might be possible for a U.S. President to absorb a limited nuclear strike against the United States and respond only with conventional force. It is prudent to ask, though, what the impact of such a move on existing deterrence regimes would be.

The first effect of a U.S. failure to retaliate in kind would be for all other nuclear parties to question the long-term credibility of U.S. nuclear deterrence. Any nation, particularly a nuclear-armed one, seeking to attack the United States might entertain a theory of victory in which the United States did not respond. Such thinking could lead to crisis instability and risk further escalation. Thomas Schelling asserted that a country's reputation for action, which he called "face," "is one of the few things worth fighting over" because it "preserve[s] one's commitments to action in other parts of the world and at later times" and hence maintains credibility.[38]

A second grave effect of failing to retaliate in kind to a nuclear attack would be a serious erosion of the concept of extended deterrence and, with it, the nonproliferation regime. Not only would future adversaries view U.S. deterrence as not credible, but so too might our allies, who rely upon the extended deterrence provided by the U.S. nuclear umbrella.[39] After a 2013 North Korean nuclear test, polls showed 66 percent of the South Korean public favored developing a domestic nuclear weapons program.[40] That number would likely be much higher if, as Schelling warned, the United States lost face in a limited nuclear scenario by not living up to its reputation for action.

While it remains desirable to eliminate U.S. dependence on nuclear weapons, the realities of the second nuclear age and the emerging strategic environment suggest this is not likely to happen soon. The knowledge to develop nuclear weapons cannot be unlearned. As Thomas Reed and Danny Stillman have observed, the proverbial train has left the station, and the "Nuclear Express now hurtles into a new century with a boxcar of nuclear technology."[41] Looking ahead to 2040, the United States can expect to still be competing in a multiplayer nuclear game in which there are more nuclear actors, possibly including both state and nonstate actors, and characterized by imbalanced political stakes and subject to the influence of dangerous catalytic escalations. It is prudent to invest now in the capabilities that may contribute to deterrence in the uncertain world ahead so that the United States is ready when the Nuclear Express once again pulls into the station.

Recommendations

High-Accuracy, Low-Yield Weapons. A number of limited nuclear use scenarios illustrate the utility of low-yield weapons to control escalation while limiting collateral damage.[42] Nuclear opponents, for example, may use low-yield weapons in demonstration attacks or selective nuclear attacks or to prevent a conventional defeat, believing the use of relatively small weapons may avoid further escalation due to a perceived lack of credible U.S. response options. Other nations, most notably Russia, find low-yield weapons attractive and are pursuing the design of sub-kiloton-class warheads for battlefield use.[43] To fill the low-yield credibility gap, the United States should pursue a two-pronged approach. First, the United States should evaluate options for leveraging existing stockpile weapons designs to field low-yield capabilities in the near term, and second, the United States should develop a new low-yield weapon coupled with a high-accuracy delivery mechanism suitable for minimizing collateral damage.

The B61-12 nuclear bomb, now under development, offers one near-term opportunity to field the recommended capability. The B61-12 program encompasses both a life-extension program to replace aging components and extend the life of the B61 bomb family, as well as a guided tail kit assembly to significantly improve the accuracy of the weapon.[44] By improving accuracy with a guided tail kit, a first for a nuclear weapon, the B61-12

General Dempsey testifies on Iran nuclear deal before Senate Armed Services Committee, July 29, 2015 (DOD/Glenn Fawcett)

is able to hold at risk the same targets as a much larger weapon.[45] The United States does not publicly disclose nuclear weapons yields. It is therefore not possible to know if the B61-12 will provide the required low-yield capability, though the technology developed for it significantly reduces the risk of fielding the needed capability. Paul Robinson, a former director of Sandia National Laboratories, has suggested using dummy secondary stages in existing weapons such as the B61 to produce yields in the low-kiloton range. By replacing the secondary stage with an inert dummy, the only yield produced would be from the fission-only primary stage.[46] The United States should continue the B61-12 program, but should consider technical options to field an accurate variant with very low yield.

The next opportunity to field a low-yield weapon in the mid-term is to design such a feature into the warhead for the long-range standoff weapon (LRSO), which is a cruise missile being designed to replace the circa 1980s air-launched cruise missile (ALCM) and is scheduled for fielding in 2027.[47] The U.S. Nuclear Weapons Council recently selected the W80-1 warhead, currently deployed on the ALCM, as the warhead for the LRSO.[48] Due to its age, the W80-1 warhead will need a life-extension program, designated W80-4, before it can be placed in service on the LRSO.[49] This life-extension program, just now entering the design phase, provides an opportunity to modify the W80-4 design to include a low-yield variant for use on the LRSO missile.

The recommendation to field low-yield variants of existing weapons could be coupled with declaratory policy stating that the United States would employ low-yield weapons only in limited-use scenarios, providing a stepping-stone to credible nuclear deterrence for the second nuclear age. These actions are not, however, by themselves sufficient. As described earlier, developments in the second nuclear age show a worrying trend toward the fielding of "highly usable" nuclear weapons that may significantly alter the firebreak between conventional and nuclear weapons. To avoid a situation where adversary decision calculus favors the early use of such weapons, the United States should pursue the design of new very-low-yield weapons coupled to highly accurate delivery systems. Similar weapons once existed in the U.S. arsenal, and, given sufficient political will, there are no technical challenges preventing their re-introduction.

EMP Weapons. In addition to low-yield nuclear weapons, a number of limited-use scenarios show weapons designed to produce electromagnetic pulse effects may be useful. An EMP is an extremely energetic radio wave that can be generated naturally by the interaction of a powerful solar flare with the Earth's geomagnetic field or artificially through nuclear or nonnuclear means.[50] The energy from an EMP interacts with electronic equipment, causing a range of effects from temporary upset to permanent damage, but causing no biological harm to humans or other organisms.[51]

Nearly all nuclear explosions produce an EMP, the characteristics of which vary according to the altitude of the explosion (also known as the height of burst).[52] A high-altitude EMP occurs when a nuclear weapon is detonated at an altitude of 30 kilometers or more, and in such a burst the EMP will affect a large area.[53] It is estimated that a multi-megaton nuclear EMP weapon detonated over the center of North America would cause severe disruption and damage from coast to coast and, according to Dr. Peter Pry, could possibly "blackout the national electric grid for months or years and collapse all the other critical infrastructures."[54]

Conducting a catastrophic EMP attack, such as the one just described, against the United States would require significant capability—the attacker would need a multi-megaton weapon and space launch capability to deliver the weapon over the United States at high altitude.[55] There is some evidence North Korea may have conducted a practice test of such a capability in April 2013 when North Korea's KSM-3 satellite passed over the eastern seaboard of the United States at the optimal altitude for an EMP attack on the East Coast electrical grid.[56]

In many scenarios, an EMP attack, having the potential to be as catastrophic as a large-scale nuclear strike, will likely be subject to the nuclear-conventional firebreak—an adversary might be reluctant to cross the firebreak and escalate to nuclear war. However, for an adversary with limited nuclear capability, an EMP attack may be seen as a way to maximize the military utility of a small arsenal. Such an adversary may be more motivated to conduct an EMP attack, which might result in no direct casualties, if it believed the United States would not respond with a

nuclear attack that could potentially kill thousands or even millions of people.[57]

It is also possible to create a smaller EMP by adjusting the detonation altitude and yield of the weapon.[58] Such a weapon capable of generating effects over a few hundred square kilometers would have much more military utility in a limited-use scenario and, like low-yield nuclear weapons, would likely shrink the firebreak between conventional and nuclear use. There is evidence that China, for example, already views EMP weapons as a means to achieve information dominance in a regional "high-tech local war." In their book *The Science of Military Strategy*, Chinese generals Peng Guangqian and Yao Youzhi write that "nuclear energy . . . will be employed to seek information dominance. For instance, the electromagnetic pulse weapon still in laboratory stage is a kind of nuclear weapon. It is possible for nuclear weapons to move from deterrence into warfighting."[59]

In a nuclear escalation scenario, the United States might also consider the use of a limited EMP weapon as a sort of nuclear halfway house to control escalation by signaling resolve and demonstrating use of a nuclear weapon without direct loss of life. Another scenario in which an EMP capability might be useful is to control escalation horizontally in a scenario in which an adversary seeks to attack U.S. space capabilities.[60] For example, if an adversary who was much less reliant on space than the United States threatened U.S. space systems, horizontal escalation by EMP attack might be more effective than a response-in-kind against the adversary's space systems.

In the heavily interconnected digital world of the 21st century, nuclear EMP weapons have the potential to create catastrophic effects both on the battlefield and against civilian infrastructure. Furthermore, these weapons are not difficult to produce for a state possessing both nuclear weapons and ballistic missile or space launch capability and, in a crisis, may be destabilizing as a limited nuclear power seeks to maximize utility of its arsenal. Conversely, EMP weapons with regional effects might also be useful to restore deterrence and control escalation if they were used to answer a limited nuclear strike or the use of an EMP weapon. The United States should field a regional nuclear EMP capability to bolster its deterrent credibility in scenarios in which adversaries may consider an EMP or limited nuclear attack.

The United States can likely develop an EMP weapon by modifying an existing warhead, and it may even be able to use a current ballistic missile warhead, launched on an SLBM or ICBM, set to detonate at the correct altitude. Utilizing ICBMs to deliver an EMP weapon is problematic, though, as the missile would in almost all target scenarios overfly Russia, and in many cases China, posing a serious escalation risk as those nations might think they are under attack.[61] SLBMs launched from ballistic missile submarines (SSBNs) are also problematic, though less so, because of overflight concerns as the SSBN patrol areas are optimized for attacks against Russia and China.[62] One possible solution is to mate an existing warhead to a new delivery system that avoids overflight concerns. An air-launched missile, for example, would allow an EMP weapon to be forward deployed and launched toward the target while avoiding most overflight issues. The U.S. Air Force developed and tested an antisatellite missile, the ASM-135, in the 1980s that was capable of reaching the required altitude for EMP generation when launched from an F-15 aircraft.[63] Another option is to modify a commercial space launch system such as Orbital's Pegasus air-launched rocket.[64] Given the political will to field an EMP weapon, there appear to be feasible technical delivery options.

Long-Range Penetrating Bomber. The triad of nuclear delivery methods—bomber aircraft, land-based ICBMs, and sea-based SLBMs—is likely to be useful to deterrence in the second nuclear age.[65] The weapons capabilities recommended in this article can likely be adapted to be delivered via any leg of the nuclear triad, though this may not be desirable. As described, ICBMs and SLBMs are problematic for a number of limited nuclear scenarios. Employing the recommended nuclear capabilities on bomber aircraft, however, eliminates most of the concerns with ICBMs and SLBMs, as bombers can avoid most overflight issues.

Bomber aircraft possess a number of other useful attributes for limited nuclear war. A 2013 RAND study examined contributions of the triad legs to crisis stability by evaluating 48 crises, concluding that long-range penetrating bombers were key contributors to crisis stability.[66] Bomber aircraft also offer flexibility; they can be recalled as well as retargeted in-flight and are also useful for signaling resolve to the adversary. For example, in response to North Korean provocations, the United States sent B-2 bombers to overfly South Korea in March 2013 in a demonstration of capability and resolve.[67] Low-yield nuclear weapons are well suited for delivery by bombers, as weapons with similar capabilities, such as the B61 bomb, already exist. To employ an EMP weapon on bomber aircraft requires development of a new air-launched missile to reach the requisite detonation altitude, although the technology to build such a missile already exists.[68]

Bomber aircraft are likely to be particularly useful in the limited nuclear wars of the future, and the Air Force should continue developing a nuclear-capable penetrating bomber. The Air Force's next-generation bomber program should be fully funded and remain a top priority.[69] The Service should also begin studying solutions for an aircraft-delivered EMP weapon compatible with the new bomber and should seek to accelerate development of the LRSO cruise missile while ensuring it is compatible with future low-yield nuclear weapons. Critics will argue that the combination of a long-range bomber and a capable, accurate nuclear cruise missile coupled with a low-yield warhead is dangerous because it offers a nuclear capability that is actually usable in a nuclear conflict. It is precisely because such weapons are usable that they offer a potent deterrent to nuclear actors who might consider limited nuclear war.

Other Considerations. In addition to pursuing highly accurate nuclear weapons with low-yield and EMP effects and a new bomber and cruise missile to employ

these effects, there are a number of other considerations important to maintaining a credible nuclear deterrent in the second nuclear age. First and foremost is a reinvigoration of strategic thought about nuclear weapons; there has been a dearth of thinking in the United States about how to actually use nuclear weapons should deterrence fail. The world is entering an age where the unthinkable may actually happen. U.S. policymakers and military leaders need to consider how to employ nuclear weapons to control escalation and restore deterrence in limited nuclear war. A reinvigoration of strategic thought about nuclear weapons must also be coupled with a robust nuclear exercise regime so these thoughts can be tested and practiced.[70] Second, the United States will need to improve intelligence gathering on adversary nuclear programs as well as improve the ability to attribute a nuclear attack.[71] In the intertwined security trilemmas of the second nuclear age, it may not be immediately obvious who initiated a limited nuclear strike, and thus attribution becomes more important than it was during the Cold War. Third, the United States should eliminate the dichotomy in the U.S. nuclear lexicon between *strategic* and *tactical* nuclear weapons. This distinction will not make sense in the uncertain world of the future where some actors may wield a range of nuclear capabilities for both tactical and strategic effect.

The grim logic of deterrence did not disappear with the end of the Cold War. Colin Gray observed in 1979 that "one of the essential tasks of the American defense community is to help ensure that in moments of acute crisis the Soviet general staff cannot brief the Politburo with a plausible theory of military victory."[72] Though the adversary may be different, this task will be no less essential in the uncertain world of 2040, where there will still be many nuclear-armed actors, perhaps more than there are today, some of whom may desire to inflict harm upon the United States. To ensure no potential adversary ever contemplates a theory of victory for limited nuclear war, the United States must maintain an effective deterrent by investing in flexible nuclear capabilities such as low-yield and EMP weapons and a long-range penetrating bomber and cruise missile to accurately deliver these weapons. Choices made today will impact the nuclear force for decades to come. By making the choice to invest in the nuclear capabilities most useful for deterring limited nuclear war, the United States can improve the odds that another 70 years pass without a nuclear weapon being detonated in anger. **JFQ**

Notes

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[6] Pavel Felgenhauer, "Putin Declares His Defense Agenda for the Next Decade," *Eurasia Daily Monitor* 9, no. 38 (February 2012).

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[8] Robert M. Gates, address at the United States Military Academy, West Point, NY, February 25, 2011.

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[31] Bennett, 229–230.

[32] Perry and Schlesinger, 23; Brown and Mahnken, 17.

[33] Lieber and Press, 51.

[34] Bennett, 211–241; Brown and Mahnken, 17–24; Lieber and Press, 39–51. *Yield* refers to the energy released during a nuclear explosion. It is generally measured in tons, kilotons, or megatons of TNT (trinitrotoluene) equivalent. Younger, 73–74.

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[38] Thomas C. Schelling, *Arms and Influence: With a New Preface and Afterword* (New Haven: Yale University Press, 2008), 124.

[39] George W. Quester, "The End of the Nuclear Taboo," in *On Limited Nuclear War in the 21st Century*, 183; Robert Windrem, "Japan has Nuclear 'Bomb in the Basement,' and China Isn't Happy," NBC News, March 11, 2014, available at <www.nbcnews.com/storyline/fukushima-anniversary/japan-has-nuclear-bomb-basement-china-isnt-happy-n48976>.

[40] Kim Jiyoon and Karl Friedhoff, *The Fallout: South Korean Public Opinion Following North Korea's Third Nuclear Test*, Issue Brief No. 46 (Seoul: The Asan Institute for Policy Studies, February 24, 2013), available at <en.asaninst.org/contents/issue-brief-no-46-the-fallout-south-korean-public-opinion-following-north-koreas-third-nuclear-test/>.

[41] Thomas C. Reed and Danny B. Stillman, *The Nuclear Express: A Political History of the Bomb and Its Proliferation* (Minneapolis: Zenith Press, 2009), 319.

[42] Bennett, 211–241.

[43] James L. Denton, "The Third Nuclear Age: How I Learned to Start Worrying About the Clean Bomb," Research Report (Maxwell AFB, AL: Air War College, 2013), 7; Central Intelligence Agency, *Intelligence Memorandum: Evidence of Russian Development of new Sub-Kiloton Warheads* (Washington, DC: Central Intelligence Agency, August 30, 2000), 3. Document is now declassified.

[44] Hans M. Kristensen, *Non-Strategic Nuclear Weapons*, Special Report No. 3 (Washington, DC: Federation of American Scientists, May 2012), 23–24.

[45] Hans M. Kristensen and Robert S. Norris, "The B61 Family of Nuclear Bombs," *Bulletin of the Atomic Scientists* 70, no. 3 (April 22, 2014), 83.

[46] C. Paul Robinson, "A White Paper: Pursuing a New Nuclear Weapons Policy for the 21st Century," Sandia National Laboratories, March 22, 2001, available at <www.sandia.gov/media/whitepaper/2001-04-Robinson.htm>. Most modern nuclear weapons are based on a two-stage design. The first stage—also called the primary—uses high explosives to implode a plutonium "pit" to produce a fission reaction. The resultant energy implodes the second stage—or secondary—that actually produces most of the weapon's yield. See also Younger, 23–24, 69–74.

[47] Hans M. Kristensen, "W80-1 Warhead Selected for New Nuclear Cruise Missile," Federation of American Scientists, October 10, 2014, available at <http://fas.org/blogs/security/2014/10/w80-1_lrso/>; Gabe Starosta, "Long-Range Standoff Missile Development Pushed Back by Three Years," *InsideDefense.com*, March 5, 2014, available at <http://insidedefense.com/201403052463350/Inside-Defense-General/Public-Articles/long-range-standoff-missile-development-pushed-back-by-three-years/menu-id-926.html>.

[48] Kristensen, "W80-1 Warhead."

[49] Ibid.

[50] Peter V. Pry, "Electromagnetic Pulse: Threat to Critical Infrastructure," Testimony before the Subcommittee on Cybersecurity, Infrastructure Protection, and Security Technologies, House Committee on Homeland Security, 113th Congress, May 8, 2014, 2–6. See also Clay Wilson, *High Altitude Electromagnetic Pulse (HEMP) and High Power Microwave (HPM) Devices: Threat Assessment*, RL32544 (Washington, DC: Congressional Research Service, July 21, 2008), 9; Guoqi Ni, Benqing Gao, and Junwei Lu, "Research on High Power Microwave Weapons," paper presented at Asia-Pacific Microwave Conference, Suzhou, China, December 4–7, 2005.

[51] John P. Geis, *Directed Energy Weapons on the Battlefield: A New Vision for 2025*, Occasional Paper No. 32 (Maxwell AFB, AL: Air University Center for Strategy and Technology, 2003), 9–10; Pry, "Electromagnetic Pulse," 3–6.

[52] Samuel Glasstone and Philip J. Dolan, eds., *The Effects of Nuclear Weapons*, 3rd ed. (Washington, DC: Department of Defense and Energy Research and Development Administration, 1977), 514, 534.

[53] Pry, "Electromagnetic Pulse," 3; Glasstone and Dolan, 537.

[54] Geis, 9; Pry, "Electromagnetic Pulse," 1.

[55] Glasstone and Dolan, 536–537.

[56] Peter V. Pry, "EMP Threat from North Korea, 2013," Family Security Matters, April 27, 2014, available at <www.familysecuritymatters.org/publications/detail/emp-threat-from-north-korea-2013>.

[57] Wilson, 20.

[58] Glasstone and Dolan, 537–538.

[59] Peng Guangqian and Yao Youzhi, ed., *The Science of Military Strategy* (Beijing: Military Science Publishing House, 2005), 404.

[60] For a discussion of horizontal and vertical escalation, see Kerry M. Kartchner and Michael S. Gerson, "Escalation to Limited Nuclear War in the 21st Century," in *On Limited Nuclear War in the 21st Century*, 152.

[61] Bennett, 235.

[62] Ibid., 229–230.

[63] Peter Grier, "The Flying Tomato," *Air Force Magazine*, February 2009, 66.

[64] Orbital ATK, "Pegasus Fact Sheet," available at <http://cms.orbitalatk.com/SiteCollectionDocuments/Orbital%20Data%20Sheets/2B2_Pegasus.pdf>.

[65] For a more complete assessment of the triad's contribution to limited nuclear war, see Bennett, 211–241.

[66] Forrest E. Morgan, *Crisis Stability and Long Range Strike: A Comparative Analysis of Fighters, Bombers, and Missiles* (Santa Monica, CA: RAND, 2013), xx.

[67] Jethro Mullen, "U.S. says it sent B-2 stealth bombers over South Korea," *CNN.com*, March 28, 2013, available at <www.cnn.com/2013/03/28/world/asia/korea-us-b2-flights/index.html>.

[68] An aircraft employing an EMP missile would likely be exposed to the resultant electromagnetic pulse. Electromagnetic hardening therefore should be a design consideration and would likely drive additional requirements for the hardening of the aircraft systems.

[69] Brian Everstine, "USAF Sends Next-Gen Bomber Requirements to Industry, Few Details Made Public," Defense News, July 10, 2014, available at <www.defensenews.com/article/20140710/DEFREG02/140710001/USAF-Sends-Next-Gen-Bomber-Requirements-Industry-Few-Details-Made-Public>.

[70] James Blackwell, "Deterrence at the Operational Level of War," *Strategic Studies Quarterly* 5, no. 2 (Summer 2011), 49.

[71] Bennett, 228–229.

[72] Colin S. Gray, "Nuclear Strategy: The Case for a Theory of Victory," *International Security* 4, no. 1 (Summer 1979), 56.