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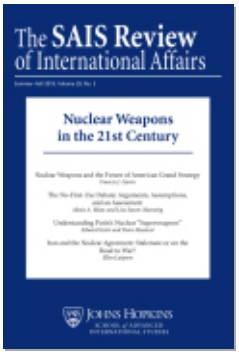

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For over eight decades, nuclear weapons have cast a shadow over world politics, transforming US grand strategy in the process. New technological innovations, especially in the digital world, threaten to further upend the international system and America's place in it once again. How should we understand the role technological change has and will continue to play in strategy and statecraft? This essay explores lessons from when the United States and the world first came to terms with the bomb, in order to better understand the choices that will face us in the years and decades ahead.

What role will nuclear weapons play in world politics in the years to come? How should the United States adapt how it employs nuclear weapons in its grand strategy in the decades ahead? How might new technologies that have recently emerged and will continue to appear, especially in the digital realm, affect the central role the bomb has played in the international system since 1945?

These questions are both fundamental and difficult to answer. Novel warfighting technologies emerge all the time. Throughout history, new capabilities have appeared to great acclaim, only to have less impact on the battlefield than anticipated. Other technologies unexpectedly offer asymmetric, non-linear effects that carry profound consequences for the balance of power.[1] Predictions on this front have often been misleading or even mistaken.[2] Nuclear weapons and the technologies around them offer a particular challenge: we often understand a new technology's impact on the balance of power only after it has been used (and adapted) on the battlefield. The bomb has been detonated during conflict just twice, within days of each other—when the Americans dropped atomic weapons on Hiroshima and Nagasaki, Japan in August 1945. Even nuclear crises have been rare after the early years of the Cold War competition between the Soviet Union and the United States.

Even without being used, however, nuclear weapons have had a profound impact on questions of war and peace. The precise nature of how and why the

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bomb has shaped international affairs is widely debated. Arguably the most important feature of nuclear weapons is their non-use and the consequences of their non-use. This quality is the most profound difference between the bomb and other military capabilities. Perhaps the most important assessment to make is how the emergence of new technologies, as well as other factors, will influence whether the bomb is more or less likely to be used. For decades, many analysts have described, advocated, and praised strategic stability—the circumstances whereby nuclear weapons provide the benefits of deterrence without generating incentives for first use. While the idea of strategic stability is not without its own controversy, a key question to explore moving forward is whether various factors, including new technologies, cause nuclear weapons to be seen as more or less usable in the future.

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This article will attempt to make sense of the complex issues surrounding the future of nuclear weapons. First, I will offer a brief overview of the history of nuclear weapons and highlight their unique qualities. I will also discuss the concept of strategic stability. Second, I will touch upon technological developments, both within and outside the nuclear realm, with an eye towards assessing their effect on international relations. Third, I will offer thoughts about how we might evaluate and frame the role technology plays in grand strategy and world politics.

Nuclear Weapons and Statecraft

What makes nuclear weapons unique amongst military capabilities—and will they retain those qualities into the future? Three characteristics of nuclear weapons stand out compared to military technologies from the past. First, the level of potential destruction and death unleashed by nuclear weapons is extraordinary. Conventional strategic bombing and even land battles generated enormous casualties in the past. However, no known technology could approach the power to level whole societies that was introduced following the creation of thermonuclear devices in the early 1950s. Second, nuclear weapons radically compressed the amount of time for delivering such devastation. Far lesser amounts of damage which would take years to inflict could now be surpassed within hours and even minutes. Third, such power could be delivered at great distances and from a variety of vantage points: from the battlefield, by dropped planes, or missiles launched from the land, air, or sea. Nuclear war, unlike battles of the past, would be devastating, sudden, and could be carried out from great distances.

It took some time before the consequences of nuclear weapons were understood.[3] Most military technologies are assessed by whether they provide advantages to the attacker or defender, or whether they are offense or defense

dominant. Many technologies can be both, depending on how they are used (the tank, for example, or aircraft carriers). Analysts have offered different explanations at different times: some that technologies aided the offensive, others that they provided a defensive advantage.

Nuclear weapons, it became clear, created a third category: deterrence dominance. The leading school of thought on nuclear weapons posited that the bomb revolutionized international politics, making wars between nuclear weapons states inconceivable. Leading scholars including Kenneth Waltz, Stephen Van Evera, Charles Glaser, and especially Robert Jervis were the most important advocates of this perspective.[4] They argued that the key distinguishing characteristic of nuclear weapons was, for those who possessed them and could protect them from a surprise attack, their ability to make enemies think twice before attacking. In others words, atomic weapons acted as invasion insurance.

What states would acquire this technology and under what circumstances? Could anything be done to stop the spread of nuclear weapons to new states? And once a state acquired the bomb, how many weapons, and in what configurations and postures, would be ideal? The nuclear revolution school had answers for all three.

Given that a country in possession of survivable nuclear weapons is more or less invasion proof, these weapons should be very popular amongst states. The technology, developed in the mid 1940s, should not have been out of the reach of dozens of developed countries in the decades that followed. Given their power and appeal, one would have expected many states to acquire the bomb. Furthermore, efforts to stop the spread of nuclear weapons would have been very difficult, if not impossible. History offers precious few examples of successful attempts to stop the spread of a military technology, especially one as effective in guaranteeing a state's security as nuclear weapons.

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Surprisingly, both of these predictions were found wanting. As of today, only nine states possess the bomb. This number is far lower than most intelligence analysts or scholars would have predicted. Many states who had the capability—ranging from Australia to Sweden—explored weapons programs but ultimately took a pass. A large reason for this lower than expected number was the nonproliferation effort of the United States, or what I have called elsewhere the "strategies of inhibition."[5] The United States used a variety of tools, ranging from coercive threats against states seeking the bomb to establishing norms. It even worked with its bitterest enemy, the Soviet Union, to prevent friends such as West Germany and Japan from getting nuclear weapons, negotiating a set of treaties whose centerpiece is the 1968 Nuclear Non-Proliferation Treaty. Arguably the most successful tool the United States deployed to limit proliferation was to offer alliances and security guarantees. States ranging from South Korea to Italy to West Germany would receive protection under America's nuclear umbrella, so long as they themselves remained non-nuclear.

How many weapons would a nuclear weapons state require and in what configuration? The nuclear revolution school posited that all a state needed was a survivable nuclear force that could unleash unimaginable damage upon an adversary, even if it was attacked first. While there were debates over the number of weapons needed to achieve this dynamic, the basic logic was that after a certain point, additional nuclear weapons did not necessarily increase the military power a state possessed.

This was another area where the nuclear revolution school's predictions came up short. If all that a state needed was a survivable force, the United States and the Soviet Union should have stopped building new forces at some point in the 1960s. Yet both countries continued to pour hundreds of billions into nuclear weapons systems. Ironically, even after the signing of the Strategic Arms Limitation Treaty and Anti-Ballistic Missile Treaty in 1972, both sides continued to develop new nuclear technologies.[6] They did not build more bombs, but rather, weapons that could be targeted more accurately, approach the enemy more stealthily, and escape any possible defense. These types of weapons systems only made sense if they were used to target the other side's nuclear weapons, or to be used pre-emptively. Much of the new (and expensive) technology surrounding nuclear systems that emerged in the 1970s and 1980s, ranging from improved antisubmarine tracking and silencing, counterforce D-5 missiles fired from submarines, the cruise missile and stealth bomber, and improved command, control, communication and intelligence (CI), made little sense if strategic stability based on survivability was the goal.[7]

Why did the United States pursue these expensive and arguably destabilizing technologies—and the Soviets respond in kind—despite arms control efforts that appeared to reflect a desire for strategic stability? Some have suggested it was bureaucratic or organizational politics—different branches of the military wanting to acquire as much of the best military equipment as possible. A better answer, however, could be found by reflecting upon the first two puzzles—why fewer states have acquired the bomb than expected, and why the United States went to such great lengths, often successful, to prevent proliferation. For states to forgo their own nuclear weapons, they must believe the patron state is willing to use the bomb on their behalf. Establishing the credibility of this promise is difficult. By seeking nuclear primacy, i.e., better nuclear weapons systems than the Soviet Union, and by having strategies that allowed it to use nuclear weapons first, the United States increased the credibility of an incredible promise. If the United States had simply posited survivability as a goal, a nuclear aspirant would be left with little reason to believe America's promise to defend it.

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Several lessons can be derived from the nuclear history of the Cold War. Nuclear weapons did revolutionize international politics; the great power wars

of invasion and conquest that plagued mankind for centuries have faded to the background.[8] Even with the increased geopolitical tensions between the United States and Russia and China, the nuclear forces possessed by all three make it hard to imagine a World War I or II scenario. That said, nuclear weapons have spread far more slowly than predicted, and the grand strategic priority the US has placed on inhibition has been relatively successful. Nor has the United States simply accepted survivability as a goal.

Will these circumstances change as new technology emerges? This is hard to answer. If you had told someone in 1960 that, sixty years later, there would be less than ten nuclear weapons states, that the number of overall nuclear weapons would massively increase then decrease, that arms control would limit the numbers but not the technological innovation pursued, and that nuclear weapons would not have been used, they probably would have been puzzled. Perhaps most importantly, nuclear weapons appear to play a far smaller role in international politics today. Is this because nuclear weapons and deterrence have become accepted and permanent features of the world order? And if so, is this something that can change?

Technological Innovation and Military Power

Over the long run, structural factors such as material wealth, geography, governance, and demographics are more likely to determine the pecking order in great power politics. Throughout history, however, technological innovation has transformed the battlefield and upended the military balance of power. Historically, states competed ruthlessly to develop, adapt, defend against, and even steal new technologies to gain an edge in geopolitical competition. Innovative states can often overcome weaknesses in other forms of power—modern Israel is a compelling example.

Nuclear weapons, unlike other technologies, have had a contradictory effect on the balance of power. On the one hand, they are an enormously powerful military tool, providing their possessor with potentially unprecedented power to destroy an adversary. On the other, their strength is so fearsome that it can cancel out other forms of military power. A state with a medium-sized or even small economy and limited conventional military capabilities can, if it possesses a nuclear arsenal, deter a far larger, more powerful state from attacking it.

There is also much debate over whether these weapons can do much more than deter. Can a state use the bomb for coercive purposes? If so, what factors—the number of weapons, the amount of resolve, the stake in the contested issue—matter the most? And what role does technology play in these outcomes?

When discussing nuclear weapons, it is important to take a broader view to analyze what might be called nuclear weapons systems. Atomic bombs are a relatively old technology that have not changed dramatically since the development of thermonuclear weapons. Other capabilities, involving the ability to deliver weapons on a target or to discover, hide, or disable nuclear weapons, have changed enormously and will continue to change. The effect of these changes on the military balance, grand strategy, and world order is contested.

American nuclear weapons systems went through at least two periods of profound technological change. The first period came in the late 1950s and early 1960s with the development of intercontinental missiles and satellites.[9] During the first decade and a half of the nuclear age, nuclear bombs were deliverable by airplanes with varying degrees of range. Both the Soviet Union and the United States later developed long-range rockets, including intercontinental missiles, which allowed them to deliver atomic weapons quickly and from great distances. These missiles could also be fired from submarines, which were hard to detect and track. Concurrently, the United States developed satellites, which in time provided a view into the location and number of nuclear weapons possessed by other countries.

The second period of innovation came in the 1970s and 1980s, and largely affected nuclear delivery systems. Missiles became far more accurate. An arms race began over stealth technologies that allowed weapons to elude detection, with capabilities that were far better at locating and targeting nuclear weapons systems. An example can be found in the realm of nuclear weapons delivered by submarines, where the United States and the Soviet Union both worked to escape detection and to both identify and target the adversary. Command, control, communications, and intelligence capabilities dramatically improved as well. Massive investments in defenses against incoming nuclear missiles had far more mixed results.

What were the consequences of this qualitative nuclear arms race? Again, this is a contested question. In a somewhat contradictory fashion, some argue it was both dangerous and destabilizing, as well as a useless waste of money. Others argue that Soviet efforts to keep up with massive American investments in nuclear weapons systems technology helped expose their deep vulnerabilities and contributed to the end of the Cold War and the collapse of the Soviet Union. A less explored idea is that since the United States possessed such a potent nuclear force, other states were dissuaded from improving their own nuclear weapons systems or pursuing the bomb at all.

We may be entering a third period of innovation in nuclear weapons systems via the advancement of cyber, machine learning, and artificial intelligence. Improvements in stealth, detection, defense, miniaturization, speed, and accuracy continue. Computer processing capabilities have increased by orders of magnitude, allowing for far more complex, interconnected systems. The United States is scheduled to spend over a trillion dollars modernizing its nuclear weapons systems over the next three decades.[10] Other nuclear powers are improving their capabilities as well. New technologies will undoubtedly emerge.

A distinct feature of recent innovations is that they have been adapted to non-nuclear systems. Many of the advancements that emerged from the second and more recent period of American innovation have been utilized in conventional weapons systems and deployed in battle. Since the first Gulf War and escalating rapidly ever since, the face of the battlefield has been transformed by new technology—especially informational capabilities—in ways that would have seemed unimaginable in the past. Some advanced conventional weapons,

like long-range conventional strike capabilities, may be used to undertake missions and targets that had previously been reserved for nuclear forces or be deployed in ways that make it unclear whether they are targeting an enemy's nuclear forces or are nuclear forces themselves. Many analysts worry that this blurring what was once seen as a clear red line between conventional and nuclear forces will be destabilizing.

Since the first Gulf War and escalating rapidly ever since, the face of the battlefield has been transformed by new technology—especially informational capabilities—in ways that would have seemed unimaginable in the past.

How will new technologies—in particular, massive increases in computational power and effectiveness—affect the balance of military power?[11] Related but separate—how will these technologies affect the nuclear balance? These are complicated questions that raise significant concerns among some observers. Henry Kissinger, one of the earliest scholars to recognize the profound consequences of the nuclear revolution, is quite worried about the impact artificial intelligence and machine learning will have on geopolitical and nuclear stability. Kissinger contends that this new and unpredictable technological revolution will have profound moral and ethical consequences, with the potential to upend the international order.[12] As he, Eric Schmidt, and Daniel Huttenlocher warned:

> In the nuclear age, strategy evolved around the concept of deterrence. Deterrence is predicated on the rationality of parties, and the premise that stability can be ensured by nuclear and other military deployments that can be neutralized only by deliberate acts leading to self-destruction; the likelihood of retaliation deters attack. Arms-control agreements with monitoring systems were developed in large part to avoid challenges from rogue states or false signals that might trigger a catastrophic response.
>
> Hardly any of these strategic verities can be applied to a world in which AI plays a significant role in national security. If AI develops new weapons, strategies, and tactics by simulation and other clandestine methods, control becomes elusive, if not impossible. The premises of arms control based on disclosure will alter: Adversaries' ignorance of AI-developed configurations will become a strategic advantage—an advantage that would be sacrificed at a negotiating table where transparency as to capabilities is a prerequisite. The opacity (and also the speed) of the cyberworld may overwhelm current planning models.[13]

There are a few things to bear in mind about cyber, artificial intelligence, and machine learning when assessing their potential impact on the military balance and stability.[14] First, we should recall that these technologies are *facilitating* technologies. On their own, they are not instruments of violence for use on the battlefield, like tanks, battleships, or cannons. For the most part, these new technologies develop their military effectiveness in conjunction with kinetic capabilities. They enable kinetic force. Another characteristic is that these technologies are dual-use, or perhaps more accurately, driven and

developed far more by and for the civilian sector. These make regulating them through arms control more complicated. Many of these new technologies are part of increasingly interdependent networks that are a feature of the globalized economy. This makes categorizing them as purely national or state capabilities difficult (the Huawei situation is a good example).

One of the keys to achieving nuclear deterrence was making one's capabilities clear. A state that hides or underplays its nuclear weapons capabilities risks losing those benefits.

These technologies offer other challenges as well. One of the keys to achieving nuclear deterrence was making one's capabilities clear. A state that hides or underplays its nuclear weapons capabilities risks losing those benefits. Exaggerating one's capabilities risks destabilizing international politics. Computational technologies, on the other hand, are far less transparent—it is hard to physically represent them without using them, and once they are used, adversaries can develop countermeasures and adapt. It is also hard to imagine what arms control would look like. Treaties limiting the number and kinds of weapons are easier to verify and measure than algorithms.

Nuclear Weapons System Technology, Grand Strategy, and International Relations

Shifts in technology have and will continue to shape both strategic stability and the shape of the international order. But changes to two other forces matter as much, and perhaps more, on questions of war and peace.

The first is change in the international political order. In the years following the end of the Cold War and the collapse of the Soviet Union, there was some hope that globalization and increasing interdependence, combined with expanding norms, shared international laws, and strengthened international institutions would dramatically decrease the dangers of conflict. In particular, there was an emphasis on reducing the dangers associated with weapons of mass destruction, particularly through arms control. Though by no means perfect, this period witnessed much success. Military spending decreased worldwide, the number of nuclear weapons decreased dramatically, and the spread of dangerous technologies was limited. Nuclear arms control between Russia and the United States, as well as efforts to strengthen the world-wide nuclear nonproliferation regime, were hallmarks of this effort.

There is reason to believe this period, marked by historically impressive levels of cooperation and coordination, may be over (or at least pausing), and that we have entered a new era, characterized by the return of great power rivalry and geopolitical competition.

This era of renewed rivalry has several components. The first is the intensification of regional rivalries and instability. Especially in the Middle East, South Asia, and East Asia, historical enmities have worsened, with the potential for arms races and conflict. Each of these regions holds the potential

for nuclear rivalry, with unknown consequences. In the Middle East, Israel is the only state with nuclear weapons, but Iran has sought and may continue to seek atomic capabilities, with the Gulf states eyeing such developments warily. In East Asia, North Korea's nuclear weapons program has generated deep concern, especially in South Korea and Japan. Will these states seek the bomb? In South Asia, both India and Pakistan possess both bitter enmity and nuclear weapons. It is unclear how these regional rivalries will develop in the next few decades, but recent trends are not promising.

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These regional rivalries take place in the shadow of the return of great power rivalry. America's relations with both Russia and China have deteriorated, and the trend lines are not promising. Russia has expressed bitterness over a variety of American-led policies since the end of the Cold War, and its foreign policy under Vladimir Putin has become aggressive, witnessed by its seizure of Crimea and its intervention in Syria. It has also violated arms control treaties while embarking on its own nuclear modernization. China's rapid economic development, combined with its assertion of both regional and global great power status, has brought it into increased competition with the United States.

How will the United States respond to both these regional and global challenges, and how will it affect the international and nuclear order? This is another uncertain variable. The United States retains far and away the world's most powerful military and remains the bedrock of alliance and security arrangements that arguably provide international political stability. It is also one of the keys to inhibiting the spread of nuclear weapons.

The second change is harder to grasp and quantify but, in the end, may be more important. Nuclear weapons are increasingly seen as unusable, which may make them less relevant to international politics. Ironically, this may be due to the success of nuclear deterrence—the absence of nuclear war since 1945 has made the possibility of a planned nuclear detonation seem remote if not impossible. Furthermore, global norms against not only nuclear use, but nuclear possession, have increased. Nuclear deterrence, however, is premised upon at least the possibility nuclear weapons would be used in extremis.

While geopolitical tensions have increased, how states fight and what they fight for has changed. In the past, state power was based on the size of its population, its land, and its resources. States conquered other states to obtain these resources. In the 21st century knowledge economy, it is hard to see where invasion and conquest pays. While nationalism and identity clashes may be on the rise, flattening demographics and aging societies decrease state appetites for war. No state at present is remotely prepared to fight the kind of grinding wars

of conquest, total mobilization, and attrition that marked much of the 19th and 20th century, nor do any appear eager to see such a world return. That doesn't mean it cannot return, of course; history tends to return and change suddenly. Historically speaking, however, today's military budgets as a percentage of GNP are not high. The combination of a world living under a nuclear umbrella and integrated through globalized supply chains constrains both what states want to do and can do.

It is unclear what impact new technologies will have on this situation.[15] On the one hand, new technologies may be able to carry out missions once reserved for nuclear weapons. Imagine this scenario: the United States launches a cyber attack to disable an adversary's ability to launch its nuclear weapons. In the past, such a pre-emptive and preventive attack could only have been achieved by launching a devastating nuclear strike, with enormous casualties and damage. Such an action would have been seen as deeply problematic at best. But what if new technologies enabled you to achieve the same result without a single casualty or even a damaged building? Strategic nuclear stability disappears in such a scenario, though it is not clear what the consequences are. New technologies may also make war less likely, perhaps by increasing intelligence about capabilities or shifting states to varieties of competition that may be intense but are less likely to lead to the kinds of great power wars of the past.

These new technologies offer one of the bigger grand strategic choices facing the United States. Will they replace nuclear weapons as the central military technology of the future? If not, will they make it more or less likely that nuclear weapons can be used? Should it invest over a trillion dollars over the next thirty years on nuclear modernization, as planned, if nuclear weapons are less useful tools to achieve national interest? Might those funds be better spent on new technologies such as artificial intelligence, nano-technology, automation, and robotics? And given the increasing hold of the nuclear taboo, would it be better to marry these new technologies to the nuclear mission or separate them from it?

Conclusion

The changing technological landscape is, of course, critical to understanding the military balance of power, the stability in the international system, and the appropriate grand strategy the United States should purse to achieve its goals and interests. After a somewhat static period, new capabilities are emerging that, on their surface, augur dramatic changes. In an uncertain world, it would be wise for the United States to both explore and develop these technologies and also prepare for the global consequences of their development.

That said, it is easy to overstate the role technology plays. Technology is only a tool that is used to pursue interests; it doesn't drive those interests alone. One mistake nuclear analysts made in the past was to analyze and assess the bomb on its own, separate from a state's political interests and goals. Nuclear strategy, arms control, proliferation and nonproliferation—all were

seen as shaped by the revolutionary, transformative effect of nuclear weapons. Politics did not go away, however, and therefore by examining what goals the United States and other nuclear (and near-nuclear or non-nuclear) states hoped to achieve, one can help explain what the security studies field got wrong. Furthermore, there are broader trends in the international system, such as demographics and globalization, that worked with nuclear deterrence to reshape world order. It is not clear that dramatic shifts in technology would necessarily overturn these other considerations.

The changing technological landscape is, of course, critical to understanding the military balance of power, the stability in the international system, and the appropriate grand strategy the United States should purse to achieve its goals and interests.

The most interesting question may be whether these technological advancements augment, replace, or are peripheral to the fundamental role nuclear weapons play.

Notes

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